An Experiment on Enforcement Strategies for Managing a Local Environmental Resource

James J. Murphy and Juan-Camilo Cardenas

Abstract: Managing local environmental resources with moderately enforced government regulations can often be counterproductive, whereas nonbinding communications can be remarkably effective. The authors describe a classroom experiment that illustrates these points. The experiment is rich in its institutional settings and highlights the challenges that policymakers and communities face in enforcing environmental regulations. The experiment has been run successfully in a variety of courses and disciplines at both the undergraduate and graduate levels, including microeconomics, public finance, and a natural resources conservation course. The experiment would be appropriate in environmental economics and game theory courses. This experiment has also been used in the field with villagers who face challenges similar to the experiment; the field results were comparable to those in the classroom.

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JEL codes: C90, O13, Q15, Q20

Economic behavior is often the result of more than just a simple comparison of marginal costs and benefits. It has been well established in both field and laboratory settings that factors such as trust, equity, and reciprocity can play an important role in individuals' decisions. Failure to account for such factors can result in unintended consequences when implementing public policies. We present a classroom experiment that focuses on moderately enforced regulations designed to reduce extraction of a local resource thereby improving environmental quality. What is particularly interesting about the typical results in this classroom experiment is that externally imposed rules, from an Environmental Protection Agency for example, can crowd out other-regarding behavior and possibly exacerbate the environmental problem the regulation was designed to address. On the other hand, allowing local communities to solve the problem on their own through face-to-face communication can be very effective, even without any formal monitoring or penalty structure.

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This experiment is a classroom adaptation of field experiments run by Cardenas, Stranlund, and Willis (2000) with rural villagers in Colombia and was motivated by real-world local environmental resource problems that these people face in their daily lives. The experiment is framed as a resource extraction problem—how much time to spend in the forest collecting firewood. The problem is that water quality and firewood collection are inversely related—the more time each person spends collecting wood, the lower the water quality will be for everyone in the community because of soil erosion.[1]

Theory predicts that rational self-interested behavior will result in overexploitation of environmental resources.[2] However, both experimental and field evidence consistently demonstrate that individuals do not always behave as if they were purely self-interested; instead, they often make decisions that balance self- and group interests (Davis and Holt 1993; Kagel and Roth 1995). Ostrom (1990) identifies a number of long-enduring, successfully managed common-pool resources and some key elements that these have in common, including a high degree of local control. Moreover, research indicates that externally imposed regulations that theory predicts *should* improve social welfare may in fact be counterproductive by crowding out civic mindedness and encouraging more selfish behavior (Cardenas, Stranlund, and Willis 2000; Frey and Oberholzer-Gee 1997; Ostmann 1998). On the other hand, communication and group involvement in organizing and governing a local resource may result in higher levels of cooperation (Ostrom and Walker 1991).

Even if regulations are well intentioned and aimed at increasing social welfare, regulators do not have a costless way of monitoring and enforcing them. Only a fraction of the monitored agents are, in fact, inspected and sanctioned for not complying. Given this imperfect monitoring, an opportunity for deriving some rents appears if an agent attempts to violate the rules and increase his or her earnings. This is also the case for self-governed solutions. A nonbinding agreement among group members still allows some members not to comply with the agreement and free ride on the cooperation of the others. This exercise offers an interactive way of discussing these cases for both external regulation and for self-governed solutions to the kind of group externalities discussed here.

EXPERIMENT DESIGN FOR CLASSROOM USE

Experiment Summary

The experiment consists of a series of rounds in which students must decide how many months to spend extracting firewood from the forest.[3] Individual payoffs are a function of both the individual's decision about how many months to spend in the forest, $x_i \in [0,8]$, and the aggregate decision of all n group members,

$$\sum_{j=1}^{n} x_j .$$

The latter term captures the negative externality that generates the divergence of private and social interests. The function that defines individual payoffs is

$$\Pi_i\left(x_i, \sum x_j\right) = \frac{2}{8,405}\left[1372.8 - \left(\sum x_j\right)^2 + 97.2x_i - 3.2(x_i)^2 + 30(8 - x_i)\right]^2. \quad (1)$$

