International Journal of the Commons
Vol. 9, no 1 March 2015, pp. 306–321
Publisher: Uopen Journals
URL:http://www.thecommonsjournal.org
URN:NBN:NL:UI:10-1-116931

ISSN: 1875-0281

A common-pool resource experiment in acequia communities

Nejem Raheem
Department of Marketing Communication, Emerson College, USA
nejem_raheem@emerson.edu

Abstract: Farmers and rural advocates in New Mexico assert that traditional irrigators are better adapted to water scarcity and variability than other communities. Data to actually test this are often scarce, but such information could be useful for planning the state's water future, especially as climate change predictions tend toward less reliable supplies. This paper reports results from a common pool resource (CPR) experiment that simulates irrigating behavior using two groups: rural irrigators and undergraduate students. Despite predictions to the opposite, there was no significant difference between mean withdrawals or predictions of other players' behavior. On average, both groups withdrew above the social optimum but below the Nash equilibrium. This work appears to be the first example of a common pool resource experiment conducted with traditional New Mexican irrigators.

Keywords: Acequias, common pool resources, field experiment

Acknowledgments: Experiment funding was provided by an NSF dissertation support grant and by a grant from the Levinson Foundation. I would like to thank the following people for their help: Estevan Arellano, Eric Biderman, Paula Garcia, William Gonzales, Ken Hughes, Ginny and Lea Johnson, Kate Krause, Vanessa Mazal, Carol Oldham, José Rivera, William Vasquez, Brian Hurd, Marie Sweetman, Kimberly Crunden, and two anonymous reviewers.

1. Introduction

Common-property irrigation ditches, called *acequias de común,* or acequias, in New Mexico (Rivera 1996, 1998; Rodriguez 2006), descend from a shared Roman, Islamic, Spanish, and Native American heritage. The name derives from the Arabic "as-sakiya," or "the water-bearer" (Peña 2003). Spanish settlers inherited Roman and Moorish irrigation systems in southern Spain (Hutchins

1928; Simmons 1972; Phillips et al. 2011), which they brought to the New World. These systems interacted and changed through contact with indigenous irrigation systems in the upper Rio Grande valley, or *Rio Arriba* (Simmons 1972; Rivera 2006).

Acequia irrigators, or *parciantes*, often informally share water amongst themselves via negotiations with the *mayordomo* (ditch boss) and their neighbors. This *reparto* or *repartimiento* (Rivera 1998) keeps water not only in the same basin, but often in the same ditch (Johnson et al. 1981; Nunn et al. 1991). Under the repartimiento, a more senior farmer can allow a junior farmer to use a part of his water rights for a specified period of time, without any sale taking place. Some advantages of this system over formal transfers are that it is a flexible system with relatively low transaction costs and that it keeps rights (and therefore flows) within the basin. The repartimiento also facilitates the continuity of Hispano traditions such as the carving of wooden santos (carved religious statues of saints) by reinforcing and facilitating the intergenerational transmission of traditional community values (Rivera 1998).

The repartimiento is a long-used cooperative mechanism, whose rules are generally well-understood in many communities. Rural advocates claim that parciante*s* are very responsive to changes in water availability (Rivera 1998; Peña 2003), as their proximity to watersheds and the visibility of snowpack all affect planting, and therefore irrigating decisions. This work investigates this claim using a common pool resource (CPR) experiment developed by Fischer et al. (2004) with narrative modifications to fit the circumstances.

1.1. Related experimental literature

A Common Pool Resource (CPR) is a good or event with relatively high subtractability and high cost of exclusion (Ostrom et al. 1994). Subtractability (rivalry) is the degree to which one user's withdrawal affects another's, and exclusion is defined as the feasibility of keeping others from using the resource; one parciante's withdrawal of water from a ditch results in less water being available to the next. Exclusion is costly on an open ditch with independently controlled gates.

Historically, CPR experiments used students (Camerer 2003; Harrison and List 2004), but field experiments increasingly use local participants (Carpenter 2000; Henrich et al. 2000; Cardenas and Carpenter 2005; Ghate et al. 2011; Janssen et al. 2011, 2012; Cardenas et al. 2013) and compare results from student and resource-using populations. Carpenter and Seki (2005) conducting public goods experiments with two groups of fishermen and students in Japan, find that fishermen in general contribute more than students do.

