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Incentivizing Cooperative Agreements for Sustainable Forest Management

*Experimental Tests of Alternative Structures and Institutional Rules**

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ABSTRACT

Non-industrial private forestland owners (NIPFs) manage the majority of US forestland. But land use conversion is highest amongst this group, in part due to the relative paucity of income earned from active forest management relative to sale of land to developers. Cooperative forest management agreements can help reduce this differential, but participation remains low. If structured well, these agreements can provide opportunities for long term payments from sales of timber and ecosystem services at levels sufficient to reduce the temptation to convert. In this paper we investigate various means of encouraging meaningful participation in cooperative agreements for forests that emphasize conservation. We report on the results obtained through a series of laboratory market experiments in which the participants play the role of NIPFs and make resource allocation decisions facing real financial incentives. Our results shed light on the relative factors that affect the success of these agreements. In particular, we find that when agreements include contribution thresholds (with money back guarantees) coupled with relatively long contract lengths, groups are able to preserve a significant fraction of forested lands through conservation agreements.

Keywords: conservation agreement, participation, economic laboratory experiment

1. Introduction

The southern United States has experienced rapid and extensive conversion of forestlands to residential development in the past decades. Over 15 million acres was converted from 1990 to 2002 with another 21 million acres expected to be lost by 2030 (Wear 2002). Conversion rates have been highest amongst small non-industrial private forest owners (NIPFs) in part due to high transaction costs and other limitations to earning revenue from active forest management that are not present for most larger landowners. Many of the traditional techniques for active forest management such as harvesting timber, controlling pests and prescribed fire are too expensive for NIPFs and only become feasible when taking advantage of economies of scale afforded by larger, contiguous acreages (Ashton et al. 2008). In many cases family farms have been sold to developers for subdivisions. Frequently the residents of these newly created subdivisions are seasonal occupants; these dwelling units are often second homes. The pace of such development has slowed due to the current recession but it is to be expected that this is a temporary phenomenon. It is unlikely that tastes for such seasonal homes have changed.[1]

The history of the forested lands in the Southern Appalachians recounts successive periods of development. Eller (1982) describes a pattern of timber development through the purchase of timber rights from the landowners, often for pennies on the acre. The timber interests were usually from outside the southern Appalachian region. And, the harvesting of the timber was usually accomplished through clear cutting and establishing local sawmills on rail lines. In more recent years the development of these southern Appalachian forests has taken the form of subdividing the land into “acreages” and building homes (often second homes) on these parcels. In the process, some of the second growth timber has been cleared resulting in a patchwork pattern of forested lands.

The problem facing Southern Appalachian forests is one that confronts most private forest owners; the opportunity cost of leaving the land undeveloped is increasingly high. While most NIPFs are willing to accept a stream of income from conservation or sustainable management that is significantly less than the benefits of converting the land to industrial forest

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[1] In addition, the impending retirements of the “baby boomer” generation will shift the demand curve for such properties to the right. Since much of the individual financing for these dwelling units has derived from mortgages on primary residences, often located in other states such as Florida, the recent downturn in housing prices and the attendant difficulties in obtaining housing backed financing has slowed the demand for such land conversion and development.

uses or land sales (see Raunikar and Buongiorno 2006) this “conservation premium” is increasingly unattractive when land prices reach several tens of thousands of dollars per acre and absent entirely when barriers to entry in ecosystem service markets remain too high. In the face of such pressure, one potential means of preserving forested lands is through the use of voluntary cooperative forest management agreements (CA). Cooperative agreements for NIPFs present an emerging area for study and development of public policy incentives, globally and across the US, especially because of the significant role they can play in management for ecosystem services across large landscapes (Yang et al. 2013; Goldman et al. 2007; Kittredge 2005; Erickson at al. 2002). Land managed under a CA, temporarily or in perpetuity, is preserved and pooled with other parcels of land by other agreement members. The agreement members manage the land with the goal of helping boost landowner incomes through the sale of timber, non-timber forest products, recreational access and emerging markets for ecosystem services. There are many benefits from joining a CA.

Small forest owners often face barriers to entry into ecosystem service markets due to the high transaction costs associated with management of relatively small parcels; pooling lands through CAs helps reduce these costs. Management for timber, wildlife habitat, aesthetics, outdoor recreation and privacy all can be enhanced by planning and managing forests at scales larger than individual NIPF ownerships (Kittredge 2005). Ashton et al. (2008) identify seven major CA benefits: opportunities to share management knowledge and techniques, improved property access, coordinated forest health, shared work activities, increased profits, increased value added, community development and political clout.

In practice, CAs vary widely from one country to another and throughout the US. Kittredge (2005) identifies four basic forms: (1) information cooperatives, where landowners share information, experiences, and advice but generally operate independently; (2) equipment cooperation, where members share equipment and machinery for harvesting timber, road management or other intensive uses but still operate independently; (3) financial cooperation, where members organize for the purpose of collective marketing of wood products, and (4) management cooperation, where landowners manage cooperatively on a spatial and temporal scale for multiple objectives. Management cooperatives are most amenable to conservation and management of ecosystem services, but have the least uptake. Therefore, the structure of incentive programs to induce greater NIPF owner participation in management cooperatives – especially those with a conservation focus – is of keen interest to researchers and policy makers.

CAs can function in many different ways. For example, landowners may sell their land outright (transfer all rights) to a Conservancy (for example, the Blue Ridge Conservancy) and the Conservancy can either manage the lands itself or transfer to a management entity such as the State or Federal Parks Service. In this case, the landowner receives a lump sum payment – effectively selling the land to conservation practices. Alternatively, the landowner can enroll their lands in a conservancy agreement which imposes limits on the development (and perhaps modification) of the lands for the period specified in the agreement. The CA can pay the landowner for this option (essentially a lease) and generate the payment funds through selling timber or other ecosystem services (carbon sequestration, habitat preservation, watershed preservation, etc.) in the emerging markets for such services.

While the potential benefits of CAs are promising, whether these agreements can effectively lead to increased conservation of forested lands is an empirical question. These agreements can be structured in any number of ways and can include a variety of different policy components. Currently there are insufficient data from existing agreements to tease out the relative factors that lead to successful (or unsuccessful) arrangements, or answer a critical policy question: what level do CA benefits have to be to induce NIPFs to participate and conserve rather than sell their lands to developers? The empirical research is limited, but informative on the range of factors that may come into play. Yang et al. (2013) found NIPFs stated willingness-to-participate in forest cooperatives was associated with demographic characteristics like education, forest-related income, size of forestland, and attitudes toward land tenure reform and cooperatives. Goldman et al. (2007) investigated cooperation in the production of ecosystem services and evaluated the relative merits of three incentive designs – the cooperation bonus, the entrepreneur, and the ecosystem service district. Their research underscored the importance of near-neighbor effects, specifically; they found that the cooperation bonus incentive is most likely to work where neighbors know each other or least interact on some level. Similarly, Parkhurst et al. (2002) found in the lab that a cooperation (agglomeration) bonus for maintaining contiguous wildlife habitat almost always stimulated conservation outcomes whereas the lack of such a bonus almost always created fragmented habitat. Warziniak et al. (2007) tested the importance of communication and reputation in a spatial coordination game amongst small landowners with payoffs designed to encourage preservation of large contiguous blocks of land. They found cheap talk to be an effective tool, and reputation to be the strongest determinant of efficiency.

