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An examination of incentive structures in recycling policy

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An examination of incentive structures in recycling policy

by

Ashley Lyndle Waltmann

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Signatures have been redacted for privacy

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INTRODUCTION

We stand now where two roads diverge. But unlike the roads in Robert Frost's familiar poem, they are not equally fair. The road we have long been traveling is deceptively easy, a smooth superhighway on which we progress with great speed, but at its end lies disaster. The other fork of the road -- the one "less traveled by" -- offers our last, our only chance to reach a destination that assures the preservation of our earth.

(Carson 1962, 277)

Problem Statement

Since 1962 the issues may have changed but the clarion call remains clear. Iowa's landfills are filling up. In 1991, Iowans disposed of 2.3 million tons of trash. This averages to four and a half pounds per day per person. By the year 2000, at current rates, that amount is anticipated to increase another twenty percent. Eighty-eight percent of this trash is placed in landfills (ten percent recycled, two percent incinerated) (Arrandale 1992, 38). The refuse problem affects every one because we all produce garbage. Over time the trash accumulates and new landfills are needed. However, no one wants a landfill: "[The] battle cry of 'Not in my backyard (NIMBY),' also means not in my front yard, side yard, on my street or in the vicinity of my eyes, ear, nose or throat" (Cronin 1989, 46). How can this be reconciled?

With an estimated average of only twelve years remaining in Iowa's landfills (Iowa, GPA 1987), the Iowa legislature has passed several laws which aim to both reduce the landfills' depletion rate and protect the groundwater sources. The 1987 Groundwater Protection Act attacks the landfill problem from a refuse reduction perspective. The law suggests reductions and offers a hierarchy of reduction approaches. The hierarchy, in order of priority, is: 1)
volume reduction at the source, 2) recycling and reuse, 3) combustion with energy recovery and refuse-derived fuel, 4) combustion for volume reduction, and 5) disposal in landfill (Iowa, GPA 1987, Div. IV, Part 1). In 1989 the legislature put some teeth in this law, creating the Waste Reduction-Recycling Act (WR-RA) mandating 25% statewide reduction in landfilled waste by 1994 and a 50% decrease by 2000 using 1988 as the baseline year (Iowa WR-RA 1989, Iowa code, Chapter 455D).

Refuse reduction is a classic collective action problem due to the public nature of the garbage collection (Sandler 1992a, 1992b). Collective action problems relate to a group's ability to provide itself a collective (public) good (Olson 1971). Determination of what goods a group should provide itself is a collective choice question. The distinction between collective action and collective choice problems is important: when a society decides what goods to provide itself, through legislation, referendum, or administration (bureaucracy), it is making a collective choice. When society provides that good to itself there is collective action. Since some goods, because of their public good characteristics, are more difficult for a group to provide to itself, there are collective action problems.

Public goods have two defining characteristics which distinguish them from private goods: nonrivalry and nonexcludability. To be nonrival is to be a good for which the consumption by one person does not limit or diminish the ability of another person to use the same unit of that good. Goods are nonexcludable when they are made available to one person, they are available to all. The reduction of landfill waste and subsequent extension of landfill life is something which benefits everyone therefore is at least an impure public good.
An impure public good is partially nonrival and/or partially excludable (Sandler 1992b). Once the life of the landfill is extended, all members of the community benefit, even if they did nothing to contribute to that extension (i.e., they did not reduce their waste), thus, it is partially nonrival. However, it may be possible to bar some people from using the landfill, making the good at least partially excludable. In this discussion, it is the nonrivalry of the benefit which is most relevant, thus, landfill life extension is considered a public good.

A second facet of the refuse reduction problem relates to the historic pricing of the landfill and other common resources. These resources, for example air, water, and soil, consistently are underpriced. The cost of maintenance and pollution clean up is often not included. The degradation of the air, water, or soil is often termed a negative externality. Externalities occur when one person's (group's, firm's) behavior affects another person's welfare but is neither compensated nor charged (Sandler 1992b). When these include costs that society will pay later, they are called social costs. Externalities are market failures in that the price set by the market is not the correct price for society. This means the pricing system fails to provide the correct signals to the decision maker in terms of society's interests.