Janssen et al. (2012) conduct asymmetrical-access irrigation games and compare across student and villager responses in Colombia and Thailand. They find no significant difference in contributions between students and villagers, but villagers who occupied the downstream-most position generally left more water in the system than did students, who took all of it out. The downstream-most villagers ("tail-enders," or what New Mexicans would call "bottom-ditchers") tended to leave more water in the system than students in the same position did (27% vs. 0%). This was explained in post-game interviews by their perspective that "there are always people downstream or that the trees and birds may need those last drops of water (74)." Villagers with more actual resource use experience tend to make more investment than others in post-first round decisions, and upstream irrigators who extract heavily make lower than average contributions to infrastructure. Higher levels of trust tend to result in higher levels of withdrawals for upstream participators, possibly due to a belief that retaliation is unlikely.

Baggio and Janssen (2013), compare field data from irrigation games to agent-based models with a varying set of parameters including degree of altruism, degree of extraction, and degree of investment in delivery infrastructure. They find that selected agent-based models show differing goodness of fit with their field data on different components of their experiment: one model specification predicts investment well whereas another predicts withdrawals well. They also find that "models that assume agents who behave altruistically and randomly reproduce data quite well (152)."

Chermak and Krause (2001) use a multi-period CPR game to test for heterogeneity in withdrawals of a shared resource. They find that the resource was generally not depleted, though 16% of participants depleted the stock before the final round. Fischer et al. (2004) conduct a similar intergenerational CPR game; one key variation was to investigate extractive behavior under three growth rates: fast, slow, and "restart." Players expressed belief in intergenerational equity and stated a desire to reduce current consumption in order to help future generations; their behavior did not reflect this intention.

2. Methods

2.1. Experiment design, setup, and implementation

This experiment is based on Fischer et al. (2004), with narrative modifications and different subjects. The shared resource is exploited by three symmetrical players. Each player i chooses the effort x_i to be exerted (with e the maximum effort) in exploiting the resource with $0 \leq x_i \leq e$. The maximum irrigating effort in this experiment is 24 h per round, so the maximum of any symmetric individual is 8 h per round. The total exploitation effort x (the sum of all three players' efforts) determines the production of the common resource. Fischer et al. use a two-piece linear function to replicate the typical, "hump" shaped common resource production function $F(x)$, which is concave with its maximum within the range of players' endowments. So, $F(0)=0$, $dF(x^*)/dx=0$, with $0<x^*<e$, and $d^2F(x)/D^2x<0$. Figure 1 graphically represents this production function.

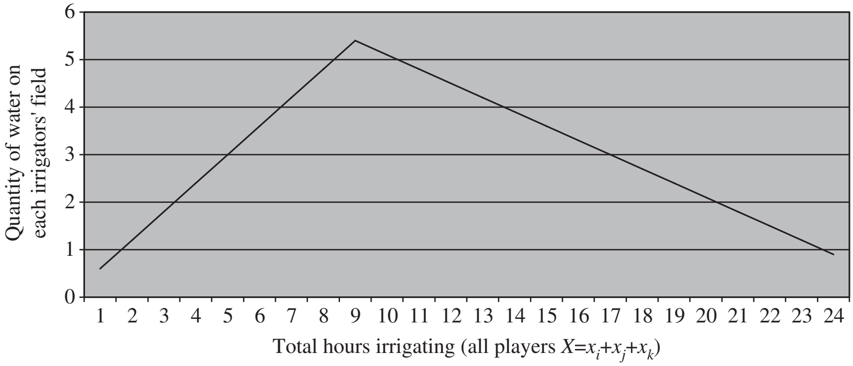

Figure 1: Quantity of water as a function of Total Hours Irrigating ($X=x_i+x_j+x_k$).