This paper builds on previous work by using controlled laboratory experiments to test the effectiveness of different agreement structures and institutional rules for a CA whose emphasis is on conservation and management of ecosystem services. In these experiments, subjects take the role of an individual NIPF and make CA membership and land use decisions facing real financial incentives that simulate the incentives forestland owners face outside of the lab.[2] To simplify the analysis so that it is conducive to experimental tests, we consider owners who have three options regarding their land. Owners can (1) sell their lands to developers who will subdivide the property and construct housing, or (2) retain their lands for present use with an option to sell in the future, or (3) join a CA and enroll all or a portion of their land.

The first two land use options are straightforward in the sense that those land use options produce benefits that accrue only to the landowner. However, the third option, enrolling land in a conservation agreement, generates a private return but it also creates public and club benefits. For example, an agreement member's return for ecosystem services is an increasing function of the entire amount of land enrolled in the CA. This is clearly a club good. However, some benefits of a CA will also be enjoyed by nonmembers who do not enroll land into a conservation agreement. For example, increased conservation efforts may lead to improved scenery, more solitude and/or improved nearby recreation resources. Therefore, the decision to contribute land to a CA is effectively a voluntary contribution to a public good (with additional club benefits). Because forest owners can free ride off the benefit of others' contributions, there is a clear prediction of sub-optimal levels (underprovision) of land tendered to conservation agreements. This study explores whether such agreements can be structured in such a way to mitigate the free-rider problem.

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[2] Laboratory methods are now widely accepted as a methodological approach in the testing of economic theory and have increasingly been used to examine various issues in public policy. Lab experiments offer a low cost means of testing policy much as wind tunnel testing is applied to aircraft and building design. A central issue in the use of economic experiments for policy evaluation is the external validity of the experimental results. This concern is most often raised in conjunction with concerns over the subject pool consisting almost entirely of students. The external validity question is, do the results in the lab generalize to the field setting? To be useful to policy decisions, experiments must satisfy the precept of "parallelism" (Plott, 1987). Internal validity, like parallelism, can be demonstrated through the evaluation of the design. External validity requires comparisons across subject pools and with such behavior as can be gleaned from naturally occurring environments that parallel the lab setting. There is little literature in this regard since many of these incentive programs are new (and even untried). The discussion in Kittredge (2005) suggests our experimental setting meets the basic conditions for external validity.

The next section develops a simple theoretical framework that captures the tensions inherent in forestland use decisions; in particular the model captures the public good/club good nature of the CA and the underlying free rider incentives. The model, and the experiments that follow, are structured as familiar collective action problems in which it is privately optimal to sell land for development but it is collectively optimal to enroll land in the CA. We explore, in theory and experiments, two institutional rules that are designed to facilitate cooperation among land owners. One is a threshold contribution level along with a money-back guarantee (land is returned to the owner if the threshold is not met). The other institutional rule is requiring a minimum contribution level by agreement members (as opposed to unrestricted enrollment). We also explore the effects of higher payments for ecosystem services (i.e., variable club benefits) and alternative lengths of CA contracts. We find that although groups of landowners contribute less land than is socially desirable regardless of the agreement structure, a longer contract coupled with a threshold level of aggregate land contributions results in significant levels of conservation.

2. A Model of forest land use decisions

Land owners have three options: (1) sell their land, (2) self-manage their land or (3) enroll land into a CA. The $i = 1, \ldots, N$ land owners start with an endowment of land (e_i) and make decisions over $j = 1, \ldots, T$ time periods. In order to capture the tensions inherent in forestland use decisions, the parameters of the model are chosen to satisfy the following conditions: First, individual profit-maximizing land owners earn more money selling their land than they do contributing it to the CA or self-managing their land. Second, the socially optimal land use decision requires that all owners contribute their entire endowment of land to the CA in the first period. Therefore, contributing land to a conservation association is a collective action problem. That is, risk-neutral, profit-maximizing landowners are better off as a group contributing all of their land to the CA, but individually are better off selling their land.

In the model, and the experiments that follow, the default (status-quo) decision for the land owner is to self-manage their land. Each unit of land that is left self-managed earns an amount equal to *SM* for each period.

2.1 Sell to developers

When a landowner sells land to developers she receives the net revenue from the sale. This revenue can be invested and, by assumption, earns the market return which will be paid for the remaining periods. With anticipated rates of return we model the future payoff as being capitalized at the time of the sale. Let *Sale* denote the expected single period sale price for a unit of land. There is also an external effect from developing land. If landowner *i* sells land for development this imposes a negative externality (loss of amenity value) on its neighbors.[3] When *i* sells a unit of land to developers the remaining $N - 1$ owners incur a cost, denoted as *NegEx*.[4] Selling land to developers in the current period, denoted as *c*, precludes the former owner from making allocation decisions for the remaining $T - c$ periods. Parameters are chosen so that selling a unit of land, in any period, earns an owner a higher payoff compared to self-managing for any length of time; that is, $Sale > \sum_{j=1}^{T} SM_j$.

2.2 Enroll land in a CA

When a landowner enrolls a unit of land in a CA she receives a per-period return that depends on both the market price of ecosystem services or environmental credits and the aggregate amount of land that is enrolled in the CA.[5] This is the club good (or member benefit) to the CA. In addition, land enrolled in the CA generates a positive externality for the neighboring land owners. This externality is the public good component (i.e., these benefits are both non-rival and non-excludable).

Land devoted to the CA yields a return that is an increasing function of the aggregate number of units devoted to the CA. Denote a_i as the amount of land enrolled in the CA by owner *i*, where $a_i \leq e_i$. Denote $A = (a_i + a_{-i})$ as the aggregate amount of land contributed to the CA, from *i* and her neighbors, where a_{-i} indicates the contributions from the $N-1$ other land owners. The period earnings to *i* from land enrolled in the CA are $(b+g)A$, where *b* is the expected club-good

[3] It is also the case that as more landowners tender land for sale the market price will fall but we abstract from this effect here and in the experiments.

[4] That is there are negative externalities imposed on the adjacent landowners arising from, for example, increased traffic, reduced views, and increasing property taxes.

[5] This discussion is based on assumptions concerning the production function of the benefits associated with the structure of the CA. These seem reasonable given the nature of the production function for ecosystem services (see Parkhurst, et al., 2002; Smith and Shogren, 2002).

payoff from land enrolled in the CA, and g is the expected public-good payoff. Note that only CA members yield the club-good benefits while all land owners, regardless of whether they are part of the CA, accrue public-good returns.

2.3 Non-cooperative Nash equilibrium

Contributing land to the CA is a collective action problem. Individually, it is more lucrative to sell land than enroll it. This requires that the payoff stream received from a unit enrolled in the CA in any period, $b + g$, is less than the sale price from a unit of land period. That is, even if a unit of land is enrolled in the first period, $Sale > T(b + g)$. In a non-cooperative Nash equilibrium, no owner devotes any land to a CA in any period. Rather, all land is sold to developers. Land owners in this case earn

$$\pi_i = Sale * e_i - (E - e_i) NegEx, \qquad [1]$$

where E is the aggregate endowment of land.