These payoffs are summarized in a payoff table (Table 1 contains a condensed version, a complete version is on the Web page) that is included with the instructions (Appendix A). The table given to students does not include the highlighted cells. This payoff table is identical for each student. The socially optimal solution is for each person to spend just one month in the forest, but this is not a Nash equilibrium. Students submit their decisions to the instructor, who tabulates the results and announces the total number of months spent in the forest by each group (individual decisions are not revealed, just the group total). The experiment consists of three different treatments that test three different policy options: (1) an unregulated environmental resource; (2) an imperfectly enforced, externally imposed regulation; and (3) communication as a self-governing tool for managing the resource, communication. (These treatments are discussed in more detail later.) For a 75-minute class, we typically run about 15 to 20 rounds divided into the three treatments. The exact number of rounds is not announced to the class.

Getting Started

To save class time, the instructor should hand out the instructions a few days before the experiment and ask students not to discuss the experiment amongst

TABLE 1. Payoff Matrix for Eight Persons in a Group[a]

Their months in the forest	My months in the forest								
	0	1	2	3	4	5	6	7	8
0	619	670	719	767	813	856	896	933	967
7	600	645	688	729	767	803	836	865	891
14	546	583	619	652	683	711	736	758	776
21	461	491	519	544	567	587	605	619	630
28	355	377	396	414	430	443	453	461	466
35	238	253	266	277	286	293	297	300	300
42	127	135	142	148	152	154	155	154	152
49	40	44	46	48	49	48	47	45	43
56	0	1	1	1	1	1	0	0	0

[a]To conserve journal space, we present a condensed version of the payoff matrix. This reduced matrix contains only the rows for which the seven "other" group members each choose the same number of months. The Web page has the complete matrix that should be given to students. For those without Web access, the complete matrix can be constructed in Excel using equation (1), and includes the 57 rows corresponding to "their months" equals 0 to 56, inclusive. The shaded cells are Nash best responses.

themselves because it only detracts from their experience.[4] We have found that students usually honor this request. Encourage students not only to read and understand the instructions but also to think about the types of decisions they might make in the experiment. Before the start of the experiment, the instructor should answer any questions but avoid suggesting how a person should play the game.

At the beginning of class, the instructor randomly assigns students into groups. All groups in both Cardenas, Stranlund, and Willis (2000) and our class experiments consisted of $n = 8$ members, and in the remainder of this article, we assume groups of eight. If there are a few extra students, we usually have some students work together in pairs jointly making a single decision so that all groups have eight participants. It is possible to conduct this experiment with group sizes smaller than eight, and at the end of the article, we provide some details on running the experiment with smaller group sizes. In larger classes, it might be useful to select one or two students to assist in running the experiments. To preserve anonymity, randomly assign each of the group members a unique player number between one and n. Only the individual should know his or her player number. All decisions will be submitted using this number so that not even the instructor will be able to link individual students to their decisions.

Running the Experiment

In each round, participants need to decide how many months to spend extracting wood from the forest. This must be a whole number between zero and eight, inclusive. Students use an experiment card (Figure 1) to submit their decision to the instructor. If there are multiple groups, we have found it convenient to have each group's experiment cards on a different colored paper. Note that the student does not report his or her name on the experiment card, only the player number, so there is no way of linking individual students to their decisions. The students also record their decisions on the record sheet (Figure 2) for their own record. The instructor collects the experiment cards and enters each decision into an Excel spreadsheet.[5] The spreadsheet tabulates the results and also plots the results for later discussion. The instructor announces the total for each group, and the students then calculate their earnings using the payoff table. The process is then repeated for the next round.

Experiment Card

Player number:

Round number:

My months in the forest:

FIGURE 1. Experiment card.

NAME: ___________________________ PLAYER NUMBER: ___________

Round no.	Column A My months in the forest (Your decision)	Column B Total group months in the forest (Announced by the instructor)	Column C Their months in the forest (Column B minus Column A)	Column D My earnings in this round (Use your PAYOFF TABLE)
1				
2				
.				
.				
.				
			Total	

FIGURE 2. Sample record sheet.