The slope of this two-piece linear function is positive up to a total withdrawal of 9 and negative from 9 to 24 such that:

$$F(x)=\begin{cases} 0.6x & \text{if } 0\leq x\leq 9 \\ 8.1-0.3x & \text{if } 9\leq x\leq 24 \end{cases} \tag{1}$$

The marginal rate of return is >0 for $x<9$, but <0 for $x>9$.[1] Given that form, the social optimum is reached at $x=9$. With three symmetrical players, the social optimum is obtained with each player i choosing $x_i=x^{so}=3$. The return from exploitation for a single player depends both on their individual choice and the withdrawal choices made by the other players. Specifically, each player's return is their own exploitation effort x_i divided by the total effort x.

$$R_i(x_i)=\frac{x_i}{x}F(x)=\begin{cases} 0.6x_i & \text{if } 0<x\leq 9 \\ 8.1\left(\dfrac{x_i}{x}\right)-0.3x_i & \text{if } 9<x<24 \end{cases} \tag{2}$$

As long as total exploitation is kept below the social optimum ($x\leq 9$), any single player's marginal return is constant and positive. That is, below a total irrigating effort of 9 h, no single player's choice will cause a negative externality for the other players. When the total time irrigating exceeds 9 (the social optimum), each player's marginal return is no longer constant, due to the negative externality caused by the other players' exploitation actions. In the symmetric

[1] $0.6x$ if $x=8$ is 4.8, if $x=9$ is 5.4. The marginal rate of return (MRR) of going from 8 to 9 is 0.6. When the function switches over to $8.1–0.3x$, we can see that $8.1–0.3(10)=5.1$ and $8.1–0.3(11)=4.8$. Therefore the MRR of going from 10 to 11 is –0.3.

Nash equilibrium, each player's choice is $x_i = x^{Nash} = 6$, well above the socially optimal level.
Since exploitation takes place over multiple generations, Fischer et al introduce the variable R^t, "a measure for the amount of resources that are available to the generation t." The payoff of player i in the generation t is defined as:

$$\pi_i = r_i R^t \tag{3}$$

The basic common pool model's return r_i is now interpreted as the fraction of the resource that player i receives. So each irrigator plays the same game in terms of relative payoffs, but each irrigator may face a change in the stock of resource available to them and a different rate of growth of that resource, so absolute payoff might or might not vary. If a given group of irrigators is inequity averse (Fehr and Fischbacher 2003, 2004) with respect to other generations, and wishes them to have the same opportunities, they must withdraw in a way that *exactly* compensates for the rate of growth of the resource. Fischer et al. call this "*growth compensating*" behavior.

Fischer vary the growth rate of the resource, while keeping all other parameters equal. They provide *fast*, *slow*, and *restart* rates. Under "fast," the growth compensating (GC) choice is $x_i^{GC} = 7$[2], under slow $x_i^{GC} = 2$[3], and under restart, there is no GC per se, as each generation receives the same starting quantity in each round no matter what the previous generation's withdrawal. Prior to administering the experiment, I conducted three focus group meetings with volunteer irrigators who provided feedback on the game design, instructions, and the instrument used to record their choices. The focus groups found the fast growth rate confusing and unrealistic. This appears to be due to the fact that they are accustomed to seeing heavy use deplete water in a ditch quite rapidly, and it tends not to regenerate very quickly. For this reason, I did not include the fast treatment in this experiment.

Finally, the authors provide a baseline control treatment (RESTART) wherein every generation starts with exactly the same amount of water as presented in Eq. 4. This treatment obviates any need to behave in a growth compensating way, as any next generation (irrigator) will start with exactly the same as any other

$$R^{t+1} = R^t \tag{4}$$

[2] The fast growth treatment (FAST) has a natural growth rate of 1.1875. Taking the exploitation effort into account, the reserves R^t in FAST develop according to $R^{t+1} = \left(1 - \frac{1}{24}(x^t - 21)\right) R^t$ Growth compensation requires that total exploitation effort is $x=21$. This can be attained with symmetric effort choices of $xi^{GC}=7$:

[3] In the *slow growth* treatment (SLOW), the water has a growth rate of 1.25. Taking the exploitation effort into account, the reserves R^t in SLOW develop according to $R^{t+1} = \left(1 - \frac{1}{24}(x^t - 6)\right) R^t$ Growth compensation for SLOW is achieved with a total exploitation effort of $x=6$, which implies $xi^{GC}=2$ under the symmetric case.

