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Creating contiguous forest habitat: An experimental examination on incentives and communication

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Abstract

Forest fragmentation exists when private landowners break up large forest stands into smaller parts. Fragmentation increases risks to endangered species that find shelter in contiguous forest habitat that falls across several landowners. Policy makers interested in reuniting these forests across fences should consider how to design a voluntary incentive scheme to meet this objective cost-effectively. Herein we consider the degree to which pre-play communication – cheap talk – between landowners could work to coordinate effectively their forest protection actions.

JEL classifications: Q0; C9

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Introduction

The land conservation literature continues to focus on the role of land owners in conserving endangered species, since many reside on private land such as forests and

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the surrounding environs (Innes et al., 1998). Agreements between landowners and government to limit development on private land, often in exchange for tax breaks, have been introduced with varying degrees of success. The European Union (EU) initially took up the role of private landowner conservation decisions in its 1992 reforms (and more recently in 2003) to the common agricultural policy (CAP), which stresses management of land to protect environmental assets and to preserve rural communities and their culture. And because farmers manage more than 50% of the European land mass, they are a critical component to any plans for land use (European Commission, 2003b).

In the United States (US), such contracts are in the form of conservation easements, which limit development in perpetuity (see for example the review in Parkhurst and Shogren, 2003). Similar arrangements exist in Finland. Under the Finnish Nature Protection Act, land is voluntarily set aside as a permanent reserve; or under the Forest Act, land is set aside with statutory authority for fixed periods of time (Tikka, 2003). The challenge is to provide incentives for land owners to work together. Many landowners individually setting aside isolated parcels does not provide the needed habitat for many species. Policy makers would like to induce owners to pool their conservation efforts to preserve contiguous parcels of land, i.e., coordinate their land retirement decisions.

In classic games of coordination players must collectively reach one of many Nash equilibria. Consider, for example, Battle of the Sexes, in which partners have agreed to meet up somewhere for dinner but have not agreed on a particular restaurant. Each player prefers one restaurant to the other, but dining with his or her partner at a less-preferred restaurant is preferred to dining alone at his or her favorite restaurant. This game has multiple pure symmetric Nash equilibria (each choosing the same restaurant) and one symmetric mixed Nash equilibrium. There is no clear reason for one Nash equilibrium to be picked over another. A similar story could be told with two landowners deciding individually which of several acres to conserve along a fence row. The greatest conservation benefit arises when each retires the acres adjacent to the other's acre. Without communication, each must guess which acres the other will set aside. Successful coordination is a matter of chance.

This problem can be overcome by nonbinding pre-play communication, or *cheap talk* (Rasmusen, 2001). In games with cheap talk, players are allowed to interact before actually announcing a strategy and are not committed to anything discussed beforehand, i.e., talk is cheap. In one-shot normal form games, cheap talk has proven to improve coordination, especially when agents' interests are closely aligned (Crawford and Sobel, 1982). When preferences completely coincide, cheap talk is no different than binding communication.[1]

Results are mixed, however, in repeated games. Parkhurst et al. (2004) examine coordination levels among players in two settings: players randomly matched with a different player each round (one-shot coordination game), and players matched with the same participant each round (repeated coordination game). Without pre-play

[1] In a coordination game with cheap talk a person's incentive is to truthfully reveal his chosen strategy (Farrell, 1987, 1988).

communication, players in repeated games have a lower frequency of coordination failure than players in one-shot games. This result is reversed when pre-play communication is allowed. Pre-play communication increases the frequency of coordination failure in repeated games relative to one-shot games; randomly assigned players had access to much more information and reached higher levels of efficiency than those with the same pairing throughout the experiment.

The previous results are based on normal form games with relatively straightforward focal points, limiting their application to the wilds. In what we believe comes closer to mimicking real landowner decisions, we extend the analysis to a repeated game in a 10×10 spatial grid game where equilibria are not so easily found. In each round four players are given 25 parcels of land and asked to choose 5 of their 25 parcels to retire, much like would happen under a conservation easement. Individual payoffs are designed so that the payoff dominant Nash equilibria also reduce forest fragmentation.[2] In this setting we test whether cheap talk increases coordination efficiency in repeated coordination games related to reuniting fragmented forest lands.

The paper proceeds as follows: Section two gives background on habitat needs of wildlife and policies aimed at coordinating multiple landowners to meet these needs. Section three describes the experiment design. Section four presents the theoretical model, and section five presents the results of the experiment. Section six concludes the paper.