2.4 Socially optimal contributions to the CA

Collectively, however, the group is better off enrolling all of its land in the CA in period one. That is, if all land is devoted to the CA in the first period then social welfare is maximized. When this is the case a land owner's earnings are

$$\pi_i = T * E\left(b + g\right). \qquad [2]$$

Comparing the revenue from selling each unit of land with equation [2], for full contributions to the CA in the first period to be socially optimal, it must be the case that $T * E\left(b + g\right) > Sale * e_i$. Parameters are chosen in our experiment so that this condition is satisfied.

Moreover, in the first period there exists a combination of own and other land contributions to the CA in which $A < E$ that is sufficient to make the stream of payoffs from CA contributions weakly greater than the sale price. Therefore, contributing land to conservancy can be *profitable* to its members in the first period even without full contributions as long as the aggregate contribution level is high enough. Thus there are financial incentives for CA activity even in the presence of nonparticipating free riders. Profitability requires that $T * A\left(b + g\right) \geq Sale * a_i$,or when rearranged, $A \geq Sale * a_i / T * (b + g)$.

The game, however, is dynamic. Once in period two, the potential stream of earnings from enrolling land in a CA has decreased by one period. Therefore, the amount of aggregate land that needs to be allocated to the CA in period two to make contributions profitable (relative to selling) must increase relative to period one. In other words, the shorter time horizon must be offset with a larger contribution level. In fact, if the owners wait too long there will be no aggregate contribution amount possible that makes contributing to the CA more profitable than selling. Let c' denote the period in which land is enrolled in the CA. If $T - c' * E(b+g) < Sale * e_i$ then it is not possible to profit from CA contributions. When this is the case, the value of selling land to developers exceeds the stream of payoffs from a CA that achieves full contributions because the land was contributed to the CA too late. Therefore, for CA contributions to be profitable, owners have to contribute enough land early on to make it worthwhile.

In summary, the payoffs are such that enrolling all land in the CA in the first period is the socially optimal outcome but achieving this equilibrium requires overcoming the collective action problem. The outcome is a behavioral (empirical) question and we have constructed a set of experiments to investigate this behavior, and the effectiveness of institutions designed to facilitate cooperation.

3. Experiment Design

The experimental setting is designed to capture the essential features of the landowner decisions regarding allocation of land as presented in the previous section. Participants in the experiment are endowed with 100 units of land and must choose to allocate their land over the three uses. The experimental sessions last for 20 decision rounds. To capture the effects of alternative contract durations for the CAs the sessions were organized into series of varying lengths (3, 5, and 7 rounds). When a series ends, the landowners are returned to the original state with their endowment of land. The landowners are informed of the length of the current series but not the total number of series being run in a session.

An experiment session proceeds as follows. The subjects are seated at individual computer stations separated by carrels. Subjects are provided a basic set of lab protocol instructions by the proctor, who runs the experiment. These include the usual informed consent process, requests to turn off cell phones, and a reminder that they are not permitted to communicate with each other – all questions are to be addressed to the proctor. Subjects are assigned to a group of five. The assignment is random and the groupings are randomly reshuffled with each new series. The individual's neighbors are described a "near" and "distant" but the individual does not know who the actual neighbors are in the lab. In most sessions there were four groups of five but due to fewer subjects showing up for one session we ran one with three groups of five. The subjects are told that the session will consist of an unknown number of series or rounds but that they will be informed of the number of rounds in a given series. In practice the sessions lasted for 20 rounds. Subject payoffs are the total earnings for the 20 rounds. The exchange rate between lab dollars and US dollars was set such that the average earnings would more than cover the subjects' opportunity cost. In these sessions, lasting a total of 60 minutes, the average earnings was just over $18.00 (ranged from $14 to $28) and the subjects appeared to be motivated to make good decisions.

In round 1 of a series the subjects are endowed with 100 units of land. They are presented a screen showing their endowment and that of their neighbors. The subjects choose their own allocation of land using slider bars to select the amount of land to sell and the amount to enroll in a CA. The subjects can also examine the effects of allocation decisions of others by moving the slider bars denoting conjectured allocations of their neighbors. Of course, these choices have no effect on the outcomes. The decision period is limited to 60 seconds and the subjects have a time counter on the bottom of the screen. If time expires before the subjects submit their choices whatever is showing on the screen when the round ends is automatically submitted. In practice we observe almost no timing out.

After all decisions are submitted the lab server computes the outcomes for each group and the results for the round are transmitted to the subjects. The subjects learn pertinent details, depending on the treatment in effect, such as whether a threshold was met, the allocations of their neighbors, and their payoffs from the round.

The decision setting is complex due to the within group interactions and the range of the decision space facing the subject. Subjects are provided a written summary instruction sheet (Appendix 1) and the computer interface is designed to assist the subject in the decision process.

Our baseline experimental treatments are designed following the land use decision model from section two. In short, our baseline results show that land owners contribute more land to conservancy than the standard theory predicts, but fall far short of the social optimum. The additional experimental treatments explore major policy options available to the organizers of the CA to encourage more cooperation, and also explore some alternative states of nature that may arise. Informed by research on provision point public good settings (Bagnoli and McKee, 1991;

Marks and Croson 1998; McEvoy, 2010) we design a CA institution in which lands are tendered to the CA but are returned to the landowners if a predetermined threshold (quantity of tendered land) is not met. This type of "money back guarantee" (MBG) has been demonstrated to implement efficient levels of public good provision through voluntary contributions. The policy motivation for the threshold in the CA setting is that there would be a minimum size that the CA requires in order to make contributing to the CA profitable (i.e., generates a higher return in comparison to selling land). A minimum size is also critical for the CA itself if it is to effectively manage to produce marketable ecosystem service benefits such as carbon sequestration, water quality, or habitat credits or timber certified as sustainably managed (Kittredge 2005; Goldman et al. 2007). Therefore, the thresholds implemented in our experiments are calculated as the minimum aggregate contribution level that makes a CA profitable for its members but also functional from the standpoint of a conservation oriented CA. Offers of lands to participate in the CA are solicited and if the aggregate lands fall short of the announced threshold by the announced date (the rounds are timed in the experiment) the offered lands are returned to the landowner for self management for this round. Since a series is of finite length, the payoff horizon for ecosystem services is reduced each round. Thus the minimum threshold increases each round within a series. It is possible that the threshold cannot be met with the remaining lands available to be allocated. Recall that lands sold in the current period are not available for reallocation in the following periods and a group that sells a large fraction of its lands in an early round may not be able to meet the CA threshold during a current series.

The other major policy option we explore is minimum enrollment amount to enter the CA and receive the member (club) benefits. As a treatment we implement two levels of individual enrollment requirement. In one, earning member benefits from the CA requires minimal participation – one unit of land. In the alternative setting the member benefits are only paid if the individual landowner allocates at least 20 units (of their 100 unit endowment). The higher level raises the threshold for rational individual participation. However, this may induce as well as dissuade participation. Since the CA functions somewhat like a fundraiser the organizers may borrow from the fundraising literature that suggests the effectiveness of stating suggested contribution levels. The risks for the individual landowner are that she will allocate this higher minimum to the CA while everyone else allocates nothing and she is much worse off than if she had sold her lands.