Table 1: Equilibria (Social, Nash, and GC) at different growth rates.

Treatment	Symmetric Choice at:		
	Social optimum x_i^{SO}	Nash equilibrium x_i^{NASH}	Growth compensation x_i^{GC}
SLOW	3	6	2
RESTART	3	6	–

Table 1 shows the social optimum (x_i^{SO}) and Nash (x_i^{Nash}) equilibrium for the two growth rates. These are the same for each treatment, but the growth compensating choice (x_i^{GC}) varies depending on growth rate. Under SLOW, growth compensation requires a lower effort than either the Nash or social optimum, or ($x_i^{GC}<x_i^{SO}<x_i^{Nash}$).

Figure 2 shows relative payoffs to one player choosing either the social optimum or the Nash as other players' combined takes increase.

2.2. Hypotheses

Fischer et al. (2004) hypothesise that withdrawals in a single generation game will exceed those in an intergenerational game according to the "intergenerational altruism" hypothesis ($Take^{INTERGEN}<Take^{SINGLEGEN}$). Their second hypothesis is called the "sustainable development" hypothesis, predicting restraint in the current generation's extraction to provide the next generation with *at least the same* available level of consumption ($Take^{SD}\leq Take^{NASH}$). This does not preclude the next generation's receiving higher levels, so it is a weaker version of the intergenerational equity hypothesis.

This paper examines an additional hypothesis. Parciantes could be more likely to exploit at the social optimum, because they are sensitive to variability

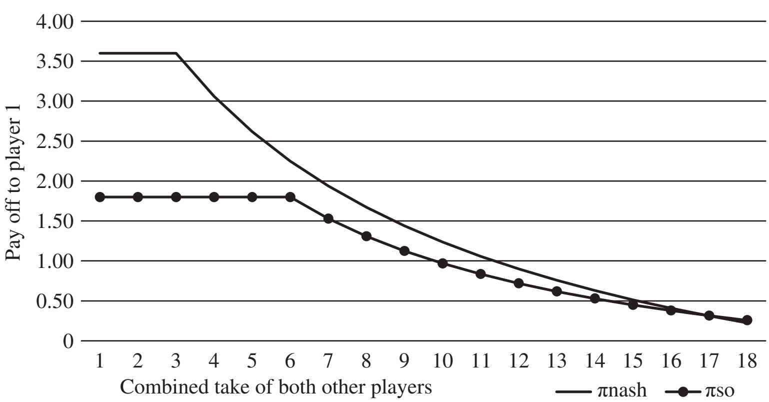

Figure 2: Payoffs as fraction of overall production from x_i^{Nash} or x_i^{SO}.

and water sharing, have a lower discount rate and a stricter norm profile than individuals not accustomed to CPR management (students). This can be written as ($Take^{\text{PARCIANTE}} < Take^{\text{STUDENT}}$).

Fehr and Fischbacher (2003, 185) define social norms as standards of behavior "based on widely shared beliefs how individual group members ought to behave in a given situation." Fehr and Fischbacher (2003, 2004) discuss two types of altruism: inequity aversion and reciprocal altruism. Under inequity aversion, players dislike payoff imbalances between players, and will typically make choices that result in a payoff distribution that does not overly favor any one player. Under reciprocal altruism, players will make costly decisions in order to ensure that others are treated fairly. Under inequity aversion, the threshold cost of punishment is typically much higher than in reciprocal altruism. Therefore sanctions are much more likely in a reciprocally altruistic society.

In each round of this game, the player could face a tradeoff between dollar payment and adherence to a socially determined norms code, which may be unobservable (Maas and Anderson 1978; Camerer and Fehr 2002). Adherence to this code could depend on a vector of observable variables, which could then depend on whether the participants were students or parciantes (Ellickson 2001). For parciantes, components of the norms code could include how involved they are with their acequia association, how organized their association is, how long their family has been farming in their region, and how socially embedded they are in their community (Riad et al. 1999). Bardhan (1993, 88) states "time discount rates of private users of resources may be higher (and therefore resource exploitation rates larger) than what is appropriate for the community as a whole." It is possible that individuals who conceptualize the game as outside their irrigation organisation's norm code might exploit the resource at a rate greater than they would if actually irrigating.