Background

Forest fragmentation and habitat fragmentation are not always the same. Forest fragmentation is the breaking up of large forest stands into smaller pieces. It has the potential to increase isolation of stands of trees and increase the amount of forest edge. Fragmentation can be detrimental when edges occur with residential development, changing the forest's dynamics by increasing its exposure to urban stresses (Medley et al., 1995) and susceptibility to invasive species (Chornesky et al., 2005). The degree to which forest stands are isolated from each other generally determines whether fragmenting forests is equal to fragmenting habitat.

Large carnivores are particularly sensitive to fragmented habitat, including forest and the interface of forests and fields due to their large home ranges. Yellowstone National Park itself is thought to be too small to support viable populations of large carnivores in the long term (Newark, 1987; Shaffer, 1992 as cited in Clark et al., 1996). In the Rocky Mountains home ranges tend to be about 150 km^2 for black bears (Amstrup and Beecham, 1976; Beecham and Rohlman, 1994, as cited in Noss et al., 1996), 400 km^2 for mountain lions (Seidensticker et al., 1973), nearly 900 km^2 for grizzlies (Blanchard and Knight, 1991), and from 250 to 2000 km^2 for packs of gray wolves (Pletscher et al., 1991; Ream et al., 1991; Paquet, 1993).

[2]The payoff dominant Nash equilibrium is the outcome that maximizes profits for all landowners (see Harsanyi and Selten, 1988).

Some small mammals may actually prefer fragmented forests. Clear-cutting has been part of a long-term management plan for ruffed grouse in the Barrens Grouse Habitat Management Area in Pennsylvania. Clear-cutting creates abundant slash left after timber removal and dense vegetation near ground level. The increase in forest fragmentation created by the cutting cycle increases habitat patchiness and edge and the likelihood of a greater variety of microenvironments and associated food resources for small mammals. Yahner (1992) found that clear cutting is beneficial to Southern red-backed voles due to increased availability of aboveground debris, suitable refuge, and nest sites. Other species that seem to benefit from forest fragmentation (not habitat fragmentation) include masked shrews, white-footed mice, and red-backed voles (Buckner and Shure, 1985).

The effect of fragmentation on birds is widely studied since bird species sort themselves according to edge and interior species. In a study by Willis (1979, as cited in Newark, 1991), 100% of understory birds that were labeled as edge species were capable of crossing gaps in woodlots compared to only 23% of interior species. It seems that some species are simply psychologically averse to crossing large gaps in forests. Distances between forest fragments and smaller parcels of forest have been shown to have a significant negative effect on number of species (Newark, 1991). Many rely on the interior for protection from nest predations (Wilcove, 1985) and brood parasites such as the brown-headed cowbird (Brittingham and Temple, 1983).

In an effort to meet the needs of both people and a wide variety of species, wildlife managers have emphasized ecosystem management. This allows the possibility of preserving smaller tracts of land provided that there are linkages between areas sufficient to preserve the total system. The degree of connectivity is an important part of the overall management plan. With connected tracts, large carnivores have the potential for dispersion in search of food and mates. Grizzly bears tend to avoid large openings and clear-cuts, but have otherwise been known to disperse from 50 to 100 km. Wolves can travel even further. (Rogers, 1987; Blanchard and Knight, 1991; Pletscher et al., 1991; Lindzey et al., 1994; Fritts, 1983; Ballard et al., 1987; Mech et al., 1995; Boyd et al., 1996). Black bears tend to avoid areas more than 25 m from cover and rarely use young clear-cuts (Lindzey and Meslow, 1977; Young and Beecham, 1983; Beecham and Rohlman, 1994). The same seems to be true for coyotes, bobcats, and mountain lions (Crooks, 2002). For those animals capable of dispersion, maintaining viable populations may be possible through management of many smaller parcels of land. Allowing movement (either naturally or manually transporting animals) between these parcels can maintain the genetic variation for a healthy population.

Regardless of the forest management goals, carrying them out in practice has proven difficult. The recent shift in ecosystem-based management requires effective management across numerous government agencies and private landowners. Wilcove and Lee (2004) examine three incentive based mechanisms for preserving endangered species habitat: safe harbor, Environmental Defense (ED)'s Landowner Conservation Assistance Program (LCAP), and conservation banking. Under safe harbor, the US Fish and Wildlife Service (USFWS) enter into a binding contract with landowners who promise to undertake conservation efforts for the benefit of an endangered species. The agreement, however, allows the landowner to undo those actions should the landowner desire at a later date, freeing the landowner from incurring any additional burdens that would arise because their property is now attractive to endangered species. ED's LCAP goes a step further by offering technical and financial assistance, as well as regulatory protection. LCAP was put in place primarily to protect the golden-cheeked warbler and the black-capped Vireo. The program starts with a free and confidential land survey to assess current bird populations and the potential of further habitat improvements. Following the survey, ED works with the landowner on a management and restoration plan that meets the needs of both landowner and birds. In most cases, ED covers part of the restoration costs. With the permission of Fish and Wildlife, ED administers a safe harbor program that covers the participating landowners.