We also vary some of the more important parameters in the experiment. We vary the series lengths within most treatments since one policy option available to the CA is the length of time a property is enrolled and the owner restricted from further development or sale and this can affect participation through varying the range of options available to the landowner (McKee and Berrens, 2000). The CA also has the potential to more aggressively market ecosystem services (at a cost to the CA) and, thus, obtain a higher stream of revenues per unit of lands allocated to the CA. We explore both high and low member benefits. Note, however, that even with the high payoff an individual landowner's dominant strategy is to sell her lands. That is, the free rider problem persists. We expect that this will likely be the case in the field. That is, it is unlikely a CA will be able to outbid property development on a single piece of land. Rather, the CA return only exceeds the private sale value when a sufficient amount of lands (greater than a single owner's holdings) are enrolled.

Table 1 contains the experimental parameters. We have conducted nine experimental sessions with a total of 175 subjects participating. Each session lasted 20 rounds with different length and numbers of series thus yielding a set of panels of different lengths for analysis.

Table 1: Experimental parameters

Parameter	Definition	Values
e	Endowment	100 units
N	Number in Group	5
SM	Self-Management Payoff	\$7 or \$0 per unit
Sale	Market Price for Land Sold	\$40 per unit
b	Club Good Payoff	\$6 or \$4 per unit
g	Public Good Payoff	\$1.5 per unit
NegEx	Negative Externality from Near Land Sold	\$0.25 per unit
Series length	Contract Length for CA	3, 5 or 7 periods
Minimum contribution	Minimum Lands to be Contributed to CA	20 or 0 units

Notes: Values for *Sale*, *b* and *g* are expected values.

4. Results

We begin our analysis of the results at the group level. Recall, that the efficient solution in each series is identical: every player in the group must contribute their entire land holdings to the CA during the first period. The two institutions we explore experimentally are the money back guarantee (MBG) and the minimum contribution amount. Table 2 reports the percentage of a group's land enrolled in CAs by institution and series (contract) length. Maximizing group earnings requires that the percentages in Table 2 are 100%.

The baseline mechanism, which we label as the voluntary contribution game, motivates groups to contribute slightly greater than one third of their total endowment to the CA, irrespective of series length. The threshold with a money-back guarantee performs relatively very poorly in the short series (16.31%) but motivates increasing contributions to the CA when the series length increases. Indeed, when a threshold with an MBG is coupled with a long series (7 periods), contributions to the CA approach two thirds of the total. The other institution, the minimum contribution amount, yields slightly more CA contributions relative to the baseline under a short series, but performs increasingly better as the series lengthens. Clearly, the best performing institution is the threshold with MBG under a long contract. Over all three institutions, land that was not enrolled in CAs (remaining percentages from Table 2) was almost always sold for development.

Table 2: Institutional rules and group-level contributions to CAs

	3 Period Series	**5 Period Series**	**7 Period Series**
Voluntary contributions (baseline)	33.93%	35.52%	36.47%
Money back guarantee (MBG)	16.31%	49.73%	62.80%
Minimum contribution amount	38.70%	42.11%	45.45%

The results reported in Table 2 are unconditional percentages. In tandem with the different institutional rules and series lengths, we also vary the level of club benefits and the value of self-managing land. While these are not policy choices, their levels may impact the ability of groups to conserve land through voluntary agreements. To explore all of these individual components, and their interactions, we estimate a linear regression model. Table 3 reports the results of model estimations of the realized group contributions to the CA on dummies for five and seven round contracts (three rounds is the omitted values), MBG (relative to baseline) and its interaction over the series length, the minimum contributions of 20 units (relative to baseline) and its interaction over the series length, and the effect of zero self management value (relative to five) and high club benefits ($4 vs. $6). The results in Table 3 control for period fixed effects (suppressed). There are 168 group-level observations. The results show that increasing the contract length independently does not have a significant effect on contributions relative to the baseline voluntary contributions game. However, given an aggregate contribution threshold and MBG, the series length matters and a longer contract can significantly increase contributions to CA relative to the baseline treatment. The results also show that a money back guarantee under a short contract length performs significantly worse than the baseline treatment. The conditional results also illustrate that a required minimum contribution of 20 units does not have a significant effect on group-level contributions to the CA, even when interacting this institution with contract length. Finally, varying the value of self managing land or the club benefits to CA membership does not have a significant on group-level contributions to the CA. Clearly, the most striking result is that agreements that include aggregate contribution thresholds and MBGs over long contract periods are likely to be most effective at fostering conservation.

Table 3: Group-level regression of land enrolled in CA

Independent Variable	**coefficient**	**std. error**	***p*-value**
constant	169.65	18.91	0.000
5 Round Contract	41.13	29.75	0.169
7 Round Contract	12.68	55.68	0.820
Money Back Guarantee (MBG)	-142.46	25.67	0.000
*MBG * 5 Round*	143.44	34.66	0.000
*MBG * 7 Round*	256.42	66.85	0.000
Min 20 Units	13.14	38.45	0.733
*Min 20 * 5 Round*	-24.09	47.50	0.613
*Min 20 * 7 Round*	21.07	71.81	0.770
Zero self-manage value	21.42	19.18	0.266
High club benefits	0.81	26.46	0.975

$n = 168$
$r^2 = 0.424$
$F = 11.56$; $p = 0.000$

4.1 Individual-level results

The results in Table 3 are group-level contributions to the CA. It is also useful to investigate the impact the different institutions and parameter choices have on *intended contributions* at the individual level.[6] Recall, when agreements include an aggregate contribution threshold and a MBG, if the threshold is not reached then the land intended for the CA is returned to the owner. Therefore intended contributions will likely not equal actual contributions in all treatments (intended contributions will be weakly higher). In Table 4 we look at individual intended contributions to the CA. However, we restrict our attention to the first round of each series. The reason for the restriction is twofold. First, the amount of land available to enroll in a CA is reduced each round as players make their decisions to enroll land or sell land for development. Second, in instances in which aggregate contribution thresholds are unmet, an individual may intend to contribute, in aggregate, more land than they have available. Therefore, over the course of the series it is possible (and occurred very frequently) that the sum of an individual's intended contributions exceeds their total endowment. The regression in Table 4 controls for period fixed effects (i.e., dummy variables for periods 2 – 20) and subject-level random effects (i.e., the error term is composed of two parts, a traditional well-behaved random error and a random variable that measures the extent to which a subject's intercept deviates from the overall intercept). Standard errors are robust and clustered at the individual level. The 780 observations included in the regression consist of the 1st round decisions made by all subjects in all series.

The individual-level results, in general, support the group level findings. Most importantly, when agreements include an aggregate contribution threshold with a MBG individuals allocate significantly more land to conservation relative to the baseline voluntary contribution case. Interestingly, the length of the conservation agreement contract has competing effects on intended contributions. A long contract (7 round series) motivates significantly higher intended contributions compared to the baseline (3 round) contract, however, a middle contract length of 5 rounds significantly decreases intended contributions. This suggests that the tie-in (negative) effect of longer contracts must be offset by the security (positive) effect of a still longer contract.[7] In contrast to the group-level results, the contribution threshold with an MBG does not

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[6] We cannot investigate intended contributions at the group level because given that some groups fail to meet thresholds in some periods, with a money back guarantee the aggregate level of intended contributions often exceeds the total endowment of land.