Alterations in the incentive or pricing system represents one way to approach the collective action problem from a public policy perspective. The idea is to change the costs and benefit payoffs which people face when making the decision of whether or not to recycle. The same incentives may create a different impact depending on the rationality, or value structure, of the individual person. Some people hold a conservation attitude, valuing the interdependence of man and nature and the possible impact on the environment. Others approach
environmental problems in the same manner they approach any economic decision, "What is the best bargain?" In order to be effective the recycling policy must consider these rationalities and creating a bargain while encouraging the conservationist's predisposition toward environmentally sensitive behavior.

Communities attempt to choose the policy strategy which best fits their needs. There are several policy strategies from which communities may choose. Some may use voluntary drop off centers or voluntary curbside collections, others may mandate curbside collection, and still others may change the pricing system using a volume based rate plus the voluntary curbside program. In different ways these policies change the face of the refuse problem as they would alter the costs and benefits of participation in the recycling effort. Some policies will have more success than others.

Research Objectives

The objective of this study is to evaluate which alternative may generate the optimal result. In order to analyze the value consequences of the various incentives, a model needs to be created of the individual decision process within each policy, considering the type of individual rationality. However, because the individual is functioning within a community, the decision-making process is dependent also on other members of the community and their contributions to the collective goods. Collective action problems, as interdependent decisions, can be structured on the basis of game theory (Mueller 1989, Sandler 1992a, 1992b, McLean 1987, Harsanyi 1977). A game theory framework can model seventy-eight distinct structures (in a bimatrix, two strategy form), three of these are used regularly to model collective action: Prisoner's Dilemma, Chicken, and

Analytically, this study changes policies into games. Each policy then is analyzed as a single encounter game. Additionally, one game will be used to model interaction between the two rationalities, another is the basis of a repeated game, and an n-person game. Social action situations, without coordination, are assumed to be Prisoner's Dilemmas situation. If the policies alter this structure to reveal a different game structure, then the change will be attributed to the incentive impact on individual decisions.

The relationships focused on in this study are the impact of incentives in recycling policy on the individual decision making process. The goal is to determine which policies affect collective action. In order to accomplish this, I first examine the recycling policy strategies. I then sift through the literature for other evaluation studies on recycling incentives, and again, for research on the use of incentives in environmental policy and collective action problems generally. In order to understand the dynamics of collective action in connection with recycling policy, I use game theory as a framework for analyzing the individual decision-making process. Game solutions are often a function of the rationality of the "player." Rationality is the last concept explored before turning to the actual analysis of the games.

Applying game theory, I generate some specific hypotheses about the likelihood of citizens to participate in the various recycling policy strategies. The hypotheses generated in this study include:

1. Voluntary approaches will lead to less refuse reduction than will mandatory or price changing approaches.

2. Voluntary curbside collection will lead to a greater reduction in
3. Whereas the success of volume based rate systems would depend on the price chosen, this price should make the benefits of recycling greater than the cost of participation.

4. Mandatory curbside collection and a correctly priced volume based pricing system should have the same landfilled waste reduction impact.

These hypotheses are drawn from the various rationalities of citizens in a local community. While these hypotheses are reasonable from the logical standpoint, they also should be subject to empirical validation. In this study I make an exploratory attempt to test their plausibility with a single sample of refuse collection data obtained from a municipality in Iowa. A more comprehensive empirical study is suggested for the future.

The practical import of this study is to find ways to structure the policy debate on the problem of refuse collection. Effective policies do not function as band-aids to problems, they attack the roots of problems. Landfill depletion is a special problem because it is addressed in every town in Iowa and throughout the United States. In order to choose well, communities need to know the facets, advantages, and disadvantages of the various potentially effective policy options.

Recycling Policies

Government regularly mediates the environmental externalities of industries and firms; however, the overuse of landfills results from citizen behavior. This behavior can be guided through many venues, including governmental action. Refuse collection traditionally has been within the local government's realm. As local policy reflects the community preferences which create it, it takes on a variety of forms. The policies vary according to the
strength or pointedness of the incentive and the type of rationality to which it appeals. Generally, the policies fit into a spectrum from no incentive (no recycling possibility) to strong, pointed incentives, such as fines and penalties (mandated separation). The policies to be discussed are: voluntary drop-off centers, voluntary curbside collection, mandatory curbside collection, and volume based pricing in conjunction with voluntary curbside collection.