Based on the CPR (Yan-Tang 1991; Ostrom et al. 1994) and acequia (Rivera 1998; Peña 2003) literature it could be assumed that parciantes would tend to have a stricter norm code about water withdrawals than undergraduate students would. In turn, students (as private, non-organized individuals from a very large population – Albuquerque) might exploit the resource at a greater rate than would irrigators accustomed to a stricter and more norms-based withdrawal system. Table 2 shows the hypotheses from Fischer et al's work and the one proposed in this research.

Table 2: Hypotheses.

Hypothesis	Prediction
Parciante*	$Take^{\text{PARCIANTE}} < Take^{\text{STUDENT}}$
Intergenerational altruism	$Take^{\text{INTERGEN}} < Take^{\text{SINGLEGEN}}$
Intergenerational equity	$Take^{\text{FAST}} > Take^{\text{NASHFAST}}$
Sustainable Development	$Take^{\text{SD}} \leq Take^{\text{NASH}}$

Note: *Denotes a hypothesis in this work.

2.3. Experimental procedure

The pencil and paper experiment was conducted at meetings of the Río de las Gallinas Acequia Association in Las Vegas, New Mexico, at the San Cristóbal Acequia Commission in San Cristóbal, NM, and at the Economics Department of the University of New Mexico in Albuquerque, NM. Students were recruited via the Economics Department undergraduate online discussion list and from fliers put up around the campus of UNM in Albuquerque. Parciantes were recruited at a series of meetings of the Rio de las Gallinas Acequia Association in Las Vegas, NM, at the annual *congreso* of the New Mexico Acequia Association in Alcalde, NM, and at a meeting of the New Mexico Acequia Commission in Santa Fe, NM.

Some experimental work (Janssen et al. 2011) characterizes the experiment differently in the lab and the field. This experiment used the same narration for both lab and field groups. Participants were given a simple narrative version of the game: three irrigators share an acequia, and withdraw from the acequia over several generations. In each generation, the combined withdrawal affects how much water remains for the next generation and the current generation's payoff. Each participant represents one irrigator. Fischer et al. do not describe the resource in specific terms. To make sense of the game to participants, I described the resource as water in an acequia. The exploitation effort units seemed abstract to the focus group members; since irrigation schedules in northern NM are typically arranged by hours. The exploitation effort was described as hours irrigating.

Participants were asked to complete three tasks:

- to make a prediction about the combined withdrawal of all the other members of their group, and to make a decision about their own withdrawal, and
- to indicate both on a decision sheet, and
- to guess the combined sum of the other two participants in each round.

The prediction is used to ascertain participants' expectations about the altruism of other group members, and to gauge the participant's own strategy. The task of guessing others' withdrawal was made more salient by an additional payoff that linearly diminished with distance of their guess from the actual sum. Participants received a payment of 16 "points" if they guessed correctly, and lost one point for each hour they were wrong. After completing the experiments, one participant was selected to pick a card from a limited deck. That pick determined the round for which they were paid. Earnings were calculated at US$0.10 or $0.15 per point, depending on the total points outcome.

Players marked their choices on a paper decision sheet, found in Appendix A. at the end of each round they gave me their sheets, I and an assistant entered the data into a programmed excel spreadsheet which calculated payoff in each round and the stock of water for the next round. Irrigation choices were limited to the integers {1,…,8} in all the treatments. The decision sheets present matrices with

8 rows (player's choices) and 15 columns (sum of combined irrigation decisions of two other players). Each cell in the matrix or table contains two entries. The upper cell represents the return *r* of the player given that the other two players select the number in the top of the corresponding column. The bottom entry represents the effect of the player's decision on the reserves R^{t+1} for the next round, which in the original paper accrued to the next generation. In this version, players were told it could accrue to them *or* it could accrue to another player. I devised a simple method to move that quantity downstream; with nine players, player 1's would go to player 9, player 2's to player 8, player 3's to player 7, player 4's to player 6, and so on. This was modified for any number of players in the Excel spreadsheet.