[7] This effect is consistent with our results but requires further investigation before such a plan were implemented.

perform significantly worse than the baseline even with three period contracts (though the coefficient is negative). Thus the individual results, like the group-level findings, suggest that voluntary conservation agreements should include threshold contribution mechanisms with MBGs to achieve significant forest conservation levels. Finally, in contrast to the group-level results the individual results indicate that conservation levels increase as the return to ecosystem services (the club good) increase.

Table 4: Panel regression of individual's intended contributions to CA

Independent Variable	coefficient	std. error	*p*-value
constant	28.22	10.16	0.006
5 Round Contract	-6.03	3.13	0.054
7 Round Contract	9.21	4.39	0.036
Money Back Guarantee (MBG)	-5.50	19.78	0.781
*MBG * 5 Round*	45.78	4.78	0.000
*MBG * 7 Round*	32.88	7.15	0.000
Min 20 Units	-16.16	14.43	0.263
*Min 20 * 5 Round*	2.20	4.95	0.657
*Min 20 * 7 Round*	-9.76	6.23	0.118
Zero self-manage value	10.00	13.99	0.475
High club benefits	59.32	19.83	0.003
n = 780			
r^2 = 0.4984			
F = 3.31; p = 0.000			

Notes: Only first-round observations are included for each series. Coefficients for subject-level fixed effects are suppressed.

5. Conclusions and Discussion

Policy makers are increasingly interested in inducing greater participation in voluntary cooperative forest management agreements (CA) by non-industrial private forestland owners (NIPFs). Global concerns over deforestation and emerging markets for ecosystem services are providing the impetus for researchers to explore alternative agreement structures and institutional rules that would help make participation in CAs more ubiquitous, especially in those with an emphasis on sustainable forest management. Previous empirical work is limited, but signals the importance of demographics, education, attitudes, communication, reputation, near-neighbor effects, active forest management income and the presence of cooperation bonuses as factors that come into play when NIPFs choose between selling off their lands to developers or enrolling lands in CAs that manage forests for multiple private and public benefits. Laboratory experiments are particularly useful in mimicking real world financial incentives that forestland owners face outside of the lab.

Our laboratory results suggest there are systematic relationships between the institutional rules governing a CA and the propensity for landowners to participate. Generally our results are consistent with economic theory. Given the degree of parallelism in our experimental design and this consistency we feel confident in our results.

We have focused on analysis of the group level data since this is the unit of analysis relevant for the CA. The aggregate results reported in Table 2 are suggestive of policy options that the CA may be able to exploit to improve participation. Setting a conditional explicit threshold is useful when the series (contract lengths) are sufficiently long. Paying a higher amount to the landowners for their CA lands is also effective in increasing enrolment, as one would expect. Signaling a higher level of participation, through imposing a minimum individual contribution, is not itself effective. The risks of others' free riding clearly dominate any potential coordination effect of the announced minimum. The results reported in Table 5 suggest that there is an interaction effect between a minimum required contribution and the length of the contract.

We saw that increasing the length of a series has no effect on the aggregate amount of land allocated to the CA in the absence of the MBG (and the explicit threshold). With a MBG, the series duration really matters and the longer series can significantly increase contributions to CA relative to the baseline holding the other conditions constant. Combining the requirement of a significant allocation of lands to qualify for the member benefits and only option value (no period earnings) for self managed lands appears to increase contributions to the CA as well.

The results from these experiments are interesting and the optimal design of CAs to encourage participation warrants further investigation in the directions suggested by the results reported here. During some, limited, debriefing subjects noted that they observed a lack of cooperation in contributing to the CA although some clearly understood that placing lands in the CA was more efficient. A period of discussion or "cheap talk" might lead to improved coordination on the efficient outcome, as indicated by Warziniak et al. (2007). Such conversations could be organized in the naturally occurring setting such as neighborhood association meetings.

Since there are potential tax incentives for assigning lands to a CA, the effects of these could be investigated. Coupled with bequest value – one element of the conservation premium landowners may put on protecting forests for future generations – this implies that the returns to individuals from the CA need not be commensurate with market prices for land sales to developers. Net returns could be significantly less and still provide incentives to conserve. Implementing this in our present setting would be straightforward. If a landowner allocates some lands (a minimum could be set) to a CA, the landowner receives a tax deduction on sales of remaining lands thus conditionally increasing the net return per unit of land sold. The parameters of this tax deduction (minimum qualifying acres, size of the deduction, etc) could be adjusted to investigate the costs and outcomes tradeoffs for the policy maker and the CA. Future experimental simulations will be useful in investigating this and many other alternative agreement structures and institutional rules to induce greater NIPF owner participation.

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Reviewer Appendix

We include a representative set of instructions here. Note that the identifying titles used here, in [], do not appear on the instructions provided to the subjects.

Instructions for the Task **[Baseline]**

- In this experiment there will be multiple series with multiple rounds within each series. You will not know the exact number of series but will be told the number of rounds within each series. You will be notified when a series has ended and a new one begins.

- When a new series begins (the first will be at the start of the experiment) you will start with **<u>100</u>** units of land that you own. In each of the rounds that follow in that series you must decide what to do with your land.

- You can do one of three things with each unit of available land: (1) sell the land, (2) enroll the land in a conservation association (CA) or (3) self manage the land.

- Land that is either sold or enrolled in the CA cannot be reallocated during the next round of play in the series. Therefore, the land you have *available* to allocate each round will equal the total number of units you are self managing (option 3) from the previous round.

- Your earnings from these decisions will depend on what you do with your land (options 1,2 or 3) and also on what the *other members* of your group do with their land (they also choose between options 1, 2 or 3).

- You are in a group of landowners. There are **<u>4</u>** other member in your group. 2 of those members are your *near* neighbors (with land close to yours) and 2 of those members are your *distant* neighbors (with land relatively far from yours).

- **<u>Earnings from selling your land and the cost of others selling their land</u>**:

    - If you sell a unit of land you will receive the current sale price for the land. The price you receive will either be high (**$45**) or low (**$35**) and you will NOT know which price you will receive until after the round ends. You will receive the high price with a probability of (0.50) and the low price with a probability of (0.50).

    - When the other group members sell their land, you incur a cost. For each unit a near neighbor sells you lose **$0.25** in that round.

    - For each unit a distant neighbor sells you lose **$0** in that round. Note that you also impose these same costs on your neighbors when you sell your land.

- **<u>Earnings from land enrolled in a CA</u>**:

  - If you enroll any number of units of land into the CA you will receive *member earnings* from belonging to the association. Specifically you will receive a dollar amount for each unit <u>you or others</u> in the group enroll in the CA. The *member earnings* will either be high (**$6**) or low (**$2**) and you will NOT know which earnings level you will receive until after the round ends. You will receive the high earnings value with a probability of (0.50) and the low earnings value with a probability of (0.50). If you do not enroll at least 1 unit in the CA, you will not receive member earnings.

  - For example, if the member earnings turn out to be low (**$2**), if you enrolled 10 units into the CA and the other four members, in total, enrolled 30, then you will receive **$2 * 40 =** $80 in member earnings.

  - In addition to the CA member earnings, everyone in the group, regardless of whether they have enrolled land into the CA, will receive the following: **$2** for each unit of land a near neighbor enrolls in the CA and **$1** for each unit of land a distant neighbor enrolls in the CA.