Treatments

The experiment consists of three treatments, usually run in the following sequence: (1) five to eight rounds of an unregulated environmental resource without communication among participants (referred to as the *Open Access* treatment), (2) five to eight rounds with exogenous regulation and random monitoring (*Regulation*), and (3) a few rounds with participants given an opportunity to communicate before making a decision (*Communication*). Clearly, the experiment could be run with any combination or sequence of treatments. The instructions given to students prior to the experiment are for the *Open Access* treatment, and students are not aware of any upcoming changes.

Open Access. The *open access* treatment presents students with a typical environmental resource extraction problem, and could be used alone or in conjunction with the other treatments. Students are not allowed to speak with each other. The efficient solution is for each person to spend one month in the forest. In this situation, the group payoffs are maximized, and each person earns E$645.[6] This is not, however, a pure strategy Nash equilibrium. With a group size of eight, should an individual expect the other seven group members to choose one month, he could increase his own individual payoff by choosing eight months and earn E$891. (The highlighted cells in Table 1 indicate an individual's best response. These cells should not be highlighted in the table given to students). The pure strategy Nash equilibrium is for each person to choose six months and earn E$155.[7] It is worth noting that at the Nash equilibrium, subjects earn about 24 percent of what they would at the efficient outcome.

Regulation. After about five to eight rounds of the *Open Access* treatment, temporarily stop the experiment and give the students a piece of paper with the new monitoring rules (Appendix B). The instructor reads these new rules aloud while the students follow along. The intent of the *regulation* is to reach the socially efficient outcome, therefore the regulation stipulates that each person may spend no more than one month in the forest. Communication among group members is still prohibited. In reality, monitoring and enforcing regulations is often costly and difficult. The experiments, therefore, use an imperfect monitoring mechanism. After students have made their decisions and the experiment cards are collected, there is a 1/16 probability that one person in the group will be monitored. For each group, the instructor tosses a coin to determine whether someone is monitored. If the coin lands tails, nobody will be monitored; if it is heads, then one person in the group will be monitored. If heads, to determine which person will be monitored, the instructor places cards numbered one through eight in a box and draws one card and the number on the card corresponds to the player monitored. Although the instructor announces the player number to the class, no one except the individual to be monitored knows the player identity. After announcing the player number, the instructor returns the card to the box. It is possible that the same individual may be monitored multiple times, but it is also possible that no one is monitored. Repeat this monitoring sequence separately for each group.

If the person monitored chose to spend zero or one month in the forest, then the person is in compliance, and there is no penalty. However, if the person monitored spent more than one month in the forest, then the penalty is E$100 for every month that the person is out of compliance. For example, if the person chose five months, he or she is four months over the standard and receives a E$400 penalty. In this case, the E$400 penalty should be deducted from that student's earnings for that round. The instructor's Excel spreadsheet will automatically track the penalties.

When we assume risk neutrality, the Nash equilibrium is reached when each player chooses to spend five months in the forest (as opposed to six months in the unregulated case).[8] The expected payoff is E$268, which is about 42 percent of the payoffs that could be attained if everyone fully complied with the regulation. However, because the regulation is intended to induce more efficient choices, each individual's expected payoff is about 73 percent higher than the Nash equilibrium in the *Open Access* treatment.

Communication treatment. After about five to eight rounds of the *Regulation* treatment, the instructor allocates the remaining time to the *Communication* treatment. In this treatment, the regulation is no longer in effect, but students are now given about five minutes to meet with their fellow group members. Students are permitted to discuss any aspect of the experiment, but they are not allowed to use threats, agree to transfer money, or show anyone their record sheet. Once students return to their desks, all decisions are private, and the experiment proceeds like the first treatment (*Open Access*). Because of time constraints, we usually run only two to four rounds of this treatment, but this is sufficient to generate meaningful discussion.