Conservation banking has been used in wetland preservation for several years. Developers who plan to alter a wetland area must first restore or enhance a comparable area elsewhere. With conservation banking, restored wetlands act as banked credits that can be sold to other developers in need of mitigation. The hope is that large-scale restoration efforts will be both more economically and ecologically beneficial than small-scale mitigation efforts (Bonnie, 1999). The same idea has been applied to the Endangered Species Act, which requires developers to minimize and mitigate development on habitat occupied by an endangered species. Such mitigation takes the form of the landowner purchasing habitat elsewhere and conveying it to a conservation entity such as the USFWS or The Nature Conservancy. These banks have a number of critics that claim that they have reduced pressure on developers to avoid harming critical habitat and that restored land is not as effective in wildlife preservation as the original habitat. Within the EU, such financial incentive schemes are also being considered among the member countries working toward the Natura 2000 ecological network, in which half of all proposed sites are forest areas (see European Commission, 2003a). Natura 2000 allows countries to consider the use of alternative compensation schemes for restrictions of ownership rights. Finland, for instance, is aiming to quadruple the size of the protected core areas in Merenkurku (near the Baltic Sea) through land purchases and landowner compensation for those giving up rights to build summer homes or develop forests.

Wilcove and Lee claim that safe harbor and LCAP have been remarkably successful; after all, they remove the regulatory consequences of attracting endangered species to private property. LCAP provides both technical and financial assistance many landowners either do not have or are not willing to devote to habitat restoration for endangered species. Assessing the success or failure of conservation banking is more difficult given the relatively small number of banks created to date. Banks also require the successful coordination of landowners and conservation agencies in a poorly defined market. This coordination has proven difficult.

Kittredge (2005) lays out a number of cooperative models found around the world and discusses their applicability to the US. Most of these cooperatives involve private landowners banding together for commercial forestry management or to gain bargaining power with larger forestry companies. Some of these cooperatives involve hundreds of owners and thousands of acres of land. There have been a few instances of collectives with stated nonmonetary goals such as wildlife habitat, outdoor recreation, and privacy; though Kittredge acknowledges that such integrated, landscape scale management collectives for nonmonetary objectives are rare.

Noss et al. (1996) provides a basic plan for regional reserve networks with multiple uses (see also Noss, 1992, 1995). The paper gives two models, one human-dominated matrix and the other a wildland matrix. In the human-dominated landscape, wildlife are preserved within core reserves and connected by corridors. The wildland matrix preserves people in the cores connected by roads, with some feature that allows wildlife to cross the road. Each model includes a buffer zone to separate people from wildlife, particularly important for species such as grizzly bears and wolves that are politically unpopular for mixing with human populations.

In some regions, wildlife and human populations inevitably mix. In other areas, the threat of such interactions is significant enough to cause heated political debate, among both government agencies and private citizens (e.g. see Theberge, 2003; Kittredge, 2005; Smith and Ferguson, 2005). Coordination once a dilemma arises is difficult, even if the overarching goals are the same for all members of the group. Cooper et al. (1992) show that communication can be an effective tool in coordination games. While communication is important, many would probably argue that the possibility of communication only leads to the possibility of disagreement. Rather rules and reputation developed before conflict arises are more important.

We test the importance of both communication and reputation in a spatial coordination game with payoffs designed to encourage preservation of large contiguous parcels of land. Treatments were run with and without cheap talk. We find communication and reputation to be important tools. Reputation was the strongest determinant of efficiency; that said, communication played a role in coordinating individuals in early rounds and served to reassure players of their chosen strategies in later rounds. We now turn to our experimental design.

Experiment design

The experiment design follows Parkhurst and Shogren (2006). The rules of the game are straightforward, but the equilibria are not readily apparent, making it more representative of landowner decisions. The experimental design has nine structural elements—treatments, players/matching, the land grid, strategies, calculator, communication, information, history, and procedures. Consider each in turn.