Participants answered questions about topics including demographics and water use in order to approximate norms. Table 3 presents descriptive statistics for both participant groups. The student group was 33% Hispanic, 53% Anglo, while the parciante group was 60% Hispanic and 40% Anglo. The group from Las Vegas was approximately representative of the county. The US Census (2000) does not provide data for acequia irrigators per se, and the Gallinas Acequia Association does not provide race data on members, so it is difficult to determine whether this sample is representative of irrigators on the Gallinas. It was not selected to be so; rather it is a convenience sample.

Table 4 shows results from the norms questions. There were few significant differences between groups. Parciantes self-identified as being more politically conservative and better informed about current events, but there was no significant difference in the average degree of social embeddedness (Riad et al. 1999). Both groups report that their families, on average, have been living in New Mexico for one hundred years.

Table 3: Selected descriptive statistics for parciantes and students.

		Parciantes			Students		
Variable	Description	N=	Mean	SD	N=	Mean	SD
AGE	Participant's age in years	18	53.28	16.25	35	25.63	8.45
ED	Highest completed level of education by category. 1=Elementary School, 2= Jr. High, 3= High School, 4=College, 5=Grad/ Professional	18	4.00	0.91	36	3.50	0.65
LIBCON	How the respondents identified themselves politically. 1= "very liberal", 5= "very conservative".	17	3.65	1.00	33	2.70	1.13
COUNTY	How many years the respondent's family has been living in their county.	18	106.11	121.17	25	111.60	386.01
IRRIGATE	How many years the individual or their family has been irrigating on the same ditch.	17	83.59	81.96			

Table 4: Responses to water questions.

Variable	Definition	Parciantes			Students		
		N	Mean	SD	N	Mean	SD
	How much the participant agrees with the following statements. 1= "strongly disagree" 5= "strongly agree"						
WATERIMPORTANT	"Water issues are important in NM."	18	5.00	0.00	36	4.81	0.47
FARMVBUSINESS	"We shouldn't put farmers out of business just so cities can grow."	18	4.78	0.94	36	4.11	0.98
FARMERWASTE	"Farmers waste a lot of water irrigating their fields"	18	2.50	1.54	36	2.78	1.02
PAYMORE	"Managing our water so there will be enough for all important uses will require all of us to use less and pay more."	18	3.28	1.32	36	3.56	1.11
NEWCONS	"Approval of any new construction should require demonstrating that a long-term water supply is available."	18	4.83	0.38	36	4.19	0.79
METERED	"All water use should be metered to ensure that people are paying for the amount of water they use."	18	3.72	1.32	36	3.92	1.11

3. Results

3.1. Withdrawals

Table 5 provides descriptive statistics on mean withdrawals for the sample. There is no significant difference between exploitation choices in the SLOW and RESTART treatments within categories (student or parciante, Wilcoxon Signed-Rank test at 0.01 and 0.10 level, two-tailed). Between-category withdrawals are not significantly different (student/parciante) in either SLOW or RESTART (Wilcoxon Signed-Rank and Kolmogorov-Smirnov tests). As shown in Table 6, there is no significant difference between overall means of parciante or student withdrawal.

3.2. Predictions

There was no significant difference between guesses in the RESTART or the SLOW treatment (Wilcoxon Rank-Sum at the 0.10 level, two-tailed). Even within

Table 5: Mean withdrawals per treatment.

	Treatment and subject pool			
	ParcianteSLOW	StudentSLOW	ParcianteRESTART	StudentRESTART
Mean	5.30	5.16	5.11	5.19
SD	2.03	1.90	1.70	1.66

categories, such as within-parciante, there was no statistical difference between guesses in either treatment. There was also no significant difference between the groups in terms of accuracy of prediction. A Kolmogorov-Smirnov test of the differences showed no significant difference between groups. Table 6 shows means for predictions by treatment and subject pool.