Paying Students in Cash

If desired, E$ could be converted to local currency at a preannounced exchange rate. Although paying students is optional, to maintain some degree of saliency and fun, we usually announce that two names will be drawn at random at the end of the experiment. We pay the winners their average earnings in cash. We prefer to use a random drawing, rather than paying those with the highest earnings, because all participants will always have a chance to be paid and therefore have an incentive to maximize earnings. With eight people in a group, average earnings usually range between E$350 and E$600 with an average of about E$450. We use average earnings, rather than cumulative earnings, so that payoffs are independent of the total number of rounds. We do not recommend that students' grades be linked in anyway to the outcome of the experiment.

Keep in mind that the experiment is designed so that the instructor cannot identify a student's decisions and therefore cannot verify how much a student earned. If students are randomly selected to be paid, the "winners" will have to provide their player number to the instructor, which removes a degree of anonymity. (The other students will still be unaware of their peers' individual decisions). Students should be made aware of this possibility.

Preparing for the Experiment

The instructor should bring the following items to class:

1. Laptop computer with a spreadsheet to tabulate results (or a calculator with some paper for manual record keeping)
2. Coin (for flipping to decide if anyone is monitored)
3. Empty box or hat (for drawing ID numbers if someone is monitored)
4. Payoff table (Table 1, one for each student)
5. Experiment cards (Figure 1, about 15–25 for each student, depending upon number of rounds)
6. Record sheets (Figure 2, one for each student)
7. Monitoring rules (Appendix B, one for each student)
8. Extra copies of instructions (Appendix A, in case some people forget to bring them)
9. Optional cash payoffs (if some students will be paid)

Running Experiments–Sequence of Steps

Getting started:

1. Answer any questions about the instructions.
2. Assign students to groups of eight.
3. Distribute experiment cards, record sheet, and payoff table.

The experiment:

4. Begin round.
5. If students are allowed to communicate (*Communication* treatment), allow about five minutes to discuss the experiment.

6. Students make their decisions and record them on both experiment card and record sheet.
7. Instructor collects experiment cards, tabulates results, and announces total number of months spent in the forest by each group.
8. If regulation is in effect (*Regulation* treatment), flip coin to decide if someone will be monitored. If coin lands heads, randomly select one group member for monitoring. Repeat for each group.
9. Students calculate earnings for the round, including any penalties. The Excel spreadsheet automatically does this accounting for the instructor.
10. Begin next round. If changing to another treatment, announce new rules before students make decisions.

RUNNING THE EXPERIMENT WITH SMALLER GROUP SIZES

It is possible to conduct this experiment with group sizes smaller than eight, but we would recommend no fewer than four students per group. The two key changes are a smaller payoff matrix and a new Nash equilibrium. For a group size of $n < 8$, delete the last $[(8 - n) \cdot 8]$ rows of the payoff table (Table 1).[9] For example, with a group size of six, delete the last 16 rows (i.e., the rows corresponding to "their months" equals 41 through 56). The values in the payoff table are unchanged. Table 2 contains the Nash equilibrium for groups of four to eight. With six students per group, for example, the symmetric Nash equilibrium is for each person to spend seven months in the forest with each person earning E$300, but the socially optimal choice is two months with each person earning E$663. The last row of Table 2 shows that at the Nash equilibrium students earn 45 percent of what they would have at the social optimum.

When the external monitoring is in effect (*Regulation* treatment), the standard may have to be adjusted to reflect the new social optimum. With six per

TABLE 2. Benchmarks for Different Group Sizes

	Group size				
Benchmark	8	7	6	5	4
Social optimum					
Months in forest–individual	1	1	2	2	3 or 4
Months in forest–group	8	7	12	10	12 or 16
Earnings–individual	645	651	663	680	711
Earnings–group	5160	4557	3978	3400	2844
Efficiency (%)	100	100	100	100	100
Symmetric Nash equilibrium					
Months in forest–individual	6	6 or 7	7	8	8
Months in forest–group	48	42 or 49	42	40	32
Earnings–individual	155	276	300	371	561
Earnings–group	1240	1932	1800	1855	2244
Efficiency (%)	24	42	45	55	79

group, for example, the new regulation should penalize those choosing three or more months.

