Experimental Investigation of Voting over Common Pool Resources

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Abstract. Common pool resource systems are governed by a wide variety of institutions designed to promote long run resource viability. Relatively little work has focused on the use of majority rule voting in managing resource stocks. This paper develops a theoretical and experimental framework for assessing the efficiency of majority rule voting in allocating appropriation rights to a group of resource users. By varying the distribution of individual capacities to appropriate, but keeping the aggregate level constant, we find that systems dominated by large scale appropriators collectively extract more of the resource than systems dominated by small scale appropriators, whether or not voting is used. When voting is used, the resulting policies are more extractive under systems dominated by large scale appropriators.

Keywords: Common pool resources, experimental economics, majority rule voting

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Common pool resource systems are governed through a variety of institutional frameworks. In the United States and the European Union, for example, policies affecting common pool resources are often made in federal or state legislatures, regional councils, resource user associations, homeowner's associations, and many other organizational structures. In many of these situations, some form of simple majority or super majority rule voting is used to assign individuals appropriation rights over the resource. Despite its increasingly common usage, however, majority rule voting is perhaps one of the least studied and understood mechanisms for assigning resource extraction or appropriation rights. How efficient is majority rule voting at assigning appropriation rights? How does the distribution of individual capacities to appropriate affect vote outcomes? This paper develops an experimental framework in which we study the benefits and limitations of majority rule voting over a shared resource. In particular, we develop an appropriation game with an explicit risk function to participants that models the potential for resource exhaustion and allows us to test the efficiency of majority rule voting over a non-cooperative appropriation game in different situations of homogenous and heterogeneous user capacity.

It is our contention that characteristics of common pool resources make them an ideal setting for empirically testing the implications of formal models of majority rule voting. CPRs are shared resources that must be divided among a group of resource users and thus each time a decision on use rights is made, there is political bargaining taking place. Second, these are often low-dimension policy problems. An individual has preferences over how much he individually wants to appropriate and over how much he wants everyone else to appropriate. In the latter situation, this could equally be framed as the individual has a preference over the aggregate risk of overharvesting the system, since the collective appropriation determines the implicit risk factor. Thus, many CPR settings can easily be identified as a simple two dimensional vote problem. Third, the resource being divided and the policy outcome are often formulated in discrete, numeric terms. For example, a policy might be over the number or weight of fish an individual can catch; or, over the cubic meters of water an individual can use to irrigate; or, over the acres of grass a herder can use to graze. Since many implications of formal theories of majority rule voting are about the range of enactable policies in low-dimensional policy spaces (i.e. Bianco and Sened 2005), CPRs are an excellent area to find real-world data that could be used to test the limitations of our formal theories.

As resource systems across the world are facing continued strain of overharvest, it is increasingly important that we understand the mechanics of the majority rule voting institutions that govern a wide array of resource settings. Beyond just voting, however, this study looks at the underlying distribution of preferences or capacities of resource users to understand how these affect aggregate appropriation behavior. We begin to examine this issue by first providing an overview of the literature on CPR governance and highlight the lack of research into voting as a means of decision-making. Next we develop a theoretical model of the preferences, vote decisions, and outcomes of a group of resource users. Using this model as a guide, we then discuss the experimental environment we developed to test the predictions in a controlled environment. Finally, we discuss the results of these experiments and the implications for future research.

Background

Common pool resources (hereafter CPRs) are a particular class of goods that are both subtractable and only excludable at high cost (Ostrom 1999). Unlike public goods, in which the use of the good by one does not prevent another from its use, in a CPR the appropriation by one necessarily limits the appropriation by others. Since many CPRs are seasonal (i.e. irrigation water) or are renewable resources from one year to another (i.e. fisheries and forests), the shared nature of the resource setting also means that individual appropriation decisions in a given time period, aggregated across the entire system, produce a particular risk of overharvest or resource collapse. This observation, discussed as early as Gorden (1954), led subsequent scholars to hypothesize about the consequences of individual appropriation over a shared resource.

In his influential article on the “Tragedy of the Commons”, Hardin (1968) argued that rationally self-interested individuals appropriating from a shared common pool resource will exploit the resource to exhaustion. Since the marginal cost to each individual’s appropriation decision is shared among all resource users, but the marginal benefit of appropriation accrues solely to the individual, CPR users will always see a net benefit to appropriating one additional unit of resource. As this game is played out across the entire CPR system, Hardin argued, it will naturally lead to overharvest and eventual resource collapse, unless either an external, disinterested entity could intervene and limit individual appropriations, or unless the resource could be privatized. Hardin’s theory continued to dominate the thinking on common pool resources for decades until scholars recognized a diversity of resource systems that have managed to persist for long periods of time (Ostrom 1990).

Scholars have studied a variety of institutional frameworks to better understand successful CPR management settings. For example, scholars have examined the role of national government intervention (e.g. Terborgh 1999), privatization of the commons (e.g. Tietenberg 2002), religious figures (e.g. Lansing 1991), and specialized courts or consensual arrangements among resource users (Ostrom 1990) in maintaining long-run resource viability. Through these studies, scholars have found that resource users are not necessarily doomed to a "Tragedy of the Commons", but are, at least sometimes, capable of crafting successful management schemes. Once a management scheme has emerged, scholars have found that external, non-ecological, factors like interpersonal relationships, communication, social sanctioning, or embedded cultural knowledge can all have positive effects on the ability of individuals to maintain a consensually agreed upon management scheme. Especially in small communities, the threat of social ostracizing is often sufficient to induce cooperation (Agrawal and Gibson 1999).