The predictions represent what each player assumes both other players will jointly withdraw, so for a symmetrical player, assume half of that value. The means are around 9, so players assume that each other player withdraws between 4 and 5. This is fairly close to the actual mean rates of withdrawal, though somewhat low. Results do not support the parciante hypothesis, that suggests *takeparciante<takestudent*. Growth rate variation has no effect on either choice or prediction of others' choices.

4. Discussion

The case could be made that certain water uses should be prioritized for consideration of public welfare benefits that those uses generate. For acequias, one suggestion is that parciantes maintain a culture of water sharing that has value in itself and might provide value in other contexts. In order to examine whether parciantes are, in fact, better at sharing water, any reasonable agency will require empirical proof, which can be difficult to obtain in the field. Experiments are one way to examine this assertion.

As Cardenas et al. (2013) point out, games in which payoff and next-round availability varies with all participants' choices and which fit the local nature of the resource will tend to be more externally valid. This game provides an alternative growth rate to the basic restart, the stock available in the next round is dependent on play in the current round, and the context is reasonably similar to the irrigating participants' daily lives. This research was designed to explore the hypothesis that parciantes would show more restraint than students in a repeated-play CPR game. They did not: at the means, parciantes showed the same withdrawal rates as students in two treatments. They also showed the same mean predictions of others' decisions. This suggests that the assumption about parciantes' comparative restraint is inaccurate, and that in terms of norms about withdrawals and their effects on other players, both groups are drawn from the same distribution. One conclusion is that parciantes are no better at restraint than urban residents. That might be so, but the game context is important to consider; real irrigation decisions are not made in a sterile context. Anderies et al (2013) discuss 'micro-situational' variations in game design such as communication and access asymmetry between players that

Table 6: Mean prediction by treatment.

	Treatment and Subject Pool			
	ParcianteSLOW	StudentSLOW	ParcianteRESTART	StudentRESTART
Mean	9.70	9.16	9.78	9.80
SD	3.58	2.06	3.99	2.89

can dramatically change the outcome of experiments. Different acequias have differing degrees of communication, and access asymmetries. They also have varying degrees of norms intensities. In any common pool situation, due to high costs of exclusion and the rivalry over the good, norms enforcement can be crucial.

In this game there was no pre-play communication, no access asymmetry per se, and no available sanctions. While this might suit urban users, it is unusual for irrigators. Ghate et al. (2011) found including communication in games with traditional resource users produced different results from no communication scenarios, reducing inequity in payoffs between users.

Ostrom (1990, 35–6) suggests that, "actions that are strongly proscribed among a set of individuals will occur less frequently (even though they promise to yield high net payoffs to individuals) than will those same actions in a community that does not censure such actions." So, even if a group believes that some norms should obtain, it seems that the enforcement of those norms is what matters, not just their existence. That enforcement is often in the hands of a ditch boss, often known in New Mexico as a mayordomo.

Mayordomos set the time for the límpia, or ditch cleaning, at which parciantes discuss the upcoming year and get to know each other again. Feuds break out or are left to simmer. At each step, the mayordomo tells the irrigators what to do, and defection can result in shunning or monetary punishment. Interviews conducted by Raheem (2014) with parciantes on the Gallinas River (where most of the participants for this game irrigate) reveal the importance of the mayordomo in the success or failure of any particular ditch (Crawford 1993; Rivera 1998, 2006; Rodriguez 2006). A strong mayordomo enforces ditch rules in accordance with group temperament; keeps abreast of changes in law, passing that information on to parciantes in a sufficiently nonconfrontational and comprehensible format; draws up a clear irrigation schedule, but remains flexible about its administration; is responsive to parciantes' complaints, but not to the point where he would be perceived as weak; is activist in support of pro-acequia legislation, but not to the detriment of either the community or his skill as a farmer or mayordomo. The mayordomo form of management differs from some of what Palerm-Viequeira (2009) describes as obtaining in Mexico, since the acequias in New Mexico were not historically run by the state, and power did not legally devolve to the local irrigators. Rather, they have always managed their ditches in this decentralized way, without recourse to professional bureaucratic support.