DISCUSSING THE RESULTS

Students quickly recognize the dilemma they face: payoffs would be maximized if everyone chose to spend one month in the forest, but there are economic incentives for individuals to deviate from this. Use this as an opportunity to introduce public goods and common-pool resources, as well as the concepts of efficiency, private welfare, and social welfare. For advanced classes that discuss game theory, instructors can point out that for the *Open Access* treatment, the pure strategy Nash equilibrium is for each person to spend six months in the forest (the Nash best responses are highlighted in Table 1). We have found that most undergraduates and noneconomists struggle with this concept. In these classes, we tend to focus the discussion on the two extreme outcomes (1 or 8 months in the forest) and their relationship to cooperative or self-interested behavior.[10]

Once these concepts have been introduced, it is interesting to discuss the results for the first treatment (*Open Access*)[11] and identify the factors that may have led to the observed outcomes. Individual decisions in this treatment usually vary, with a mean and median typically between four and five months. However, the modal choice is consistently eight months. The mean decision for a typical group by round for the three treatments is shown in Figure 3. If the mean is around four or five, ask students why purely self-interested behavior by all group members was not observed. Were individuals consciously playing a Nash strategy? Is the distribution bi-modal, with the group divided between free riders and group-oriented individuals, so that the mean is somewhere in the middle? The key is to understand and discuss why groups' outcomes are the result of a population of both types. More advanced courses or discussions could review the literature on agent types, including Ostrom's (2000) article on social norms and collective action.

The second treatment, *Regulation*, parallels a situation in which an external government agency imposes regulations on the group in an attempt to reach a more efficient solution. These regulations are sometimes imperfectly enforced, particularly in developing countries. Research indicates that individuals are sometimes made worse off when faced with an imperfectly enforced government-imposed regulation that standard theory predicts would be welfare enhancing (Cardenas, Stranlund, and Willis 2000; Frey and Oberholzer-Gee 1997; Ostmann 1998). The rationale for this mystifying result appears to be that when individuals were confronted with a regulatory constraint, they tended on average toward more self-interested behavior (i.e., toward pure Nash strategies), whereas in the absence of regulatory control, their choices were significantly more group oriented.

When the regulation is imposed, compliance is typically high in the first few rounds. But this compliance usually deteriorates and decisions are often at the same levels that they were in the *Open Access* treatment. This result would be consistent with the notion that external regulation may crowd out other-regarding behavior. The results from a single experiment that demonstrates this pattern

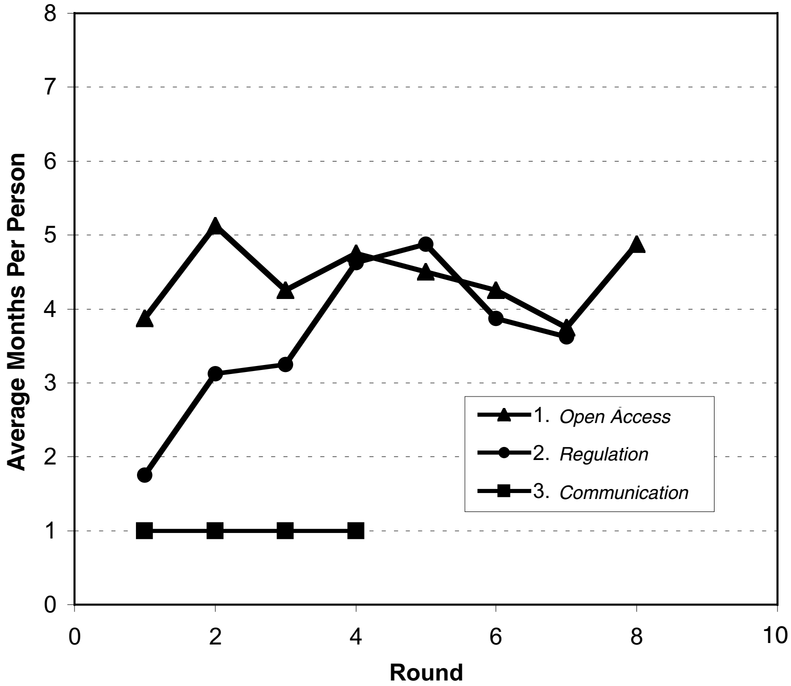

FIGURE 3. Average individual decisions from one group.