Little work has focused, however, on the underlying individual preferences of resource users and how these preferences influence consensual agreements before they are crafted. Scholars have found a variety of mechanisms for sustaining cooperation once a system is in place and scholars have posited a variety of design principles for successful institutions (Ostrom 1990), but few have attempted to understand how underlying preferences for resource use influence arrangements before they are finalized. For example, before a group of fishermen agree on limiting catches to a certain amount per boat, does the size of the boats the fishermen use influence the limit that is set? Or, are the catch limits independent of the fishermen's capacity to catch the fish—are they based on the ecology of the system? This is a fundamental distinction between systems of governance in which policy is based on the underlying ecology of the system and systems of governance in which policy is based on the underlying capacities of the resource users. It is our contention that the latter case is more often what happens, particularly in the developed world, and that we should therefore be interested in understanding how capacities affect policy outcomes.

Laboratory experiments have long been a primary means to study different governance regimes in CPR settings. Ostrom, Gardner, and Walker (1994) developed a simple model of a generic CPR in which members of a group choose to invest tokens in one of two markets. The first, a private sector, provided a constant return, while the second market returned a nonlinear profit that was decreasing in aggregate group investment. By extending this design to situations of cheap talk, face-to-face communication and sanctioning, scholars have shown the importance of contextual variables to the long run viability of resource management institutions. In an earlier experimental work, Ostrom, Walker and Gardner (1992) had already argued that self-organization of resource users to overcome collective action dilemmas was possible given their self-interest in the resource setting. The results of these early appropriation games showed that the Tragedy of the Commons is not inevitable, but that some institutions perform better than others.

Many such studies into CPR success and failures focus on case studies from the developing world or modeling local, village-based resource management schemes. In much of the developed world, however, CPRs are managed on a much larger scale and through large bureaucracies, legislatures, commissions, or resource user associations that are more complex than small scale resource system. For example, while a village of fishermen along the Colombian coast may have successful management institutions that rely on agreement among all the resource users or at least a large consensus of resource users, solely relying on interpersonal relationships to determine appropriation policy over the European Common Fisheries policy, for example, is unrealistic. Instead, many settings in the developed world rely on majority rule voting to determine CPR management policies.

Examples of majority rule voting over CPR systems are plentiful. The Maine lobster fishing industry, for example, uses state sanctioned exclusive management zones that are overseen by elected boards of lobster fishing representatives. These boards set catch limits and technological requirements (net size, etc.) for the zones through majority rule voting at council meetings (Acheson 2003). Until recent reforms with the Common Fisheries Policy, the European Council of Ministers also used majority rule voting to determine the Total Allowable Catches of member states over specific species in defined fishing zones. In the United States, ocean fishery policy, particularly the catch limits and sizes, are decided by the eight Ocean Fishery Commissions, 17-member boards of industry, recreation and government representatives, that use majority rule voting[2]. In ground water management, many states or regional governments have set up water management boards, like the West Basin Municipal Water District in which the commission uses standard majority rule voting procedures to implement regional water policy (Blomquist 1992). Despite the variety of such situations, majority rule voting as a management institution remains woefully understudied in the broader literature on CPRs.

Two recent experimental studies, however, have examined the role of majority rule voting in a CPR setting. Walker, Gardner, Herr and Ostrom (2000) develop a voting game in which groups of 7 individuals vote over precise appropriations for each of the seven members. Subjects share an identical cost and benefit function. In their game, subjects receive a fixed profit for each token appropriated, but then are charged a nonlinear cost that declines with aggregate group withdrawal. Similar to the current study, subjects first play a ten-period non-cooperative game and then play a ten-period voting game. Each subject makes a proposal for the precise appropriation each member of the seven person group will receive and then subjects vote over the proposals. They find that the introduction of voting over a non-cooperative game increases group efficiency, but that in many cases subjects resort to a strategy of minimum winning

[2] The Ocean Fisheries Commission's decisions are actually just recommendations that must be approved by the Secretary of Commerce. However, the Secretary's approval is considered a formality for the most part, and thus policy is de facto determined through majority rule voting by these Commissions.

coalitions. In these instances groups of 4 subjects vote to appropriate large amounts of tokens among themselves, but shut out the other 3 members from appropriating anything.

Margreiter, Sutter and Dittrich (2005) expand on the original Walker et al (2000) design by incorporating heterogeneous costs into the profit function. These authors point out that most users of a CPR are not all equal in capacity; some have larger boats or some may have better appropriation technology. They find that homogenous and heterogeneous groups show no difference in aggregate appropriation when playing the uncoordinated game, but that homogenous groups more easily reach a majority rule decision over appropriation when voting is allowed. In the latter case, proposals that successfully are implemented using majority rule are closer to social optimum than when no decision is reached or when the uncoordinated game is played.

Serious questions remain about the applicability of the Walker et al (2000) and Margreiter (2005) designs to real-world situations of CPR voting. While it may be the case that in small scale CPR settings individuals vote over individual appropriation rights, it's not so clear that this is how many of the institutions in developed countries operate. For example, fisheries are usually regulated through the use of Total Allowable Catch (TAC) that either specify some aggregate fishery-wide seasonal quota or that sub-divided an aggregate quota into individual rights to catch a pre-determined amount of fish. Furthermore, we know that in many real-world settings the option to 'shut-out' some resource users is infeasible or illegal. For example, Acheson (2003) discusses how in Maine regional lobster fishery councils use majority rule voting to set boat catch limits, but these boards must allow all pre-existing fishing boats to continue using the resource. The experiments discussed in this paper more closely model the

TAC process by excluding the possibility of shutting out some users with a dominate Minimum Winning Coalition.