When shifting recyclables out of regular trash and into recyclable collection, there may be a "proper" and or "complete" way to do so. By “proper” I mean that the citizen follows the instructions of the collector. This could include washing items, removing labels, separating certain items from others (e.g., milk jugs from other plastic bottles) or combining them (e.g., clear and colored glass together). If one had followed the recycling instructions completely, it would mean that all possible recyclables would have been separated from the trash. Complete separation is not always easy because some recyclables may not be distinguishable from non-recyclables (e.g., metal ends of cardboard frozen juice concentrate containers).

**Voluntary drop off centers**

Voluntary drop off centers represent the minimal infrastructure which makes recycling possible for most citizens. At a specified place(s) people can take separated recyclables and leave them. These places may be separate buildings, parts of buildings, or unattended collection centers in department store parking lots. These centers are usually the first recycling step for many communities. The provision of drop off sites appeals mostly to those who want to
recycle for ethical reasons. For those with no ethical stance on reducing refuse, the incentive structure remains the same as for no policy.

**Voluntary curbside collection**

Voluntary curbside collection refers to a recyclable collection provided by the sanitation company which collects the "regular" trash. The separated items are placed on the curb beside the regular collection. Voluntary curbside recycling amplifies the impact of voluntary drop-off centers. Still voluntary yet without direct appeal to economic incentives, the voluntary curbside collection method generates a cost to the individual, i.e., time and effort, reduction. This will impact those predisposed to recycle, more than those who are indifferent to recycling.

**Mandatory curbside collection**

A most dramatic approach to recycling is to mandate curbside recycling. Mandatory curbside collection would require a penalty for non-recyclers. Possibly, a fine levied or the trash not taken away. In order to be effective, the fine needs to exceed the costs of recycling so that it becomes in each person’s individual interest to participate. Also, the probability of receiving the fine for not participating must be fairly certain, so the policy would reduce the number of nonrecyclers.

**Volume based pricing plus voluntary curbside collection**

The last approach considered here is the voluntary curbside collection plus volume based pricing. This is the only policy which directly affects the pricing
system. The first three policies described above would charge a flat fee unrelated to the amount of garbage collected. Volume based pricing uses a lower flat fee to cover the fixed costs then adds an additional charge per unit collected. When combined with a "free" curbside collection of recyclables, the idea is for citizens to shift recyclables out of the charged unseparated collection and into the "free" recyclable collection.

This policy is structured to be a self-enforcing version of mandated recycling. Self-enforcing policies do not require mandate enforcement, rather, the price structure is expected to lead people to compliance. The changes in the pricing system itself, rather than the external price of a fine, are the impetus to reduce refuse. The strength of the incentive will vary as the price per unit varies filling the "incentive space" between voluntary curbside and mandatory curbside.
LITERATURE REVIEW

In most cases the prerequisite for social gains is the identification, not of villains and heroes but of the deficits in the incentive system that drive ordinary decent citizens into doing things contrary to the common good.

The incentive system can be defined as the system of costs and benefits that each individuals face when making a decision. When the individual's mirrored costs and benefits are not true reflections, then there is a defect in the incentive system. This false reflection is common in environmental issues.

Literature on the use of incentives in recycling policy is extensive. Incentives are classified as extrinsic, intrinsic, or social. Extrinsic incentives offer external rewards or benefits for certain behavior, e.g., participation in a recycling program. Luyben and Bailey (1979) found offering prizes to be effective; Jacobs' and Bailey's (1982) lottery eligibility increased participation; while, Witmer and Geller (1976) considered prompts, raffles and contests. These incentives are often criticized because once removed, recycling ceases (Couch et al. 1979; Luyben and Bailey 1979, Geller, Winett, and Everett 1982). Deci (1975) called this the "over justification effect." In essence, he says, the participants recycled for the external incentive without shifting to a intrinsic satisfaction.