are contained in Figure 3. The mean and median of all rounds combined is usually about one month lower than the *Open Access* treatment; the modal decision is usually one month, although modes of eight months are not uncommon especially in the later rounds. For groups that do not display the early compliance pattern shown in Figure 3, it is still common to observe a one to two month decrease in the mean.

Under *Regulation*, notice that players initially choose a relatively low number of months, but as the experiment progresses students usually return back to the levels they were showing in the first stage (*Open Access*). Further, the crowding out of civic-minded behavior can be more strongly verified if we consider that under the regulation the players are facing an expected cost that shifts their Nash strategy to fewer months. That is, the average behavior observed under the regulation (*Regulation*) is substantially closer to the Nash best response than under no regulation at all, confirming that the regulation actually induced a more self-oriented behavior (Cardenas, Stranlund and Willis, 2000).

The last treatment, *Communication*, is a proxy for allowing a weak form of self-governance over the shared local resource. It is particularly interesting that this treatment is the high degree of compliance that communication fosters, even in the absence of any regulation. In over 75 percent of the experiments we have run, there is perfect or near-perfect compliance by all group members (Figure 3). Prior to the last round, we announce that this will be the end, but rarely observe any significant end-game effects. A discussion can begin with why one might expect end-game effects and then focus on the reasons why these effects were or were not observed in the classroom.[12]

The results of the last two treatments usually generate a lively debate about self-governance versus external regulation. In theory, even a modestly enforced regulation should improve social welfare, whereas nonbinding communication should have absolutely no impact. Yet in the experiments, we consistently observe the opposite. The instructor should ask students why communication was so effective and ask them to discuss the appropriate level of government (national, state, local) for confronting various environmental and shared-resource problems. To what extent did communication help to foster the development of social norms, and what role did these norms play in managing the resource?

APPENDIX A
INSTRUCTIONS FOR CLASS EXPERIMENT

Please read through these instructions carefully before class. Be sure to bring these instructions along with you to class. PLEASE DO NOT DISCUSS THE EXPERIMENT WITH OTHERS IN THE CLASS. However, I encourage you to begin thinking about the types of decisions you might make in the experiment. If you have questions, feel free to call or email me before class. Before the experiment begins, everyone will be given an opportunity to ask questions. Once the experiment begins, you may raise your hand if you have questions. Talking with the others during the experiment is NOT permitted.

In each round of the experiment, you will have the opportunity to earn cash in experimental dollars (E$). After the experiment is over, we will compute your average earnings per round. Then, I will draw the names of two individuals who will be paid in cash the U.S.$ equivalent of your experiment earnings at an exchange rate to be announced. I would like to point out that, in terms of cash earnings, your incentives are *identical* in this setup with a random drawing for two names as they would be if everyone were paid his/her earnings. The more you make in E$, the more you will make in U.S.$ if your name is called.

Introduction

This experiment attempts to recreate a situation in which a group of families must make decisions about how to use a shared resource, for example, a forest, a water source, or a fishery. In this experiment, the resource will be referred to as the forest. You will play for several rounds that are equivalent, for instance, to years or harvest seasons. Make no assumptions about the number of rounds.

The Payoff Table

At the start of the experiment, you will receive a PAYOFF TABLE identical to the one attached at the end of the instructions. All participants will have the same payoff table as you. This table contains all the information that you need to make your decision in each round of the experiment. The numbers that are inside the table correspond to the E$ that you would earn in each round for a given set of decisions. Each of you must decide the number of MONTHS that you want to allocate to "time extracting from the forest" (in the columns from 0 to 8).