Beyond just fisheries, however, there are other reasons to believe a new model of CPR appropriation is necessary to understand real-world processes. For example, several scholars have pointed out that national budgets are similar in kind to common pool resources and have used the CPR model to understand bargaining over budget appropriations (e.g. Shepsle and Weingast 1985). In the Congressional legislative process that leads to omnibus appropriations, individual legislators each fight for particularized district benefits ('pork'). Because it is not the case that Minimum Winning Coalitions, in this instance the majority party, shut out benefits to minority party members, we have reason to suspect the applicability of Walker et al's original model design. In the current paper, our addition of a probabilistic destruction of the resource mimics the potential for default or over-spending on the part of the legislature and the inclusion of all group members in appropriation, even after a vote, more closely mirrors real budgetary processes.

The study of common pool resources has come a long way over the past two decades toward identifying key variables that make long run resource sustainability more likely. However, most of this research has looked at small scale resource systems or assumed that policy can be decided with ecological considerations in mind. In the next section, we develop an updated model of the CPR setting in which a rational agent can favor limiting aggregate appropriation even if this comes at a personal cost to himself. We then discuss how this insight can be used to develop a new voting game over CPR appropriation in which the distribution of capacities over appropriation may influence policy outcomes.

Theory

We begin with the assumption that preferences over common pool resources are naturally multi-dimensional, but that a two-dimensional model captures a significant portion of the variance. Often scholars assume that individuals have preferences over only their own personal appropriation. For example, Hardin (1968) assumed that individuals cared only about personal benefits without considering costs because these were too diffuse throughout the system to be individually tangible. Because of this assumption, his model necessarily predicts resource system collapse. However, if we allow individuals to have a preference over both her personal appropriation and over the aggregate appropriation of the entire resource system, then Hardin's model begins to falter. Similarly, we can build a model that better explains the results of Ostrom (1990), among others, that institutional frameworks can sustain resource systems over multiple generations. In particular, if there is not a second dimension of preferences, it is unlikely that institutional emergence will occur since there are no individual incentives to work with others in the system.

A rational agent should be concerned about the consequences of over-appropriation. If a system is over-appropriated, there could be resource collapse at the extreme or at the least a lower available resource stock to appropriate. It seems reasonable to assume, given this situation, that a rational agent assigns an array of probabilities of resource collapse that correspond to different system-wide levels of appropriation. A rational individual would then utilize this personal array to determine a profit maximizing collective appropriation level that balances his own personal risk attitude. The more risk-taking an individual, the more likely that individual will prefer larger collective appropriation levels, especially if the collective appropriation is divided up among the different resource users. On one level, then, his preference over his personal appropriation level is a function of risk attitude as well. What is clear, however, is that using this simple model of a rational agent, we can identify two dimensions of preference: personal and collective appropriation. The latter is a simple transformation of his risk attitude and the former is a combination of risk attitude and capacity.

Underlying the individual preferences for a CPR is the individual capacity one has to appropriate from the resource. For example, in a fishery, boats have different hold sizes and in irrigation farmers have different acreages. Should we expect someone with a large-hold fishing boat to favor the same levels of appropriation as one with a small-hold fishing boat? Indeed, if we assume that individuals want to individually appropriate as much of a CPR as is technically feasible for himself, then we can identify his personal capacity, or capacity, as a suitable substitute for the first dimension of preferences over the resource use.

Thus far we have discussed a rational agent's preference for collective withdrawal as being a substitute for his risk-preference. But are all collective withdrawals the same? If 3 appropriators in a given resource setting are capable of collectively appropriating 10 fish, does it matter how the individual capacities of the resource users are distributed? Ehrhart, Gardner, von Hagen and Keser (2007) asked a similar question about budget processes. In their experiment, the authors investigate whether it makes a difference if a budget process is top-down or bottom-up—i.e. if the aggregate budget amount is determined and then divided among the group, or if the aggregate budget amount is determined by individual funding requests from within the group. They find that top-down processes lead to overall smaller budgets. One area they stop short of investigating, however, is differences in final policy outcome resulting from different distribution of subject ideal points.

Distribution of preferences matters in a voting situation. In formal theories of the voting process, outcomes are predicted through Euclidian distances between policy proposals and individual preferences. As the distribution of preferences becomes skewed, outcomes vary. In a uni-dimensional model, the distribution of preferences determines the median voter. In a multi-dimensional space, it determines the Core (e.g. Fiorina and Plott 1978) or the Uncovered Set (Miller 1981). Understanding how these distributions lead to different policy outcomes in a CPR setting allows us to better craft institutions to reduce the upward pressure on policy when the dominant coalition of resource users want large appropriation.

In our experiments, we model a resource system in which five users have an aggregate capacity to appropriate 200 resource units. In the first treatment, Homogenous Distribution, each of the five users has an individual capacity to harvest 40 units. In the other two treatments, however, we vary the individual capacities. In the 'Small Boats Dominant' treatment, three users can appropriate 34 units each and two users can appropriate 49 units each. Finally in the third, 'Large Boats Dominant' treatment two users can appropriate 34 units each and three users can appropriate 44 units each. We assign a known risk factor to over-appropriating in which each unit harvested above 125 collective units. In particular, each unit appropriated above 125 leads to a 1% chance of complete over-exhaustion. Thus, if the users collectively withdraw 150 units there is a 25% chance of over-exhaustion and collapse, and so on. If the resource is over-appropriated, subjects in the group all earn $0 for the round. If the resource is not over-appropriated, however, subjects earn $0.05 per unit individually appropriated and are charged a $0.02 opportunity cost for each unit not appropriated short of their capacity. Subjects play a 10-round game with no coordination and then play a second 10-round game in which they are able to vote over a maximum cap of individual appropriation.

In particular, subjects are asked to each make a proposal over a Maximum Individual Withdrawal that limits the appropriation of all group members. If they successfully vote for one of the proposals, it is costlessly and perfectly implemented so that each subject appropriates either his personal Capacity or the group's Maximum Individual Withdrawal, whichever is less. In this sense they are voting for an individual Total Allowable Catch. If the TAC is above the individual Capacity, it doesn't matter to the individual because he still can only catch what he is feasibly able to keep. If the TAC is below the capacity, however, he may only appropriate up to that level. A more detailed explanation of how the sessions operated is discussed in the next section.