- **<u>Earnings from land you hold on to</u>**:

  - At the end of each round, for each unit of land you self manage, you will earn the self management value shown on your screen.

- Once a series has completed you will be notified.

[MBG]

Summary Instructions

- In this experiment there will be multiple series with multiple rounds within each series. You will not know the exact number of series but will be told the number of rounds in a series. You will be notified when a series has ended and a new one begins.

- When a new series begins (the first will be at the start of the experiment) you will start with **100** units of land that you own. In each of the rounds that follow in that series you must decide what to do with your land.

- You can do one of three things with each unit of available land: (1) sell the land, (2) enroll the land in a conservation association (CA) or (3) self manage the land.

- Land that is either sold or enrolled in the CA can not be reallocated during the next round of play in the series. Therefore, the land you have *available* to allocate each round will equal the total number of units you are self managing (option 3) from the previous round.

- Your earnings from these decisions will depend on what you do with your land (options 1,2 or 3) and also on what the *other members* of your group do with their land (they also choose between options 1, 2 or 3).

- You are in a group of landowners. There are **4** other member in your group. 2 of those members are your *near* neighbors (with land close to yours) and 2 of those members are your *distant* neighbors (with land relatively far from yours).

- **Earnings from selling your land and the cost of others selling their land**:

    - If you sell a unit of land you will receive the current sale price for the land. The price you receive will either be high (**$45**) or low (**$35**) and you will NOT know which price you will receive until after the period ends. You will receive the high price with a probability of (0.50) and the low price with a probability of (0.50).

    - When the other group members sell their land, you incur a cost. For each unit a near neighbor sells you lose **$0.25** in that period. For each unit a distant neighbor sells you lose **$0** in that period. Note that you also impose these same costs on your neighbors when you sell your land.

- **Earnings from land enrolled in a CA**:

    - The entire group must enroll enough units in the CA to meet a threshold. If the threshold is not met the land you intended to enroll will be returned to you for self management. Each round you will be told what the threshold is.

- If the threshold is met *and* if you enroll any number of units of land into the CA you will receive *member earnings* from belonging to the association. Specifically you will receive a dollar amount for each unit <u>you or others</u> in the group enroll in the CA. The *member earnings* will either be high (**$6**) or low (**$2**) and you will NOT know which earnings level you will receive until after the period ends. You will receive the high earnings with a probability of (0.50) and the low earnings with a probability of (0.50). If you do not enroll at least 1 unit in the CA, you will not receive the member earnings.

- For example, if the threshold is 20 and if the earnings turns out to be low (**$2**), if you enrolled 10 units into the CA and the other four members, in total, enrolled 30 (so the threshold is met), then you will receive **$2 * 40 =** $80 in member earnings.

- In addition to the CA member earnings, everyone in the group, regardless of whether they have enrolled land into the CA, will receive the following: **$2** for each unit of land a near neighbor enrolls in the CA and **$1** for each unit of land a distant neighbor enrolls in the CA.

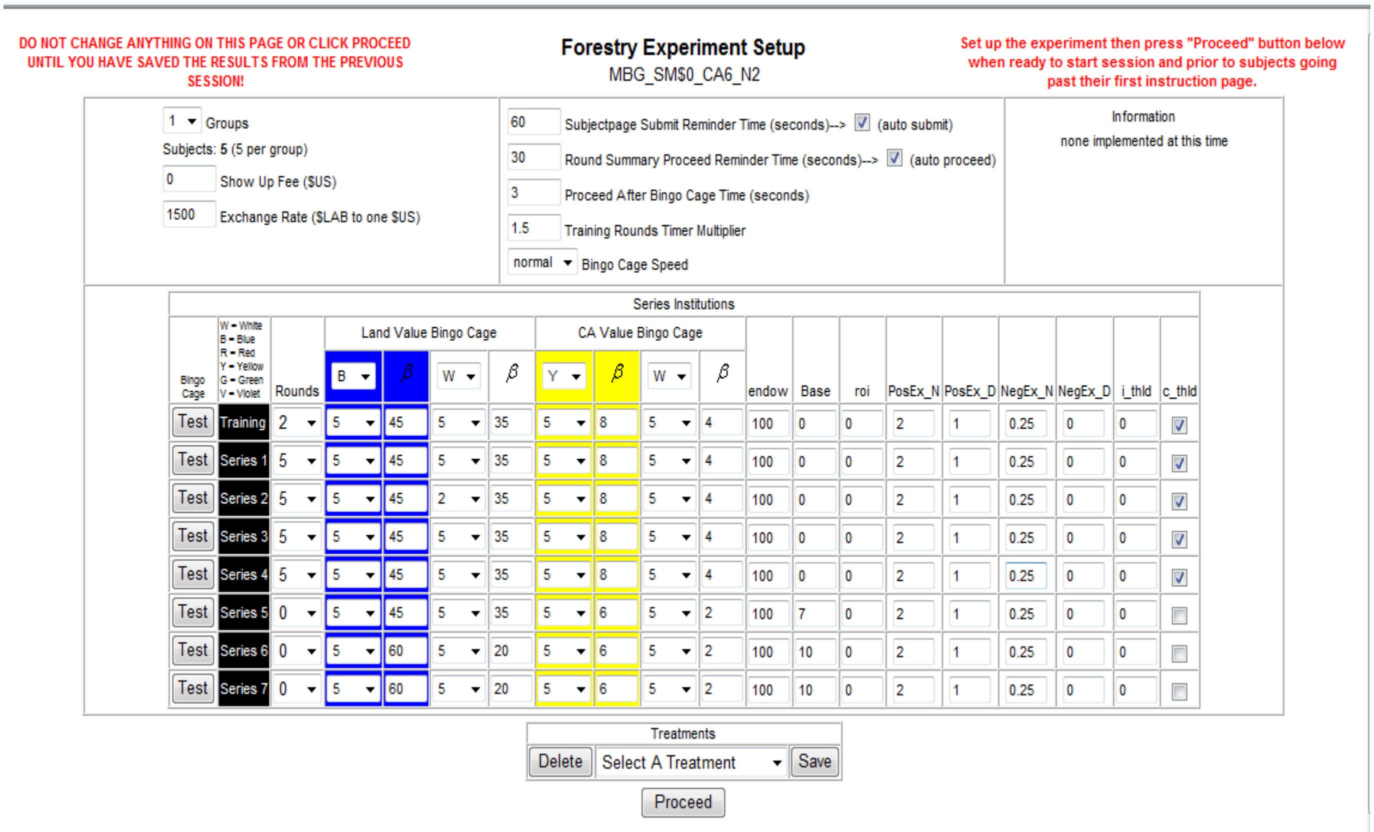
* **<u>Earnings from land you self manage</u>**:

  - At the end of each period, for each unit of land you self manage, you will earn **$0**.

* Once a series has completed you will be notified.

Screen Images from Experiment – Selected Screens

Screen 1 – The Setup Screen. This is used by the experimenter to create the treatment by setting the parameters to be used in the session.



DO NOT CHANGE ANYTHING ON THIS PAGE OR CLICK PROCEED UNTIL YOU HAVE SAVED THE RESULTS FROM THE PREVIOUS SESSION!

Forestry Experiment Setup

MBG_SM$0_CA6_N2

Set up the experiment then press "Proceed" button below when ready to start session and prior to subjects going past their first instruction page.