To play in each round you must write your player ID (which the instructor will give you), the current round number, and your decision (a number between 0 and 8) on an EXPERIMENT CARD that the instructor will give you. (There is an example attached to the end of the instructions).

It is very important that you keep in mind that your decisions are completely private and you may not show them to the rest of members of the group. Moreover, the instructor will not know what you decided and will not divulge your decisions to anyone.

After everyone has made his/her decision, the instructor will collect the EXPERIMENT CARDS from all 8 group members and will calculate the total number of months that the group decided to spend extracting from the forest. When the instructor announces the group total, each of you will be able to calculate the E$ that you earned in the round. An example follows.

In this experiment, we assume that each player has available a maximum of 8 MONTHS to work each year extracting a resource like firewood or logs. In the PAYOFF TABLE (Appendix Table A1) this corresponds to the columns from 0 to 8. Each of you must decide from 0 to 8 in each round. But, to be able to know how much money you earned, you need to know the decisions that the rest in the group made. (See example in Appendix Table A1.)

The Record Sheet

OK, let us look how the experiment works in each round. Each participant will receive a RECORD SHEET like the one attached to the end of these instructions.

Using the example above (Table A1), let us see how to use this RECORD SHEET. (Table A2) Suppose that you decided to spend 2 months in the forest this round. On the EXPERIMENT CARD, you should write 2 next to "My months in the forest." You must also write this number in the first column (A) of the RECORD SHEET. (You are writing your decision down in 2 places: the EXPERIMENT CARD you give to the instructor, and the RECORD SHEET you keep).

The instructor will collect the EXPERIMENT CARDS from everyone in your group and will calculate the total time spent in the forest by the group. The instructor will

TABLE A1. An Example of How the Payoff Table Works

Their months in the forest	My months in the forest: 0	1	**2**	3	4	5	6	7	8
19	488	520	550	578	603	625	645	661	674
20	475	506	**535**	561	585	606	625	640	653
21	461	491	519	544	567	587	605	619	630
22	447	476	502	527	548	567	584	597	608

- You decide that "MY MONTHS IN THE FOREST" will be 2.
- The instructor collects all the Decision Cards and announces that a TOTAL of 22 months were spent in the forest.
- Therefore, you know that "Their months in the forest" was 20, and your earnings for the round are 535.

TABLE A2. Record sheet

NAME: ____________________________ PLAYER NUMBER: ____________

	Column A	Column B	Column C	Column D
Round no.	My months in the forest (Your decision)	Total group months in the forest (Announced by the instructor)	Their months in the forest (Column B minus Column A)	My earnings in this round (Use your PAYOFF TABLE)
1	2	22	20	535
2				

announce this total to the group. Suppose that the total was 22 months. Write 22 in column B of the RECORD SHEET. To calculate "their months in the forest," subtract column A from column B, and record this in column C. In our example, "their months in the forest" is 20. To calculate your earnings, use the payoff table as described earlier. If "my months" equals 2, and "their months" equals 20, then your earnings would be 535. So in this example, you would have written the following on your record sheet:

It is very important to clarify that nobody will know your decisions in each round or your earnings for the experiment. Only the **group total** is announced in public. No one, including the instructor, will know what each participant in your group decided.

If you have any questions about how to earn money in the experiment, please email me, or ask before the experiment begins.

SUMMARY OF STEPS FOR PLAYING ONE ROUND OF THE EXPERIMENT

How it is played: In each round, you must decide how many months in a year between 0 and 8 that you want to devote to extracting resources from a forest. Your earnings in each round depend on both your decision and the decisions by the rest of the group, according to the PAYOFF TABLE.

What you need: To play you need a PAYOFF TABLE, a RECORD SHEET, and several EXPERIMENT CARDS. You also need a player number. The instructor will provide all of this.

Steps for each round:

1. Using the **PAYOFF TABLE**, decide how many months you will spend in the forest.
2. On the **RECORD SHEET**, write your decision (My Months in the Forest) in Column A for the current round.
3. On an **EXPERIMENT CARD**, write the round number, and your decision (My Months in the Forest). Make sure it corresponds exactly to what you wrote on the **RECORD SHEET**. Hand the experiment card to the instructor.
4. The instructor will collect all the experiment cards and announce the **TOTAL GROUP MONTHS**.
5. On the **RECORD SHEET**, write this total in Column B (Total Group Months in the Forest).