In this simple design, there are significant differences in the Nash Equilibrium and Social Optimum strategies between the voting and non-voting stages, but are not significant differences across treatments. Most of the variation between the voting and non-voting stages comes from the imposition of a symmetric policy proposal—if a proposal receives a majority of support it is implemented equally on all group members. When subjects are not allowed to vote over appropriation levels, the social optimum occurs when each of the five subjects appropriates 28 units, but the Nash Equilibrium is an appropriation in which two subjects appropriate 40 units and the other three subjects each appropriate 39 units. In all three treatments with voting, however, the Social Optimum and Nash Equilibrium both coincide to a proposal of appropriating either 27 or 28 units per individual.

If it is the case that collective withdrawal levels are different across treatments, then we would suspect that subjects are not just playing a Nash or Social Optimum strategy. Instead, there would be some evidence that the fundamental underlying distribution of capacities leads to different levels of collective withdrawal, which might indicate different tolerances for risk in different distributions. One possible strategy that subjects might play in the voting stage is a simple uni-dimensional median voter strategy. In other words, if the resource setting is fundamentally a one-dimensional choice space, we should expect that the median voter's capacity will be implemented. In this case, we would expect successful proposals of 34, 40, and 44 in the Small Boats Dominant, Homogenous Distribution, and Large Boats Dominant treatments, respectively.

We hypothesize that during the voting stage the 'Large Boat Dominant' treatment will, all else equal, have higher collective withdrawals than the Homogenous Distribution and Small Boats Dominant treatments. This is because there is greater upward pressure to withdraw larger individual quantities when the dominant coalition consists of large capacities. These three individuals can successfully pass a policy proposal that favors them at the expense of the smaller capacity appropriators. What is not so clear, however, is whether we should expect differences in collective withdrawals during the non-voting stage. Even though the same dominant coalition exists, there is no mechanism for coordination in the non-voting stage of the experiment, so individuals make a personal withdrawal decision based solely on individual preferences for earnings and risk. It is not clear why, on the whole, we would expect a difference among the treatments in the uncoordinated setting, since the aggregate capacities are the same.

In the next section we describe in detail the procedures used to run the experiments and discuss the rationale for why we chose some of the characteristics. Since we are particularly interested in the collective withdrawal levels as a proxy for sustainable, long run policy outcomes, we pay particular attention to what collective withdrawals groups make.

Procedures

Experiments took place during February and March 2009 at the Interdisciplinary Experimental Laboratory at Indiana University-Bloomington. Subjects were undergraduate students at Indiana University, recruited using a pre-existing database of undergraduate students that had voluntarily signed up to receive notification of experimental opportunities. The treatments were programmed by the author using Z-Tree software, a freeware program designed to allow easy programming for a variety of experimental economics designs (Fischbacher 2006).

As subjects arrived at the lab, they were asked to read an informed consent statement that explained they would be participating in a group decision-making experiment. Subjects were also informed at this point that they would receive a $10 show-up fee, to be paid with earnings at the end of the experiment. Experimental sessions were conducted with either 2 or 3 five-person groups at a time, so that individuals could not be certain which other subjects were in their group. Once 10 or 15 subjects had arrived, they were escorted into the computer room and sat at individual computer terminals separated by dividers.

Instructions were read aloud and subjects were also asked to read along on their computer screen (a copy of the instructions is available in the appendix). Subjects were told that they would first play a game for 10 rounds and then would play a separate game for another 10 rounds. Instructions were then read for the non-voting stage. After the first stage was finished, new instructions were read for the voting stage. By allowing subjects to participate in a non-cooperative appropriation game first, this allowed them to become somewhat familiar with the characteristics of the choice space and thus allowed for more informed voting later on. In addition, the inclusion of the baseline stage allows us to see if differences across treatments are solely attributable to differences in voting, or whether there are simply fundamental differences in the treatments themselves.

Subjects were told that they would be making a decision over how many tokens to withdraw from a shared pool of tokens in each round. It was made clear that each round was an independent event, that the pool of available tokens reset each round, and that therefore there was no carry over from round to round. We then explained in detail how subjects would be making money.

In each round, subjects could collectively withdraw up to 125 tokens without any risk of over-drawing the resource. However, for each token collectively withdrawn above 125 tokens there was a 1% chance that the resource would be over-drawn and all subjects in the group would earn $0 for the round if this happened. In order to determine if an over-draw occurs, subjects were informed that each round the computer would create a 'Chance of Over-Draw' equal to the collective withdrawal minus 125 and then draw a random number from 0 to 100. If the random number was less than or equal to the 'Chance of Over-Draw', subjects will have over-drawn the pool of tokens and earn $0 for the round. Subjects were able to see the collective group withdrawal, corresponding Chance of Over-Draw and the randomly generated number each period to ensure them that the experimenter had no control over the outcome. In addition, subjects were given a copy of a table that listed each possible collective withdrawal level and the correspond Chance of Over-Draw, to ensure that everyone could easily calculate the risk of over-draw.

We are particularly interested in how the distribution of preferences over a CPR affects vote outcomes. Since we cannot adequately assign preferences per se, we instead gave each subject a 'capacity' that represented their maximum individual token withdrawal. In the first treatment, Homogenous Distribution, subjects are homogenous in capacity. Subjects in this treatment were each assigned an individual capacity of 40 tokens. In the second treatment, Small Boats Dominant, three members of the group had an individual capacity of 34 and two members of the group had an individual capacity of 49. Finally, in the third treatment, Large Boats Dominant, three members of the group had an individual capacity of 44 and two members of the group had an individual capacity of 34.