1 Groups
Subjects: 5 (5 per group)
0 Show Up Fee ($US)
1500 Exchange Rate ($LAB to one $US)

60 Subjectpage Submit Reminder Time (seconds)--> ☑ (auto submit)
30 Round Summary Proceed Reminder Time (seconds)--> ☑ (auto proceed)
3 Proceed After Bingo Cage Time (seconds)
1.5 Training Rounds Timer Multiplier
normal Bingo Cage Speed

Information
none implemented at this time

Series Institutions

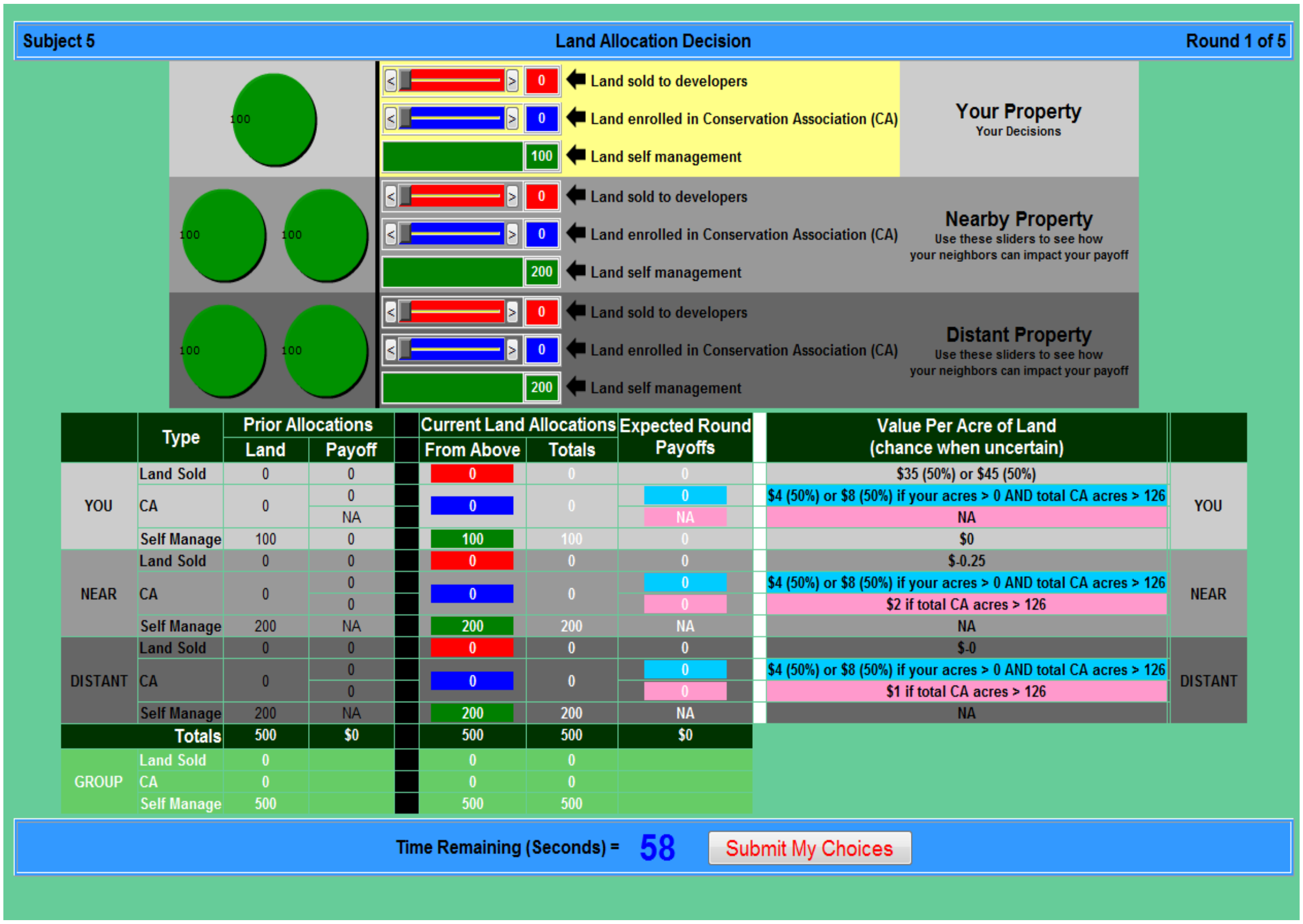
W = White, B = Blue, R = Red, Y = Yellow, G = Green, V = Violet

Bingo Cage		Rounds	Land Value Bingo Cage: B	β	W	β	CA Value Bingo Cage: Y	β	W	β	endow	Base	roi	PosEx_N	PosEx_D	NegEx_N	NegEx_D	i_thld	c_thld
Test	Training	2	5	45	5	35	5	8	5	4	100	0	0	2	1	0.25	0	0	☑
Test	Series 1	5	5	45	5	35	5	8	5	4	100	0	0	2	1	0.25	0	0	☑
Test	Series 2	5	5	45	2	35	5	8	5	4	100	0	0	2	1	0.25	0	0	☑
Test	Series 3	5	5	45	5	35	5	8	5	4	100	0	0	2	1	0.25	0	0	☑
Test	Series 4	5	5	45	5	35	5	8	5	4	100	0	0	2	1	0.25	0	0	☑
Test	Series 5	0	5	45	5	35	5	6	5	2	100	7	0	2	1	0.25	0	0	☐
Test	Series 6	0	5	60	5	20	5	6	5	2	100	10	0	2	1	0.25	0	0	☐
Test	Series 7	0	5	60	5	20	5	6	5	2	100	10	0	2	1	0.25	0	0	☐