Intrinsic incentives are more attitudinal, personal, even moral in nature. Altruism (Hopper and Nielsen 1991, Davidson-Cummings 1977) and intrinsic satisfaction, or feeling good about what one has done, (Oskamp et al 1991, De Young 1986, Hopper and Nielsen 1991) are but two examples. These attitudes, however, are difficult to measure and attempts to measure any underlying proenvironment factor have been unsuccessful (Cook and Berrenberg 1981, Tracy and Oskamp 1983-1984). The situation is complicated further by the lack

A second facet of intrinsic incentives reflects social influences or incentives. These affect one's image or reputation via desired family and/or neighbors' perceptions of one evaluated against "community" standards and norms (Vining and Ebreo 1990). Thus where there is general community support for recycling, each individual, wanting to belong, also will support recycling (McGuiness, Hones, and Cole 1977). The impact is greater for curbside collection programs, making participation obvious to all (Vining and Ebreo 1990, Burn 1991, Oskamp et al. 1991, Cook and Berrenberg 1981).

The approach to extrinsic or material incentives in the literature, is not the lead which I follow in this paper. Their approach appears almost trivial and, I believe to be, off the mark, betraying a fundamental misunderstanding of the problem. First, landfill life extension, the ultimate purpose for recycling, can be achieved only through the collective effort of the individuals of the community. However, citizen options and perceptions were not examined nor were they forced to reevaluate them themselves. When attempts have been made to examine and alter perceptions and options in significant ways, e.g., through the use of either intrinsic or social incentives, the long-term success rate improved dramatically over external incentives (DeYoung 1986, Burn 1991).

Additionally, landfill use has been undervalued. This undervaluation is demonstrably evident when one considers the size of the federal superfund program to clean hazardous landfills or the political, social, and real costs of choosing a new landfill site. Are these costs included in most garbage bills? The difference between garbage bills (private costs) and the superfund program
(social costs) should be the crux of external incentives. The extrinsic, economic incentive should reflect garbage's true cost to society, rather than a gimmick to induce recycling. The process of shifting the social cost of garbage disposal not included in the private cost to the individual is called internalizing the externality. Internalization represents a pricing system change.

Pricing system changes directly address this undervaluation (Schelling 1984, Baumol and Oates 1988). Often pricing system corrections are themselves called incentives. There are several advantages to internalizing these social, public costs. First, by introducing the true costs to each individual, the increased costs of the behavior should effectively reduce the quantity of that behavior, thus, mediating the impact before it occurs. Secondly, it is appropriate that the costs of mediation should be paid by those who negatively impact the environment, rather than an even distribution of those costs across society through public costs paid through tax revenues (Schelling 1983).

This pricing system perception of incentives is common in economics. The discussion usually is carried out in terms of either industries and firms or individuals and collective action problems, although the division is not necessarily rigid (Schelling 1983). The industry and firm discussion relies heavily on the functioning of the market and purely economic (price changing) incentives. Assuming firms and industries maximize their profits, an alteration to the costs which affect the bottom line, incentives, induces a change in behavior (Baumol and Oates 1988). The firm must pay a higher price to continue its harmful activity.

Pricing system alterations translate into individual decision making in the following way. The market functions based on an assumption that individuals
make decisions which maximize their interests. Through an incentive, or change in the pricing system, environmentally aware behavior is in the interest of each citizen. "We need not actually forbid a citizen to [do something]; we merely make it increasingly expensive for him to do so. Not prohibition, but carefully biased options are what we offer him" (Hardin 1968, 1247).

Beyond strictly economic or monetary incentives, Olson (1971) takes a broader approach. He does not limit private interest to Schelling's narrower economic vision: "Economic incentives are, to be sure, not the only incentives" (Olson 1971, 60). Olson's incentives, "selective incentives," provide benefits which are received if and only if one participates in collective action. Beyond economic (or monetary) incentives social incentives such as prestige and status are selective, as are moral incentives. "Even in the case where moral attitudes determine whether or not a person will act in a group-oriented way, the crucial factor is that the moral reaction serves as a 'selective incentive'" (Olson 1971, 61). Social incentives or sanctions describe conventions shared within a group, the sanction reinforces the convention and vice versa. These are most effective when the conventions are clear and members of the group are sensitive to those standards (Reisman 1990).