As discussed in the previous section, we view preferences as a two-dimensional choice space in which an individual has a preference over his individual withdrawal and a preference over the aggregate withdrawal of all CPR users. To operationalize this view in the context of a CPR setting, we assign each individual a Capacity that represents the maximum number of tokens an individual may withdraw in a given round. In addition, to represent the opportunity cost of not utilizing full capacity, subjects incurred a cost of $0.02 per token not taken up to the capacity. Not only did this cost work as an opportunity cost, however, but it also was a method by which to ensure that the capacity was a tangible 'ideal withdrawal' point for subjects. In this sense we hoped to bring our experiments into line with spatial experiments of majority rule voting in which subject payments are dependent on the distance from their ideal point to outcome (e.g. Baron and Ferejohn 1989). In each treatment, subjects were informed of the distribution of capacities in their group, but were not informed which particular individual had which capacity.

At the beginning of each round in the baseline game, subjects were asked to withdraw tokens simultaneously, but without interaction from one another. Each subject would enter an amount up to their personal capacity level and then they saw a screen that listed their individual withdrawal decision, the collective group withdrawal level and then their profit for the round and their profit for the experiment to that point.

After the first 10-rounds were completed, subjects were read a second set of instructions that described the voting stage of the experiment. They were informed that for the last 10 rounds of the experiment they had the opportunity to enact a 'Maximum Individual Withdrawal' that would be perfectly and costlessly implemented on the entire group. In order to keep the results of the voting stage as comparable to the non-voting stage as possible, subjects were told that if a Maximum Individual Withdrawal level was successfully implemented through majority rule voting, that each individual would automatically withdraw either this amount or his personal Capacity, whichever was less. Thus, subjects do not necessarily withdraw a symmetric amount in the voting stage—for example, if the Maximum Individual Withdrawal was 35 in the Large Boats Dominant treatment, the three individuals with a Capacity of 44 would withdraw 35 tokens and the two individuals with a Capacity of 34 would only withdraw 34 tokens. Similar to the first 10 rounds, they were informed that the collective withdrawal level would determine a Chance of Over-Draw and that they would also be charged $0.02 per token they failed to withdraw up to their Capacity.

During the voting stage of the experiments subjects were asked to first make a proposal for the Maximum Individual Withdrawal. After everyone had submitted a proposal, each subject saw all 5 proposals for her group and was asked to vote for one of them. If two or more subjects made the same proposal, this was treated as one proposal and votes for either were consolidated together. If a majority of subjects (3 or more) voted for a particular proposal level, this was implemented in the manner discussed above. If none of the five proposals received a majority of support, then subjects reverted to the uncoordinated game played in the first stage of the experiment.

Majority rule voting does not take place under a unitary set of procedures. Rather, there has been considerable attention paid to how different institutional procedures influence vote outcomes. The purpose of these experiments is not to determine the benefit of one set of procedures over another, nor to determine the 'optimal' procedures to crafting sustainable outcomes, but rather to understand how voting can, at its root, mediate risky behavior in common pool resource settings. Therefore, we chose a specific set of institutions that mimic real-world common pool resource conditions and kept these institutions constant across the different treatments.

Unlike many policy areas in which the timing of final passage makes little to no difference in the effect of the policy, common pool resource harvesting often occurs seasonally and the level of harvesting one season may have dramatic consequences for the amount harvested the next. If the decision making body of the resource system fails to implement a cap on fishery catch levels, forestry harvests, or cattle grazing acres, for example, then the reversion policy is followed until such a policy can be enacted. Thus, there is a natural finite time-frame in which the policy must be agreed upon, after which point regulations for that particular season are meaningless. To capture this idea, we implement a reversion policy, that is implemented in the event that no majority vote is reached, equal to the baseline uncoordinated game. This is also the procedure used in Walker et. al (2000) and Margreiter et al (2005).

At the end of the 20th round, subjects were told the experiment was over and were asked to fill out a brief questionnaire while the experimenter prepared payments.

Results

Results from the experiments are still preliminary, as we have not yet fully exploited the dataset gathered in the experiments. To date, we have run 40 subjects in the SBD treatment (8 groups), 40 subjects in the LBD treatment (8 groups) and 30 subjects in the Homogenous Distribution treatment (6 groups). The data analysis that follows in this section focuses primarily on aggregate by-period results, as we have not yet been able to investigate some individual-level hypotheses to be addressed in subsequent research. In addition, the analysis focuses on differences between the SBD and LBD treatments, as analysis on the Homogenous Distribution treatments is still preliminary.

The first question to be addressed is whether or not subjects play a uni-dimensional policy game or not. If indeed subjects view the game as a simple choice space about individual withdrawal, then we should expect that successful proposals in the voting game coincide with the uni-dimensional median voter. This is not the case, however. In the SBD treatment, the median voter's capacity is 34 and in the LBD the median voter's capacity is 44. Table 1 lists the successful proposals, i.e. those proposals that were successfully enacted with majority rule voting, and frequency that these proposals occur. In the SBD treatment, the most commonly enacted proposal was 30, while in the LBD treatment the most commonly enacted proposal was 32, both far below the median voter's capacity. In both treatments the distribution of successful proposals is statistically significantly different from the predictions of the median voter model.