Treatments. We tested two treatments. In sessions 1–4, participants could communicate in the manner described below. In sessions 4–8, participants were prevented from communicating. Each treatment had 20 rounds.

Number of players and random matching. Eight subjects participated in a session. They were told they would be randomly assigned to a group of four subjects. We chose random groupings for two reasons: (1) the regulator is likely to only have one shot at creating the desired habitat. Land development can be considered irreversible within the time frame we are considering (this presumption does not hold everywhere); and (2) experimental evidence in normal form coordination games with cheap talk indicates that randomly paired subjects coordinate to the dominant Nash equilibrium about 6% more frequently than do subjects in a repeated game (Parkhurst et al., 2004), which creates the best opportunity for coordination.

The land grid. After each subject sat at his or her own computer terminal, the screen revealed the 10×10 land grid (Fig. 1). Each subject knew they owned a 5×5 portion of the 10×10 grid, and identified himself or herself as the *U* participant. The computer matched subjects and transposed each subject's 5×5 grid within the 10×10 landscape to reflect their position in relation to the other subjects. The subject is the row participant for his row participant and the column participant for his column participant. Subjects are faced with an identical 5×5 grid of values for each round. Subjects knew the values of land parcels for each of the other subjects in their group. We assume people are maximizing their own private rate of return from the land use and the subsidy system. The value in each cell represents the productive value of that cell.

Strategies—brown out cells. Subjects were instructed that they could leave their cells *green*, in which case they earned the value in the cell, or they could *brown out* cells, in which case they forfeit that value in that cell. Browning out a cell is the equivalent of preserving the parcel for conservation purposes, and the landowner must forgo revenues from the next best use of the land. Each subject was required to brown out 5 cells. Note the large set of potential strategy permutations. By presenting subjects with the land grid and the choice of any 5 cells to brown out the subjects have tens of thousands of strategies to choose from.

Agglomeration bonus. Assume the regulatory agency has identified the conservation target. They now design an agglomeration bonus mechanism to create incentives

40	40	40	40	30	30	30	20	20	20
40	40	40	40	40	30	30	30	20	20
40	40	40	40	40	40	40	30	30	20
40	40	40	40	40	40	40	30	30	30
40	40	40	40	40	40	40	40	30	30
50	40	40	40	40	40	40	40	40	40
50	50	40	40	40	40	40	40	40	40
50	50	50	40	40	40	40	40	40	40
50	50	50	50	40	40	40	40	40	40
50	50	50	50	50	40	40	40	40	40

Fig. 1. The 10×10 experimental land grid.

to persuade each landowner to conserve the parcels that achieves the conservation objective.[3] Our agglomeration bonus is a subsidy menu mechanism with four specific subsidies: (1) a per conserved habitat acre subsidy; (2) an own shared border subsidy; the landowner receives a subsidy for every border shared between two of his own conserved acres; (3) a row shared border subsidy; a landowner receives a subsidy for every border shared by one of his habitat acres and a habitat acre of the row neighboring landowner (neighbor to the south of the green area in Fig. 1); and (4) a column shared border subsidy; a landowner earns a subsidy for every border shared by one of his habitat acres and a habitat acre of the column neighbor (neighbor to the east of the green area). These subsidies can be positive, negative, or zero, and depend on productive values and desired configuration and location of the habitat. This four-part subsidy system plays a key role throughout the experiment since it provides the incentives that create the coordination game between the landowners/subjects. Subjects are given the four-part subsidy without explicit instructions on what lands should be retired. We assume each subject chooses to retire their land based on the incentives provided and that they prefer more money to less.

The subsidy menu serves two purposes – making voluntary conservation profitable, and creating a network externality between landowners. Since each landowner can decide which of 5 parcels to conserve, he or she has 53,130 possible strategy choices within the grid, creating over 53,130 total potential payoff outcomes with thousands of Pareto-ranked Nash equilibria, only one of which is the Pareto dominant outcome.[4] This implies that landowners have imperfect information about how all strategy sets translate into potential payoffs.

Calculator. To aid the subjects in calculating profits a grid calculator was provided on the computer screen. The grid calculator was a 10×10 grid of cells with borders to differentiate each player's portion of the section. The subject's portion of the calculator was tied directly to his 5×5 grid and reflected the choices made on the 5×5 grid. This means that if a subject clicked on a cell in his grid, changing the color from green to brown, the same cell turned brown on the calculator. For the other players portions of the calculator the subject clicked the cells directly. The subject's own potential profits, based on the configuration of brown cells on the calculator, were calculated and displayed on the computer screen.