Olson (1971) defines three groups distinguished by their ability to provide themselves with a collective good. He refers to the group (possibly a subset of a larger group, or not) which provides itself the collective good, whether or not anyone else contributes, a privileged group. The second group, the intermediate group, is not so small that it can provide the good independently, but is not so large that its contribution to the provision of the collective good goes unnoticed by the other members of the group. In this case, social incentives have a greater
impact than in the largest, latent group. In the latent group each individual's contribution and its impact goes unnoticed and unnoticeable by other members of the group. However, this group, due to its size, has the greatest "latent" potential for collective provision of the good.

Using game theory, it becomes possible to analyze social situations to determine to which group the players belong. The Olsonian privileged group is redefined because of the interesting distinction between some and all members providing the collective good. When all members provide the collective good, the group is called fully privileged, when at least one member provides the collective good, the group is called privileged. The latent group still refers to the situation where no one participates in the public good provision.

Despite the variety of approaches to recycling incentives, the literature appears to side-step the critical pricing issue. Economists address pricing issues, but usually in terms of industrial situations. As a result, the pricing aspect of local government issues, such as refuse disposal, has not been explored explicitly. It is this which I seek to explore. When public policy addresses collective goods issues, it happens on to behavior patterns that resemble players in a game. The bridge between public policy and game theory is built on interdependent decision process (e.g., "I will if you will," and "I know that you know that I know, etc."). The players in a collective action game can be categorized into Olsonian groups. In the section which follows, some of the basic ideas mentioned thus far, game theory, collective action games, rationality, will be explored. The exploration will conclude with a summary in terms of the propositions which can be made about the impact of recycling policies on citizen participation and successful landfill life extension.
CONCEPTS AND THEORIES

Game theory represents a methodology for objectively analyzing a social situation. Game structures are superimposed on a social situation. Without government intervention, the refuse reduction problem would appear as what game theorists call a Prisoner’s Dilemma situation. Since the purpose of recycling policy is to give citizens the opportunity to reduce their refuse, the policy game requires a shift in the cost-benefit structure to a Fully Privileged game. The citizens make their decision—whether to recycle or not—based on their rationality and the policy structure, not formally based on any knowledge of collective action problems or solutions. With this framing of the social situation, I turn first to game theory and then rationality.

Game Theory

In order to discuss game theory, it is first necessary to define a game. Ken Binmore states: "A game is being played by a group of individuals whenever the fate of an individual in the group depends not only on his own actions but also on the actions of the rest of the individuals in the group" (1990, 1). The essence is dependent interactions between two or more persons; the implication is a framework for the analysis of these strategic (dependent) decisions. The use of the word "game" does not limit its application to the trivial or merely entertaining; rather, "game" is used in the sense of rules, strategies, and preferences of outcome, also when each player knows each other’s options and preferences (Schelling 1988). Clearly, many social situations fit into this description of "game."
Dependent decisions resemble crystals which must be reduced to their simplest pattern to be fully understood and amenable to manipulation. The first step towards understanding is to rid dependent social situations of all but detail relevant to the decision at hand. "[Game theorists] are simply attempting to separate those features of a problem that are susceptible to uncontroversial rational analysis from those that are not" (Binmore 1992, 4). By focusing only on those aspects of the problem which factor into the decision process, one may avoid many of the emotional and moral questions which "muddy the water." Sidestepping these questions is appropriate since the analysis is of the situation and not of the individuals (Schelling 1988). A different question of what criteria individuals use in the decision process is a rationality assumption question.

Game theorists assume that players optimize or maximize their outcomes. Implicit assumptions of player rationality and perfect knowledge of all options round out the self-interested economic man. Such an assumption does not restrict one from varying the goals of the economic man, and therefore his rationality. As discussed earlier, attitudes and preferences are part of the situation and "game theory takes them as data" (Schelling 1984, 216).

The game model employed is based on the player's strategy choice. Strategies embody all decisions necessary for one player to finish a game. Thus, the games are presented in normal, bimatrix form, that is, in matrix form where each cell contains two payoff entries. The strategy choices for each player define the rows or columns. Within each cell of the resulting matrix are the payoffs for that strategy combination. It is these payoffs which the players seek to maximize.
In game theory there are a few things which must be explicit before beginning. These "rules of the game" include defining the players, the rules of the game, information available to each player, and the consequences of that action for all (Harsanyi 1977, 88). These plus the rationality assumptions combine to form the game theory model.