Table 1. Incidence of Successful Proposals

Small Boats Dominant Treatment		*Large Boats Dominant Treatment*	
Proposal	Count	Proposal	Count
25	6	25	1
27	4	27	5

28	2	28	4
30	9	30	6
32	2	32	8
35	1	34	1
		35	3
		37	1

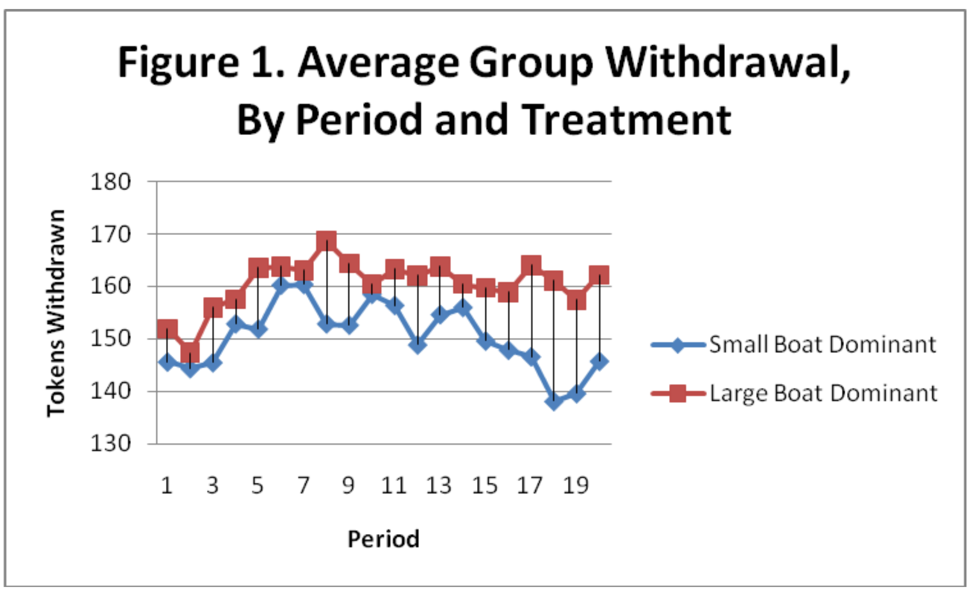
So, if preferences are perfectly aligned with capacity (which is a big assumption), then we have evidence of a multi-dimensional policy space, consistent with our theory that incorporates risk preferences. Another interesting finding is that LBD treatments enact larger successful proposals than SBD treatments. In particular, the average successful proposal in the LBD treatment is 30.48, whereas it is only 28.46 in the SBD treatment (significant at the .01 level). This may indicate that LBD treatments are more tolerant of large aggregate withdrawals than in SBD treatments.

Further evidence for this can be seen in looking at the average collective withdrawal per period or per stage for both treatments. There is a statistically significant difference between treatments on the average collective withdrawal (p-value < .01), but there is not a significant difference within treatments between stages. Table 2 lists the average withdrawal in the SBD and LBD treatments for the non-voting stage, the voting-stage, and then disaggregates between successful votes and failed votes. One result is immediately striking: In both treatments, there is no statistical difference between the collective withdrawals in periods with a successful vote and the non-voting stages. Only when we incorporate failed vote periods do the voting-stage results increase significantly over non-voting. One explanation for this finding is that subjects vote for policies that mimic their strategies without voting. If a proposal fails, however, the subjects may be playing a punishment strategy by withdrawing larger quantities of tokens following the failed vote.

Table 2. Average Withdrawal Levels Aggregated by Stage and Successful vs. Failed Votes, Standard Deviations in Brackets			
	Small Boats Dominant Treatment	Large Boats Dominant Treatment	Homogenous Distribution Treatment
All Periods (1-20)	150.42 (17.09)	160.53 (14.37)	152.17 (13.47)
Non-Voting Periods (1-10)	152.49 (17.09)	159.71 (14.61)	154.4 (12.28)
Periods with Successful Vote	145.1 (16.84)	155.65 (13.88)	145.78 (14.26)
Periods without a Successful Vote	158.1 (14.17)	169.03 (10.58)	157.09 (11.55)

Notice also that the difference between treatments increases in the voting stage relative to the non-voting stage of the treatments.

Figure 1 below provides the average withdrawal rates across the two treatments by period. Notice that the LBD treatment withdraws more in aggregate than the SBD treatment in all every period.



One final question to be addressed concerns the frequency of reaching a successful vote. Margreiter et al (2005) find that the frequency of successful votes is higher in homogenous groups than in groups with heterogeneous costs. Table 3 lists the frequency of reaching a successful majority proposal during voting stages.

	Table 3. Frequency of Reaching a Successful Vote		
	LBD	SBD	HT
Frequency	0.575	0.750	0.633
# Periods	80	80	60

Unlike Margreiter et al (2005), we find no evidence that homogeneous subjects managed to reach a successful proposal more often than heterogeneous groups. Indeed, the only statistically significant difference is between the SBD treatment and the other two. In our study it appears that small group dominant settings are more capable of reaching agreement than either a large group dominant setting or a homogenous distribution.

Conclusions and Discussion

In the experiments presented here, we allow resource users to vote. This is not necessarily what happens in modern democracies, but in some sense it is. For example, the lobster fishery councils in Maine are comprised of elected lobster fishermen (Acheson 2003), US Ocean Fisheries Commissions are comprised of industry and recreational interests, and many smaller scale situations use some form of explicit or implicit voting among users to set resource limits. Legitimate criticism of these experiments could be that resource users themselves are rarely the individuals actually voting over appropriation.

The experiments presented here have shown preliminary evidence that differing the distribution of user capacities can have significant consequences for aggregate appropriations. However, no evidence was found that voting by itself produces significantly different aggregate appropriations within treatments than an uncoordinated game. Finally, evidence suggests that users are indeed playing a multiple dimension voting game when considering group withdrawal levels.

Further study is needed before broad claims can be made about the results so far. In the coming weeks, additional sessions are being performed to get at least a reasonable sample of 30 individuals per treatment. Once that is completed, additional statistical analysis can be completed, including panel-level analysis of individual behavior. For example, we would like to know better how individuals with a capacity of 34 function in both the Small Boats Dominant and Large Boats Dominant treatments. If these individuals behave similarly in both treatments, but aggregate withdrawals remain significantly different across treatments, this would seem to indicate that most of the variance occurs because of the dominant coalition in the voting game.