Communication. The difference between treatments was the ability to communicate via a chat window. In half of the treatments subjects were provided the opportunity to communicate one message per round. Communication was nonbinding, unstructured with no restrictions on timing or content, and all messages

[3]The agglomeration bonus can also be attached to the border of a land characteristic such as national forest land or a river or other land attribute so landowners receive an additional payment when their conserved land borders a desired land attribute such as a river. The value of the various subsidies can differ and the magnitude of each subsidy will depend on the productive value of the land. Although the values of the various subsidies can differ across subsidy type, the subsidy value does not differ across landowners. For example, if the per acre subsidy is set at \$10, every parcel set aside for habitat by every landowner would earn the same \$10 per conserved parcel subsidy.

[4]See Parkhurst and Shogren (2006) for details.

were sent in English (Crawford, 1998).[5] Subjects had 2 min to send messages, use the calculator, and send their choices.[6] In half of the treatments, subjects were not allowed to communicate in any way.

For those groups that were allowed to communicate, the messages followed a predictable pattern. Most communication during rounds 1–5 focused on figuring out the game and coordinating efforts. After round 5 most groups had "figured it out," and the chat was centered on assuring each other to stick with the current strategy. By round 10, participants seemed to be assured of the strategy, though some questioned whether the group could improve on their situation; occasionally a player would "experiment" and brown out cells for a nonoptimal strategy but always returned quickly. Messages sent after round 15 were routinely about matters outside of the experiment – whether or not they were hungry, when the football game was this weekend, expressions of boredom, etc. It was common for a group to have at least one leader who offered very specific advice to other players about which cells to brown out. The number of messages sent varied greatly between groups, sending 71, 38, 17, and 3 messages.

Public and private information. After all four subject's choices were submitted the resulting grid was presented to the group. The subjects' 5×5 grid of values, the maximum allowed number of brown cells (5), a message box, and the grid calculator came up on the computer screen and subjects chose the cells to brown out. Subjects had common knowledge regarding individual payoffs per round and strategies. Each subject's accumulated payoffs were private information.

History. The entire 10×10 grid showing the configuration of brown cells and the payoffs for each subject within the group then appeared in the history box. Subjects were provided with record sheets, as well as the history box, to help them keep track of their own and the other group members' choice of strategies and associated payoffs in previous rounds.

Procedures. All experiments were run on computers. Subjects were not told the objective of the experiment and all wording in the instructions and on the computer screens was context free. Following standard protocol, subjects were recruited campus wide and were told to report at a computer lab at a given time. Experimental

[5] Sally (2005) postulates that introducing cheap talk into a game creates an additional stage prior to strategy selection in which subjects must learn to coordinate their messages; the transmission of messages sent and received is not immediate. Considering the coordination game presented here, students are inserted into an artificial unfamiliar environment and allowed to convey their thoughts through a restricted media – a text window. Following Sally's (2005) conjecture we would expect efficient transmission of messages to take several rounds as evidenced in our results. In the real world, neighbors typically meet face-to-face, and a common spatial vernacular is established (the *back forty* has a specific meaning and is understandable by all), the cheap talk coordination problem likely does not exist. We would expect convergence to the payoff dominant Nash equilibrium to occur faster.

[6] The 2-min time period for sending messages and making decisions was timed manually. The experimenter used a clock and informed students when there were 90 s remaining, 60 s remaining, 30 s remaining, and then when 0 s remained. When the 2-min were up, subjects who had not yet sent their actions were asked to do so at that time. Subjects always complied. In almost all sessions, the 2-min time limit was a binding constraint in the initial rounds. In latter rounds, however, subjects rarely used the entire 2-min.

instructions were provided to each of the participants and the monitor read them out loud while the subjects followed along. Subjects were given an opportunity to ask questions concerning the experimental procedures, which were answered by the monitor. The monitor also walked the subjects through two practice rounds to familiarize the subjects with the experimental design. The subjects then entered their name and student identification number into the computer, and the computer randomly assigned the subjects to groups of four.

Model

We now consider models to explain economic efficiency and strategy choice at the group and individual levels. Consider each in turn.