In the examination of the impact of recycling policies on refuse reduction, I analyze how the policies affect the "everyman" individual decision maker, that is, on the assumption that community reduction is the aggregation of individual reductions, the community-wide effective polices will be those which alter or appeal to each individual. Thus, the players of the game are everyman and everywoman. The individual decision maker has only two strategies, to recycle or to not recycle. The players need only know which policy operates in their community and what the procedures for compliance are, I assume that both players are capable recyclers. The consequences of recycling or not correspond to the payoffs and these are known by all players.

As discussed at length above, rationality assumptions form the core of a decision-making model. In this analysis I use two sets of rationality assumptions (see below). The first is a short-term biased, calculative rationality; the second, conservationist rationality, is a long-term biased, consequentialist rationality. Common to both are a knowledge of the rules of the game, knowledge of each other's preferences, and a decision process whereby each player attempts to maximize her payoffs.

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1Of course communities have more than two individuals, however, the purpose of this model is to simplify the system, then later, add the complexities of the real world.
Collective action games

Collective action situations are common in social arenas. So common that the general structures have been modeled as games (Mueller 1989, Sandler 1992a, 1992b, McLean 1987, Reisman 1990, Axelrod 1984). Each situation's structure is different (and there are many more structures not included here), altering the likelihood of public good provision and the solution to that provision problem. In order to emphasize the structural differences among the situations the games will be presented with ordinal payoffs or rankings where 4 is the best and 1 is the worst. Within each cell of the matrix the left-hand numbers belong to the row person and the right-hand numbers belong to the column person. In this analysis I choose three games as examples of the basic situations in collective action. The situation which is least likely to result in public good provision is called Prisoner's Dilemma, then Chicken, and finally Fully Privileged where it is most likely to develop (Sandler 1992a). Each game has its own story and special characteristics. While going through the games, I will introduce several ideas basic to any discussion of games.

Prisoner's Dilemma

The most discussed and analyzed game in political science is Prisoner's Dilemma. The story line revolves around two prisoner's who must decide whether or not to confess to a crime. The police set the stage, telling each that if she confesses and the other does not then they will let her off with a light sentence and throw the book at the other person. However, if both confess there will be a moderate sentence for each, and if neither confess then they will be convicted of a lesser crime. The ordinal payoff is in Figure 1.
Each prisoner reasons, "it is best if I confess and you don't, second best if we both don't confess, then if we both do confess, and worst of all for me if I don't confess and you do" (McLean 1987). It is the goal of each player to choose a strategy which is the best for her no matter what the other prisoner does, a dominant strategy. Dominance means that the payoffs of one strategy are greater than the corresponding payoffs of all other strategies, given the opponent's strategy choices.

|        | prisoner 2 
|--------|-------------
| don't confess | confess |
| don't confess | 3, 3 | 1, 4 |
| confess | 4, 1 | 2, 2 |

Figure 1. Collective action games: Prisoner's Dilemma (ordinal ranking: 4 is best, 1 is worst)

Examining prisoner 1's choices, if prisoner 2 does not confess then if prisoner 1 confesses she gets 4 or if she does not, 3. Confessing is the preferred choice. If however, prisoner 2 does confess, then prisoner 1 can either not confess and get 1 or confess and receive 2. Again the better choice is to confess. Since, given either of the opponent's choices, confessing yields the greater payoff (4>3, 2>1) prisoner 1's dominant strategy is to confess. Both prisoner's will reason to the same conclusion, both will confess, and both will receive 2 (this cell is marked with an asterisk, *). Collective action, in the sense of working together for a preferred outcome, both not confessing, does not materialize. In Olsonian terms, the prisoners are members of a latent group. Because neither
sees her own contribution to be worth the cost of silence (not confessing), neither contributes, both are worse off.