Works Cited

Acheson, James M. 2003. Capturing the Commons: Devising Institutions to Manage the Maine Lobster Industry. Hanover, NH: University Press of New England.

Agrawal, Arun and Clark Gibson. 1999. "Enchantment and Disenchantment: The Role of Community in Natural Resource Conservation." *World Development* 27(4): 629-649.

Baron, David and John Ferejohn. 1989. "Bargaining in Legislatures." *American Political Science Review* 83(4)

Bianco, William and Itai Sened. 2005. "Uncovering Evidence of Conditional Party Government: Reassessing Majority Party Influence in Congress and State Legislatures." *American Political Science Review* 99: 361-371.

Blomquist, Bill. 1992. *Dividing the Waters.* ICS Press: San Francisco.

Ehrhart, Karl-Martin, Roy Gardner, Jurgen von Hagen, and Claudia Keser. 2007. "Budget Processes: Theory and Experimental Evidence." *Games and Economic Behavior* 59(2): 279-295.

Fiorina, Morris P. and Charles R. Plott. 1978. "Committee Decisions under Majority Rule: An Experimental Study." *The American Political Science Review* 72(2): 575-598.

Fischbacher, Urs. 2007. "z-Tree: Zurich Toolbox for Ready-made Economic Experiments." *Experimental Economics* 10(2): 171-178.

Gordon, H. Scott. 1954. "The Economic Theory of a Common-Property Resource: The Fishery." *The Journal of Political Economy* 62(2): 124-142.

Hardin, Garret. 1968. "The Tragedy of the Commons." *Science* 162: 1243-1248.

Lansing, J. Stephen. 1991. *Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali.* Princeton, NJ: Princeton University Press.

Margreiter, Magdalena, Matthias Sutter and Dennis Dittrich. 2005. "Individual and Collective Choice and Voting in Common Pool Resource Problem with Heterogeneous Actors." *Environmental and Resource Economics* 32: 241-271.

Ostrom, Elinor. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action.* New York, NY: Cambridge University Press.

Ostrom, Elinor. 1999. "Coping with Tragedies of the Commons." *Annual Review of Political Science* 2: 493-535.

Ostrom, Elinor, Roy Gardner, and James Walker. 1992. "Covenants With and Without a Sword: Self-Governance is Possible." *American Political Science Review* 86: 404-417.

Ostrom, Elinor, Roy Gardner, and James Walker. 1994. *Rules, Games, and Common-Pool Resources*. Ann Arbor: The University of Michigan Press.

Shepsle, Kenneth and Barry Weingast. 1984. "Legislative Politics and Budget Outcomes." *In Federal Budget Policy in the 1980's,* G. Mills and J. Palmer, Eds. Washington DC: Urban Institute Press: 343-367.

Tietenberg, Tom. 2002. "The Tradable Permits Approach to Protecting the Commons: What Have We Learned?" In *The Drama of the Commons*. National Research Council, Committee on the Human Dimensions of Global Change. Washington, D.C.: National Academy Press. 197-222.

Walker, James, Roy Gardner, Andrew Herr, and Elinor Ostrom. 2000. "Collective Choice in the Commons: Experimental Results on Proposed Allocation Rules and Votes." *The Economic Journal* 110: 212-234.

Appendix: Instructions Used

Instructions…………Start.

Welcome! At this point you are not permitted to speak to other people in the room or to look around at other people's computers. Please turn off your cell phones and put other work away. You have already earned $10 by participating in this experiment, which will last about an hour. You may earn more money, however, depending on the choices you make individually and the choices everyone else in your group makes collectively.

Please read along on screen as I read aloud. Please do not continue to the next screen until I say. You have been randomly assigned to a group of 5 people. Each member of your group will be making identical, but separate, decisions over how many tokens to withdraw from a shared pool of 250 tokens. Each of these tokens has a potential real-cash value of $0.05. When a round starts, you will be entering how many tokens you want to withdraw into the computer where prompted and then will wait for the other four members of your group to do the same. After that a screen will display with your earnings for the round.

There are 20 rounds of decision making in this experiment. The directions on the following pages apply to the first 10 rounds. After each group has finished the first 10 rounds, you will be giving new instructions for the second set of 10 rounds.

(Please Click ok to Continue)

///NEW SCREEN///
During each of the first 10 rounds of the experiment you will be deciding how many tokens you wish to withdraw from a pool of tokens that is shared by all 5 members of your group. You will make your decision of how many tokens to withdraw privately and at the same time as the other members of your group. At the start of each round, the pool of available tokens is reset and you will make another withdrawal decision. Each round is an independent event.

If your group collectively withdraws more than 125 tokens, then there is a chance that you will over-draw and that the pool of tokens is worth $0. In this event, everyone in your group will earn $0 for that round. The likelihood that you over-draw increases with each token collectively withdrawn above 125. In particular, there is a 1% chance of over-drawing for each token withdrawn above 125.

Thus, if your group withdraws 175 tokens collectively there is a 25% (175 - 125 = 25) chance that you will over-draw for the round; if you withdraw 189 tokens collectively there is a 39% (189 – 125 = 39) chance that you will over-harvest for the round, and so on.

Please refer to the handout if you want to know what percentage chance of over-drawing there is for a corresponding collective withdrawal. Notice that if your group withdraws 125 tokens or fewer, then you are guaranteed that all of the tokens you individually withdraw are worth money. If you have any questions so far, please raise your hand. If you are satisfied with the instructions so far, please press “Continue”.