Groups. There were eight groups of four that participated in the twenty rounds of the experiment. Half of these groups were allowed to chat in the manner described above, half were not. Success for group j in time t is measured by economic efficiency ($\mathrm{EE}_{j,t}$) and is the percentage of possible monetary gains captured by the entire group. Write $\mathrm{EE}_{j,t}$ as

$$\mathrm{EE}_{j,t} = (\text{earnings} - \text{min earnings})/(\text{max earnings} - \text{minimum earnings}).$$

We test whether cheap talk and reputation improve group performance. We model the effect of communication with a dummy variable for cheap talk ($\mathrm{CT}_{j,t} = 1$ if the group was allowed to communicate). Communication is widely believed to improve the ability of groups to communicate, thus the coefficient on $\mathrm{CT}_{j,t}$ should be positive.

It could be, however, that what we are observing is that groups learn how to play quickly, and that the observed coordination is a product of past play. We use past play as our measure of reputation because without cheap talk, players must rely heavily on past actions, assuming that the current round will be much like the previous. Players who have successfully coordinated may not be completely sure of this, especially in complicated settings. With cheap talk, we observe players sending messages asking whether the current situation is the best they can do, and persuading others to try out another scenario. Including reputation, measured by lagged efficiency ($\mathrm{EE}_{j,t-1}$), in the model will allow a more accurate measure of the effects of cheap talk. We expect the coefficient on reputation to be positive. Finally, we add a cross-term of cheap talk and reputation ($\mathrm{EE}_{j,t-1} \times \mathrm{CT}_{j,t}$); the coefficient on the cross term may be negative given our story.

The random effects panel model is given by

$$\mathrm{EE}_{j,t} = \alpha + x'_{j,t}\beta + (\mu_j + \varepsilon_{j,t}),$$

where α is the constant term that picks up the mean of the unobserved heterogeneity and $x_{j,t}$ is the matrix of exogenous variables. We assume the group effects are strictly uncorrelated with the regressors, allowing the use of a random effects model.[7]

[7]Since each group has either CT = 1 or CT = 0, it was impossible to run a fixed-effects model because there is no variation in the groups. We do not run the fixed-effects model at the individual level because of

Subjects were recruited from across campus and each participated voluntarily; therefore, we believe this assumption to be innocuous. μ_j is the random component associated with the jth group and is assumed to be constant over time. $\varepsilon_{j,t}$ is the error associated with the jth group at time t. It is assumed to be mean zero, homoskedastic, and uncorrelated across time and groups.

Individuals. Thirty-two individuals participated in the experiment over twenty rounds. Half of the subjects participated in the "chat" treatment and half were in the "no chat" treatment. We assume the goal of an individual is to maximize payoffs, which is accomplished by playing a payoff dominant strategy. As individual payoffs rise so does group efficiency. Should each individual within a group play a Pareto dominant strategy, the group has successfully coordinated and economic efficiency is one. Because of the complicated nature of our spatial game, subjects may not find the payoff dominant strategy right away (or at all for that matter). Subjects allowed to communicate gave advice to other players even when the other player's action did not affect their own payoffs, thus the effect of cheap talk ($\mathrm{CT}_{i,t}$) should be to increase the likelihood of playing a payoff dominant strategy. Our measure for an individual's reputation is whether or not he or she played a payoff dominant strategy in the previous period ($\mathrm{PAYDOM}_{i,t-1}$). We expect reputation to have a positive effect on individual play of the payoff dominant strategy for the same reasons it improves group efficiency. Likewise, the cross-term in the individual model should have a negative coefficient.

The general underlying and unobserved likelihood function for individual i playing a dominant strategy in round t is

$$y^*_{i,t} = \lambda + \gamma' z_{i,t} + \delta_i + \xi_{i,t},$$

where $y^*_{i,t}$ is the latent variable, λ is a constant that picks up the average heterogeneity across individuals, $z_{i,t}$ is the matrix of exogenous variables described above, δ_i the error term associated with individual i, and $\xi_{i,t}$ the population wide error term. We assume the errors are mean zero with constant variance and zero correlation across individuals and periods. Our subjects are believed to represent a random sample of the general population, allowing us to use a random-effects model.

We do not observe individual likelihoods, only whether they played a payoff dominant strategy. Assume

$$\begin{aligned} &\text{if} \quad y^*_{i,t} > 0, \quad \text{then} \quad y_{i,t} = 1, \\ &\text{if} \quad y^*_{i,t} \leqslant 0, \quad \text{then} \quad y_{i,t} = 0, \end{aligned}$$

where $y_{i,t} = 1$ if player i plays a payoff dominant strategy in period t, $y_{i,t} = 0$ if player i does not play a payoff dominant strategy. This gives us the following

(*footnote continued*)
the incidental parameter problem which causes the parameters to be biased and inconsistent (see Greene, 2004).