**Chicken**

In the game of Chicken, with the story line from James Dean's *Rebel without a Cause*, collective action is a life or death decision. In a dare of nerves, two players driving for a head-on collision where each rebel can either swerve or not swerve her car before crashing. The players reason, "My best situation is for the opponent to swerve while I don't, second best if we both swerve, then that I alone swerve, and worst if we both don't swerve and crash." The ordinal ranking is in Figure 2.

<table>
<thead>
<tr>
<th></th>
<th>don't swerve</th>
<th>swerve</th>
</tr>
</thead>
<tbody>
<tr>
<td>don't swerve</td>
<td>a 3, 3</td>
<td>b 2, 4</td>
</tr>
<tr>
<td>rebel 2</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>swerve</td>
<td>c 4, 2</td>
<td>d 1, 1</td>
</tr>
</tbody>
</table>

Figure 2. Collective action games: Chicken (ordinal ranking: 4 is best, 1 is worst)

In the analysis for dominant strategy we see that for rebel 1 if rebel 2 swerves it is best not to swerve (2>1); but, if rebel 2 doesn't swerve it is best to swerve (4>3). Since the strategy choice for rebel 1 changes, as rebel 2 changes her choice, there is no dominant strategy. Without a dominant strategy, there is a broader solution mechanism: *Nash equilibrium*. A Nash equilibrium is a strategy combination from which neither player will voluntarily change
strategies (a dominant strategy is also a Nash equilibrium, although not vice versa). Each cell represents a different strategy combination and must be examined for each player's strategy choice. In cell "a" (don't swerve, don't swerve) rebel 1 prefers swerve to don't swerve (4>3) as does rebel 2 (4>3) and each unilaterally will change (change assuming the other player's strategy choice is given); therefore, cell a is not a Nash equilibrium. Cells b and c are symmetric, so only one needs to be examined. Cell b represents rebel 1 not swerving and rebel 2 swerving. The alternate choice for rebel 1, swerve, yields a lower payoff (1<2), she will not want to move. For rebel 2, a change to don't swerve would also decrease her payoff (3<4), therefore, she does not change. Neither rebel will change, therefore, cell b (and cell c) is a Nash equilibrium. Since cell d represents the worst payoff for both rebels each will want to change, thus, it is not a Nash equilibrium. Collective action materializes in cells b and c but is provided by only one player.

Unlike Prisoner's Dilemma where no collective action is an acceptable solution for the players, avoiding the worst payoff; in Chicken games this is the worst possible outcome for both players. The costs of both doing nothing are large enough that at least one person will cooperate to avoid the crash. In Olsonian terms, Chicken players are members of a privileged group. At least one member will provide the collective good; yet, each would rather not be the provider.

**Fully Privileged**

The Fully Privileged game gets its name from Olson's privileged group. The distinction "fully" means that all members of the organization or society
trying to provide a collective good will cooperate. In order to be Fully Privileged, all participants must have a dominant strategy to cooperate. In Figure 3, the ordinal payoffs reveal the structure of the game.

In this study, public good provision is assumed to fit into a Prisoner's Dilemma structure. As society identifies the public goods it wishes, wants, or needs to provide itself, which in this case is refuse reduction, the community seeks to move itself out of a Prisoner's Dilemma and into a Fully Privileged structure. A policy which falls short of Fully Privileged may create a Chicken game. These games serve as the standards against which I will evaluate the effectiveness of the policies.

<table>
<thead>
<tr>
<th>Person 1</th>
<th>Cooperate</th>
<th>Don't Cooperate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperate</td>
<td>4, 4</td>
<td>* 2, 3</td>
</tr>
<tr>
<td>Don't Cooperate</td>
<td>3, 2</td>
<td>1, 1</td>
</tr>
</tbody>
</table>

Figure 3. Collective action games: Fully Privileged (Ordinal rankings: 4 is best, 1 is worst.

Within the evaluative process, one must consider the individual decision making process. As a framework for modeling this process, game theory makes certain assumptions about human rationality. However, human rationality is not a singular phenomenon, it may be as varied as are people. Even so, there are some basic characteristics which can be generalized and used as assumptions of rationality.
Rationality

Garret Hardin (1968) popularized the basic environmental management problem in his *The Tragedy of the Commons*. The environment is a commons, that is, for the most part all people or groups of people have equal access to the environment (Sandler 1992a). It is in each person's best interest to maximize his utility of the commons. As all other people also maximize their utility, the commons may be destroyed. Hardin put it eloquently,

> Each man is locked into a system that compels him to increase his [use of the commons] without limit—in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons (Hardin 1968, 1244).