All of this suggests that perhaps it is not the individual parciantes who should be compared to other users; rather institutional contexts between acequias should be compared. Extensions to make the experiment more realistic, and perhaps more useful to decision makers, include expanding the sample size, adding institutional modifications such as sanctions or some sort of mayordomo figure, and including ecological feedback, integrating a multidisciplinary model similar to that described in Fernald et al. (2012) as uncertainty in the resource regime affects withdrawal and investment decisions (Anderies et al. 2013). Additionally, access asymmetry similar to Janssen et al. (2012) would make the context richer. In those experiments, participants are given specific roles from most upstream, (position A) to furthest downstream (position E). That treatment more closely models how these systems actually function.

Small-scale irrigation systems globally and in New Mexico face uncertainty from climate change (Gutzler 2012) and resultant variation in available water supplies and crop yields. While in the US we are accustomed to thinking of farming as a large scale industry, as McIntyre et al. (2009) point out, small-scale farms (<2 ha) comprise roughly 90% of the world's farms. Understanding how these systems work or do not work is crucial to facilitating food provision globally. For these systems to persist in their current institutional form, cooperation between irrigators, between ditches, and between ditches and other organizations is essential. Janssen et al. (2012) point out that a "necessary condition of irrigation systems to self-organize is the development of norms to allocate fair shares of the water in order to recruit sufficient labor to construct and maintain the physical infrastructure (65)." Fehr and Fischbacher (2003) suggest that even in a majority-altruist society, a small core of selfish individuals can skew decisions toward a non-cooperative equilibrium. As it may be difficult to identify these individuals, limiting access based on some relative scale of altruism would be impossible. During the interviews, William Gonzales, a parciante on the lower Gallinas, argued that a decrease in communication can give these individualists more power. Since disruption of communication and therefore cooperation becomes easier when members of any community see each other less often, the gradual loss of agricultural traditions could precipitate such a non-cooperative outcome. This would be sad indeed.

Appendix A: Decision sheet

Id#____________

Round#___________

DECISION SHEET

Total hours you think the other two irrigators on your acequia will irrigate

⇨

Hours you will irrigate ⇩		2 [ ]	3 [ ]	4 [ ]	5 [ ]	6 [ ]	7 [ ]	8 [ ]	9 [ ]	10 [ ]	11 [ ]	12 [ ]	13 [ ]	14 [ ]	15 [ ]	16 [ ]
1	[ ]	60	60	60	60	60	60	60	51	44	38	32	28	24	21	18
		+13	+8	+4	+0	-4	-8	-13	-17	-21	-25	-29	-33	-38	-42	-46
2	[ ]	120	120	120	120	120	120	102	87	75	65	56	48	41	35	30
		+8	+4	+0	-4	-8	-13	-17	-21	-25	-29	-33	-38	-42	-46	-50
3	[ ]	180	180	180	180	180	153	131	113	97	84	72	62	53	45	38
		+4	+0	-4	-8	-13	-17	-21	-25	-29	-33	-38	-42	-46	-50	-54
4	[ ]	240	240	240	240	204	175	150	129	111	96	83	71	60	51	42
		+0	-4	-8	-13	-17	-21	-25	-29	-33	-38	-42	-46	-50	-54	-58
5	[ ]	300	300	300	255	218	188	162	139	120	103	88	75	64	53	43
		-4	-8	-13	-17	-21	-25	-29	-33	-38	-42	-46	-50	-54	-58	-63
6	[ ]	360	360	306	262	225	194	167	144	124	106	90	76	63	51	41
		-8	-13	-17	-21	-25	-29	-33	-38	-42	-46	-50	-54	-58	-63	-67
7	[x]	420	357	305	263	226	195	168	145	123	105	88	74	60	48	37
		-13	-17	-21	-25	-29	-33	-38	-42	-46	-50	-54	-58	-63	-67	-71
8	[ ]	408	349	300	258	223	192	165	141	120	101	84	68.6	54.5	41.7	30
		-17	-21	-25	-29	-33	-38	-42	-46	-50	-54	-58	-63	-67	-71	-75

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