likelihood function for a random-effects model[8]:

$$L_i = Pr[y_{i,1}, \ldots, y_{i,T}|Z]$$
$$= \int_{-\infty}^{\infty} \left[\prod_{t=1}^{T} Pr(Y_{i,t} = y_{i,t}|z'_{i,t}\gamma + \delta_i)\right] f(\delta_i)\, \mathrm{d}\delta_i.$$

Since $y_{i,t}$ is unobserved, we assume a standard normal distribution for the errors so that the probabilities inside the product are $\Phi[q_{i,t}(z'_{i,t}\gamma + \delta_i)]$, where Φ is the standard normal CDF and $q_{i,t} = 2y_{i,t} - 1$.

Results

Table 1 summarizes the unconditional results – it shows the average group efficiencies and percentage of subjects who played payoff dominant strategies by round. Two trends are obvious before we run a regression. First, group efficiency is higher among those groups allowed to chat compared to those that were not allowed to chat, especially in earlier rounds. They neared 100% efficiency by round 5, whereas the average for groups not allowed to chat only went above 98% in two rounds. Second, payoff dominant strategies were played more frequently among individuals allowed to communicate with each other (after accounting for the one group).[9]

Now consider the conditional results. Table 2 shows the generalized least squares results for the group model and the maximum likelihood (Probit) marginal effects for the individual model. As would be expected cheap talk has a positive effect on both group efficiency and individual play of payoff dominant strategies; however, the effect is small compared to reputation. The most important factor in determining coordination is past play. People either *got it* (the Pareto equilibrium) or they did not. If a group was fortunate enough to have all its players "get it", communication would not have been all that important. Likewise, if a group is entirely composed of individuals playing payoff dominated strategies, they are not likely to see large gains from communicating with each other. In such a case, the group is likely to remain in an inefficient outcome.

The interaction term in the group model allows for the slope of lagged efficiency in relation to reputation to differ by sample, we see the coefficient for cheap talk is statistically significant and increases in value. Controlling for response differences to past experience provides the strongest implications of the influence of cheap talk on group behavior. When cheap talk is allowed the effect of past experience on

[8]See Greene (2003) for an explanation of Butler and Moffitt's (1982) method for Probits with panel data.

[9]When examining the frequency in which individuals played payoff dominant strategies, we present results for those allowed to chat and those allowed to chat minus one group (G10) that only sent three messages over all twenty rounds. This group only played four payoff dominant strategies throughout the entire experiment. Using a Wald test, we find that this group is statistically different than the other chat groups, further highlighting the importance of communication in coordination. Since this group is not representative of the "chat" participants we omit it in our analysis. These results are available on request.

Table 1. Average group efficiencies and percentage of people who played payoff dominant strategies

Round	Efficiency (%)			Played payoff dominant (%)			
	Chat	No chat	Difference	Chat	Chat w/o G10	No chat	Difference
1	76.3	79.6	−3.3	31.3	33.3	37.5	−4.2
2	91.5	84.1	7.4	43.8	50.0	31.3	18.8
3	97.0	84.3	12.7	56.3	75.0	37.5	37.5
4	98.5	96.7	1.7	62.5	83.3	43.8	39.6
5	99.9	90.1	9.7	75.0	100.0	43.8	56.3
6	97.8	89.1	8.7	81.3	100.0	62.5	37.5
7	98.3	92.4	5.9	62.5	83.3	68.8	14.6
8	95.6	96.8	−1.2	75.0	100.0	68.8	31.3
9	99.9	97.5	2.4	75.0	100.0	75.0	25.0
10	99.9	93.4	6.4	75.0	100.0	75.0	25.0
11	99.1	99.1	−0.1	68.8	91.7	75.0	16.7
12	97.7	94.5	3.2	68.8	91.7	68.8	22.9
13	99.9	98.3	1.5	75.0	100.0	75.0	25.0
14	99.3	97.2	2.1	68.8	91.7	75.0	16.7
15	99.0	97.7	1.4	62.5	83.3	81.3	2.1
16	98.4	97.0	1.4	62.5	83.3	87.5	−4.2
17	97.8	97.2	0.6	75.0	100.0	93.8	6.3
18	99.9	97.0	2.9	68.8	91.7	93.8	−2.1
19	99.9	94.4	5.5	75.0	100.0	93.8	6.3
20	99.2	92.9	6.3	81.3	100.0	93.8	6.3

efficiency drops to 0.28 relative to 0.55 when cheap talk is not allowed – as expected past experience is less important. Also, from the individual results, our interaction term allows for changes in relative gains from past play between samples. Here we see that the interactive term is negative; with cheap talk, playing a dominant Nash strategy is less dependent on whether or not one was played in the previous period. The coefficient on PAYDOM_{t-1} falls from 0.49 to 0.18 in the samples with cheap talk. We see communication plays an important role in reassuring subjects about their chosen strategy and confirming that other subjects plan to play that strategy in the future.[10]