//NEXT SCREEN//
When the first round begins you will be prompted to enter your withdrawal decision. Once all members of your group have made their individual decisions, your screen will show you how many tokens your group as a whole withdrew, and then the 'Percentage Chance Over-Draw'. The computer will then randomly generate a number to decide if your group over-drew for the round. If your group does not over-draw for the round then you will earn money in the following way:

You can individually withdraw up to 40 tokens each round. This is referred to as your 'Capacity'. Each token you withdraw up to your 'Capacity' is worth $0.05 to you individually. If you withdraw less than your 'Capacity' amount, you will be charged $0.02 per token that you did not withdraw.

Thus, if you withdraw 30 tokens, you will earn $1.50 (30 x $0.05) for the tokens you withdrew, but will be charged $0.20 (10 x $0.02) for each of the tokens you did not withdraw. In this case, you would earn $1.30 for the round. Similarly, if you withdrew 37 tokens you would earn $1.85 and be charged $0.15. In this case, you would earn $1.70 for the round.

If you have any questions at this time, please raise your hand. If you are satisfied with the instructions so far, press "Continue" to proceed to the next screen of the instructions.

///NEW SCREEN///
Recap
--You are in a group of 5 people
--The decisions made in each round do NOT carry over to the next round
In each round:
--If your group collectively withdraws above 125 tokens, then there is a chance that everyone your group will over-draw the pool and everyone earns $0 for the round. This chance is determined by how many tokens above 125 were withdrawn.
-- If your group does not over-draw, then each individual earns $0.05 per token up to their 'Capacity'. You are also charged $0.02 per token you fail to withdraw up to your 'Capacity'.
--The amount of money you make depends on your individual withdrawal level and on the collective withdrawal level of all 5 members of your group.
--You cannot lose money in a round. The minimum you can 'earn' per round is $0.00.

At the end of each round you will see a screen that lists:
1) Your individual withdrawal decision
2) Your group's collective withdrawal level
3) The 'Percentage Chance of Over-Draw'
4) A randomly generated number
5) Your profit for the round
6) Your total profit for the experiment so far.

Rounds 2-10 will follow the same instructions. If you have any questions at this time, please raise your hand and an experimenter will come talk to you.
Once everyone has clicked "Continue", the experiment will begin.

VOTING TREATMENT
The following ten rounds will be identical to the first ten rounds, except that now you will be able to implement a ‘Maximum Individual Withdrawal’ that may be above, equal to, or below your ‘Capacity’. Your group will be collectively voting over what amount this ‘Maximum Individual Withdrawal’ should be. This amount is different from your Capacity.

At the start of each round, you will be asked to enter a proposal that will correspond to the maximum amount of tokens you propose each member of the group can withdraw. Notice this is one number for all five group members—if a proposal is voted as the 'winner' it will be imposed identically on each group member.

If a proposal for a ‘Maximum Individual Withdrawal’ successfully receives a majority of support from your group, then this will be automatically imposed equally on each member of the group. The computer will then automatically withdraw tokens for you, up to either your ‘Capacity’ or the ‘Maximum Individual Withdrawal’, whichever is less.

So, if the ‘Maximum Individual Withdrawal’ is 15, but the ‘Capacity’ is 40, you will automatically withdraw 15 tokens. If the ‘Maximum Individual Withdrawal’ is 75, but the ‘Capacity’ is 40, you will automatically withdraw 40 tokens. Whichever of these two numbers is LESS will be automatically imposed on each member of the group.

Please press “Continue” to proceed to the next screen of instructions.

///New Screen///
After each member of your group has made a proposal, you will be asked to vote on which of the five proposals you want implemented. You will see the full list of proposals that each individual makes.

After seeing the proposal list, you are asked to enter which ‘Maximum Individual Withdrawal’ you want to have implemented. You will enter the actual numeric value of the proposal you want to vote for. If you attempt to enter a number other than one of the five proposals, you will be prompted to re-enter your decision.

Once each member of your group has voted for a proposal, one of two situations may arise.

1) If a proposal receives a majority of votes (3 votes), it will be implemented and each member of your group will withdraw either that number of tokens or their ‘Maximum Capacity’, whichever is less.

2) If no single proposal receives a majority of support after the initial vote, then you will revert to the uncoordinated game from the first 10 rounds. You will see a screen that indicates you did not have a single proposal get a majority of votes. You will then be asked to enter an individual withdrawal level. This operates identically to the first 10 rounds of this experiment.

If you are confident that you understand these instructions, please press "Continue" to proceed to the next screen of instructions.

///NEW SCREEN///
Recap
As in the previous rounds, there will be a corresponding "Percentage Chance of Over-Draw" that everyone in your group earns $0 for the round. The "Percentage Chance of Over-Draw" is calculated in the exact same manner as in the first 10 rounds—for each token withdrawn above 125 there is a corresponding 1% chance that everyone in the group will earn $0 for the round. Also as in the previous rounds, if your group does not over-draw for the round, then you will earn $0.05 per token withdrawn and will be charged $0.02 per token you did not withdraw up to your 'Capacity'. Notice that if the 'Maximum Individual Withdrawal' is less than your 'Capacity', you are still charged for each of the tokens you were unable to withdraw.

In each round:
--You will first make a proposal that is the number of tokens you propose each individual in the group can withdraw at maximum.
--You will then vote for one of the 5 proposals
--If a majority of votes has been obtained for some proposal, you will automatically withdraw that number of tokens, or your 'Capacity', whichever is less.
--If a majority of votes is not obtained for some proposal, then you will be asked to make an individual withdrawal decision, similar to what you did in the first 10 rounds of the experiment.
The game will continue for 10 rounds. If you have any questions, please raise your hand and an experimenter will come talk to you.
If you are satisfied with the instructions and have no questions, please click the 'Okay' button. As soon as everyone has clicked okay, the experiment will automatically start.