6. On the **RECORD SHEET**, calculate Column C (Their Months in the Forest). This equals Column B minus Column A.
7. On the **RECORD SHEET**, write in Column D the total amount you earned for this round. To know how much you earned, use the **PAYOFF TABLE** and columns A and C (My Months and Their Months).
8. Play another round (Go back to step 1).

APPENDIX B
External Regulation

In addition to the rules for the rounds we just completed, there is now an additional rule in effect. The goal of this new rule is to help obtain the maximum earnings possible for the group. We will try to guarantee that each player in your group chooses to spend no more than one Month in the Forest.

However, it will be very difficult to inspect everyone's decision. Thus, we will select someone at random to be monitored. To determine who will be monitored: The instructor will flip a coin. If TAILS, then *nobody* will be monitored this round. If HEADS, then *one person* will be monitored this round. The monitor will draw one name from a box with all eight participant numbers. If that person spent more than one month in the forest, a penalty will be imposed (Table B1).

The penalty is E$100 for each <u>additional</u> month. For example, if a player is selected randomly, and he had chosen to spend three Months in the Forest, the monitor will subtract E$200 from his total earnings in that round.

If someone is monitored in the round, no one will know who that person is. Moreover, only the individual and the monitor will know whether that person was in compliance. The card for the person who was monitored will be returned to the box. Thus, it is possible for someone to be monitored more than once during the experiment. It is also possible that someone may not be monitored at all.

NOTES

1. Some experimentalists suggest that experiments ought to be devoid of any context to avoid having the setting affect decisions, but there is no consensus on this. We choose to present the environmental problem with a specific example, or frame, to make the experiment more tangible for students and to add to the richness of the experiment. For those who are concerned about the framing of the problem, it would be trivial to edit the instructions to remove any such context. We do not expect that the results would change significantly.
2. In this context, *self-interested* means that an individual's utility function depends exclusively on his or her own gains and does not include the welfare of others.
3. All materials useful for running the experiment are available from James Murphy's Web site: http://www.umass.edu/resec/faculty/murphy/teaching.html. For those with access to a computer lab, the authors have also created a computer-based version of this experiment that is freely available on the site.
4. We make this request because in an ideal setting without time constraints students would read the instructions in class at the start of the experiment and would not have an opportunity to discuss the experiment. This request reduces the chances of introducing any biases or collusion.
5. The spreadsheet is a convenient way to record results but is not necessary. In the class, you can just as easily use a calculator to sum the individual decisions.

TABLE B1. Penalty if You Are Monitored

My months	0	1	2	3	4	5	6	7	8
Penalty (E$)	0	0	100	200	300	400	500	600	700

6. We use E$ to denote experimental dollars.
7. Because each group member has identical payoffs, the Nash equilibrium is symmetric.
8. The spreadsheet on the Web includes a payoff matrix with *expected* payoffs and highlights the Nash best responses.
9. The Web page contains the payoff matrices for group sizes of four through eight.
10. For the more advanced classes, emphasize that the payoff maximizing choice is not always to spend eight months in the forest. In some cases, a purely self-interested individual may earn more by spending fewer months in the forest. Note that if the individual expects all the other group members to average, say, seven months in the forest (i.e., their months equals 49), his or her payoff maximizing decision is to choose four months and earn E$49. A slightly more advanced exercise would be to have students calculate the *expected* payoffs and Nash responses under regulation. These expected payoffs are available for downloading from the Web page. Using expected payoffs, the Nash equilibrium for the *Regulation* treatment is five months.
11. The Excel spreadsheet automatically plots the results as they are entered. This allows the instructor to present some results immediately after the experiment or to make results available for discussion in the next class.
12. As an alternative, instructors could elect not to make the last round known, but it is likely that students will be able to anticipate when the end is near.

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