In summary, a coordination model should include reputation and communication. Reputation, however, is the strongest determinant of group coordination and individual play of the dominant strategy. That said, adding cheap talk allows groups

[10]We also test our model against alternative specifications. We restrict the model to a version with only chat and a model with only reputation. Using the standard *F*-test we reject both of these restrictions at the 1% significance level. Neither a model with only communication nor a model with only reputation explains the data. These results are available from the authors on request.

Table 2. Regression results

Variable	Group results
Constant	0.43***
	(0.066)
CT	0.28**
	(0.12)
EE($t-1$)	0.55***
	(0.070)
CROSS	−0.27**
	(0.13)
R-squared	0.47
N	133
Individual marginal effects	
Constant	−0.16***
	(0.038)
CT	0.32***
	(0.073)
PAYDOM ($t-1$)	0.49***
	(0.053)
CROSS	−0.31***
	(0.085)
Predicted correctly[a]	88%
N	532

We test for autocorrelation using Durbin (1970) test with lagged dependent variable. We reject the null as there is no autocorrelation.
Significance levels: ***1%, **5%, *10%.
Standard errors in parentheses.
[a]As given by LIMDEP, where the value is predicted to be 1 if the value of the Probit is greater than 50%.

to coordinate faster to the Pareto optimum and serves to diminish the importance of reputation. Subjects who choose to communicate shared information that both affirmed past play and confirmed future play.

Conclusion

Finding effective tools to reach an efficient outcome is important for a number of reasons. First, the areas we are most interested in conserving are often sparsely populated. Getting people to come together is logistically hard. Second, land conservation can be a contentious issue; bringing groups together can cause more conflict than resolution. When parties have an inherent distrust of each, cooperation is difficult. The problem is compounded by information asymmetries, differences in negotiating skills, differences in ability to finance legal opposition, and personal feelings (see for example, Rhoads and Shogren, 2003).

Casual empiricism would lead one to believe that communication can lead to higher rates of coordination among groups, and in an uncomplicated world this could hold. But policy aimed at recreating contiguous habitat in forests or any land cover is seldom set in such a world. Even the game presented here is relatively trouble free compared to decisions landowners face regarding habitat preservation and coordination with neighbors.

In the past governments have resorted to command and control policies (e.g. Endangered Species Act, Clean Water Act) to ensure adequate protection of natural resources. These policies often lead to anti-conservation sentiments of businesses and landowners that have restrictions imposed on them. These policies, and the feelings they invoke, have led to an era of minimum standards; landowners conserve exactly what is required by law. In a move towards better public relations and better conservation, many governments have emphasized cooperative conservation.

Cooperative conservation is not new; programs such as safe harbor and ED's Landowner Conservation Assistance Program have proven their merit for years. However, the widespread political appeal is new. President G.W. Bush just signed the Executive Order of Facilitation and Cooperative Conservation Act in August of 2004, and Congress has been trying to work out the kinks and implications ever since. Agglomeration bonuses like those set out in Parkhurst and Shogren (2006) have proven to be effective cooperative conservation tools for meeting large scale land conservation goals; however, we have shown that these subsidies alone may not be enough to reach an efficient outcome. They must be paired with communication.

Groups in our experiment that were allowed to communicate reached higher levels of efficiency sooner than those prohibited from communicating. Those early rounds matter when conservation actions are irreversible or when regulators only have one chance to get it right as is the case with conservation easements. In one-shot games, communication has proven to be invaluable (Parkhurst et al., 2004). Communication is important for pointing out what the actual goals are and how to get there. Jim Berger, the former President of the Wyoming Stockgrowers Association, put it well: "the best wildlife management we can have is a local game warden, a rancher, and a cup of coffee" (Kruckenberg, 2000). The "cup of coffee" is important. The advantage of our subsidy scheme is that once the subsidies are properly designed and once landowners are informed, there should be less need for perpetual management. With open and facilitated communication, landowners should help each other realize the efficient outcome. Communication decreases the likelihood of being stuck in a bad conservation outcome and ensures landowners will stick to the status quo because it is in their best interest.

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