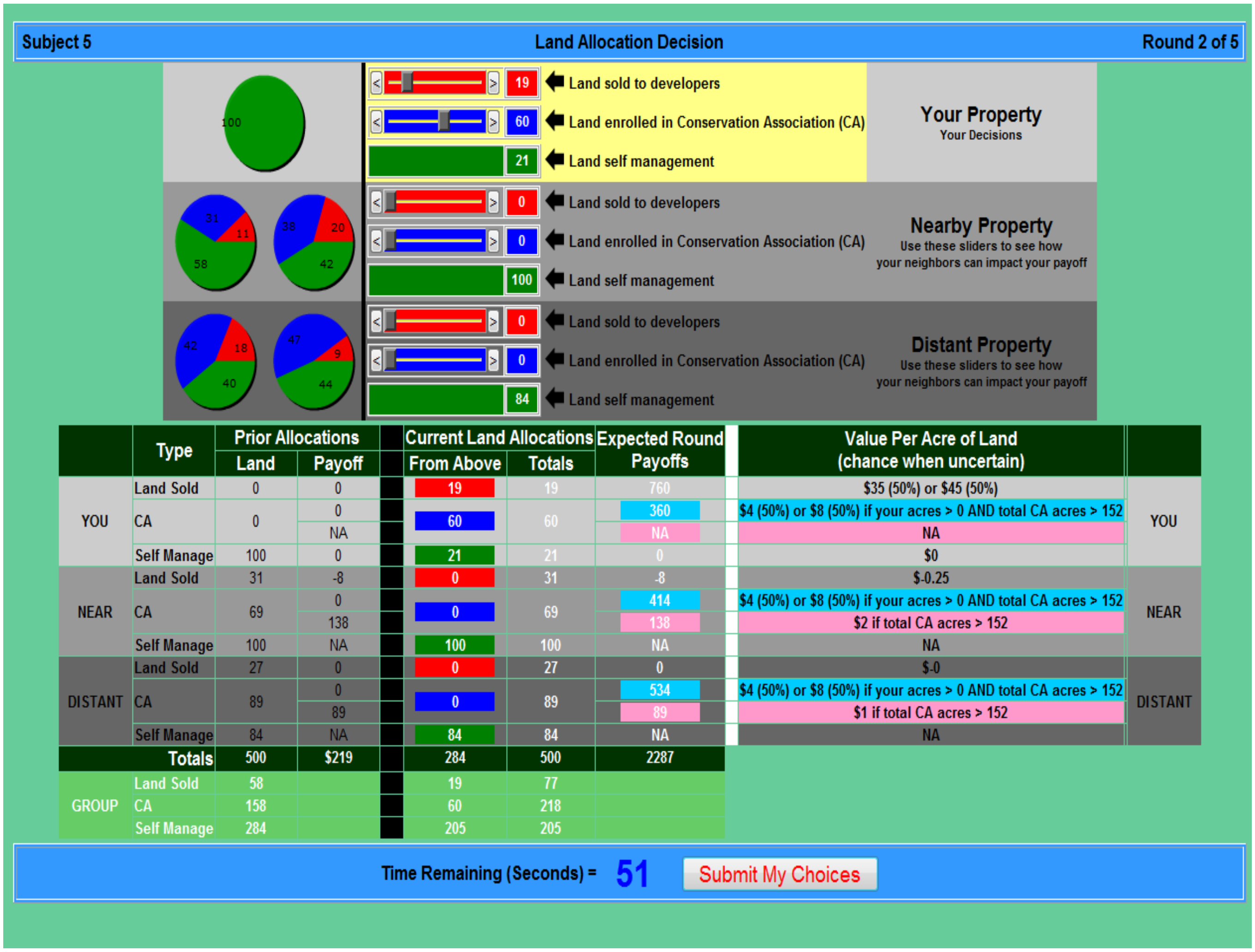
Treatments
Delete | Select A Treatment | Save

Proceed

Notes:
The Land, CA (identified as CA throughout the experiments), and Self Manage (identified as Base in the experiments) values are set here, as are the series length, number of series, endowments, externality effects, and the toggles for the membership threshold and whether or not the MBG (and the group threshold) are in effect.

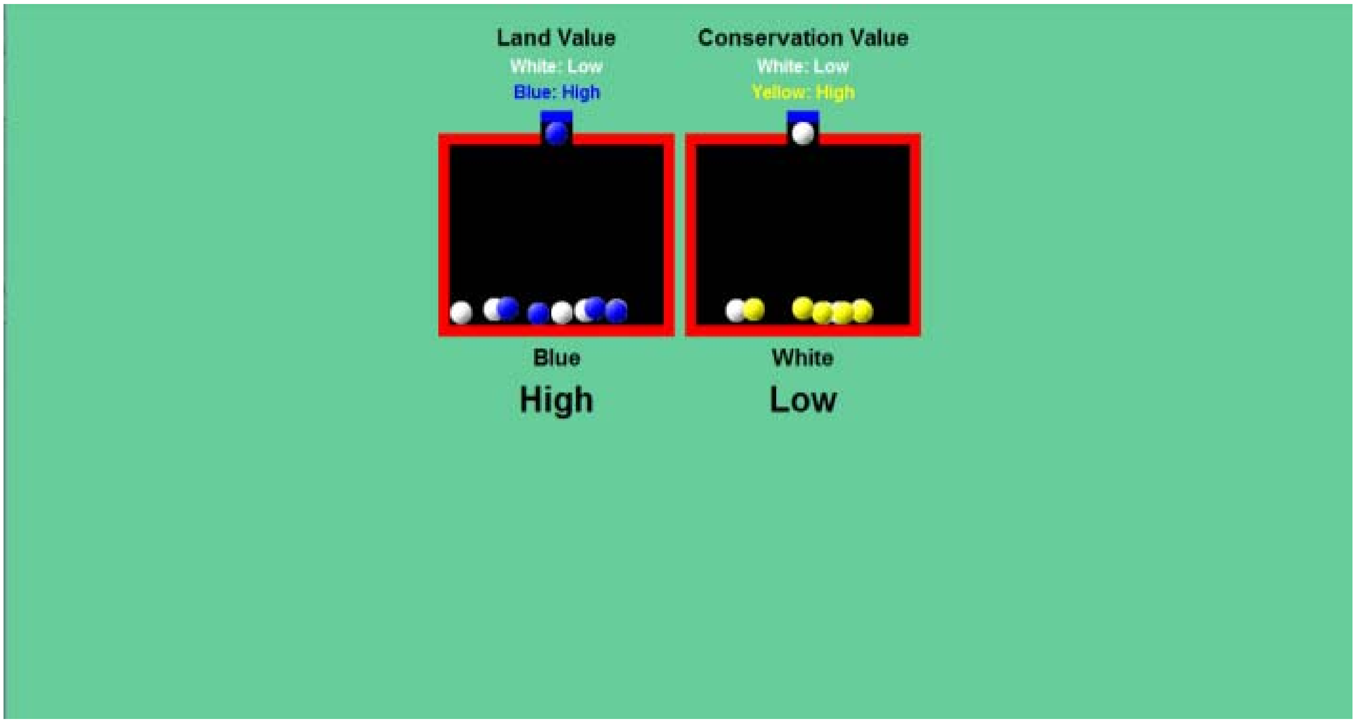


Screen 2 – The Subject Page. At the beginning of a new series all lands are shown as being self managed (colored green here). Land sold is denoted in red and land allocated to the CA is blue. The subject used the slider bars shown to choose her allocation. She is free to "experiment" by moving the sliders of her neighbors to investigate the interaction effects. Of course, these movements have no actual effect on the neighbors' choices. The payoffs from allocations are shown in the lower half of the screen as well as the allocations made in prior rounds within a series.



Screen 3 – A Subject Screen in Round 2. Here we see a subject screen in the second round of a 5 round series. This individual chose to Self Manage all 100 land units in round 1. Thus, she has all 100 available to be allocated this round. The neighbors chose to allocate some to the CA (blue) and some to sales (red). The payoffs are shown in the lower left portion. Self management pays $0 in this setting so our subject earned $0 in round 1. The earnings of the neighbors (in aggregate) are shown.

Screen 4 – The Payoffs to Sale and CA. The payoffs to selling land and the allocating lands to the CA are stochastic to simulate market uncertainty. The random process is shown by animated "bingo cages" shown on the screen. The subjects are informed of the outcome (which ball is drawn from the respective cage). This determines their payoffs to land sold an allocated to the CA in the current round.



Screen 5 – The Round Summary. At end of a round, the subjects are informed of their earnings. In the round shown here, the subject sold 11 units in the previous round. Note that no one from the group allocated land to the CA. The setting implemented for this screen was MBG – the group was required to meet a threshold if the CA was to be set up. Since the threshold was not met (the group offered to enroll 131 acres) the intended acres were returned to the individuals (the MBG) to be self managed.