The tragedy is a result of both the system and the rationality of the commons users. The individual rationalities do not reflect the needs of the collective, that is, the aggregated individual rationalities are not collectively rational. The self-interested maximization of utility is but one definition of individual rationality emphasized in economics. In other disciplines, such as, sociology, political science, or psychology, rationality is defined as goal-oriented behavior (Simon 1946). It is the nature of the goal which determines what is rational. When self-maximization is the goal, economic rationality is the basis of decisions. If honesty and goodness in relationships are the goal then moral rationality (or value maximization) will be the foundation. In the examination of recycling, if responsibility to society both present and future is the goal then tapping economic, moral, and collective rationality is appropriate. Any situation may appeal to various individual rationalities.
The questions for policy formulators to address are to which rationality does their rationality appeal? To which are they trying to appeal? How can the appeal to individual rationalities lead to a collectively rational outcome? Public policy makes assumptions about human behavior. The literature discusses at least three models of rationality. Each rationality reacts differently to the same policy; thus, similar policies can lead to a variety of outcomes. The two individual rationalities explored and then used as the decision-making foundation in the games analysis are economic and ethical. Collective rationality is explored as a basis for evaluating the effectiveness of the policies' appeal to individual rationalities.

**Economic rationality**

Economic rationality is a consequentialist theory. Unlike moral theory which is based on the rightness or wrongness of the action, classical economic rationality is based on the expected utility\(^2\) of an action. Kristen Monroe outlines seven basic assumptions of economic rationality: 1) actors pursue goals, 2) these goals reflect the actor's perceived self-interest, 3) behavior results from conscious choice, 4) the individual is the basic actor in society, 5) actors have preference orderings that are consistent and stable, 6) if given options, actors choose the alternative with the highest expected utility, and 7) actors possess extensive information on both the alternatives and the likely consequences of their choices (Monroe 1991, 78). These assumptions form the basis of utility analysis and all classical economics. Even broader Olson states, "Economic (or

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\(^2\)Utility analysis is quite different from utilitarianism. Mill's utilitarianism is a moral theory which defines right action as that which yields the greatest benefit to the greatest number of people (greatest social benefit). Utility analysis has no such social impact and guides the behavior of the individual in terms of only what is best for him or herself.
more precisely microeconomic) theory is in a fundamental sense more nearly a theory of rational behavior than a theory of material goods (Olson 1969, 146)." In this sense economic rationality is synonymous to calculative rationality (Reisman 1990). Calculative because of the calculation and weighing of costs and benefits as a basis of decision-making.

Several of the assumptions of calculative rationality, are demanding of human cognitive abilities, such as, knowledge of consequences of actions and of the expected utilities of all possible actions. Many scholars shrink away from accepting such assumptions. Herbert Simon (1946) suggests a "bounded rationality" as more realistic. He outlines several factors limiting human abilities: (1) "skills, habits, and reflexes no longer in the realm of consciousness," (2) "his values and those conceptions of purpose which influence him in making his decisions," (3) "the extent of his knowledge of things relevant" (161). Thus, Simon leads us to believe that people make decisions on the basis of "bounded rationality," and attempt to satisfice rather than maximize (Simon 1957). While granting these, John Harsanyi (1977) states that the economic rationality assumptions yield good predictions over a wide range of social situations. Answering the question of why these assumptions provide good predictive results, Binmore (1992) suggests that most social situations are repeated and lend themselves to learning what is needed to function rationally. Beyond all this, the assumptions continue to be made and used because they are "simple and unambiguous (Schelling 1988, 239)," the goal of any model.

There is still another facet of economic rationality, the intertemporal value of utilities. Due to the possibility of investments and opportunity costs, future costs and benefits are worth less today, that is, the future is discounted.
Discounting is based on a given rate of return. One who is oriented towards the present will require a higher rate of return in order to invest in or worry about the future. While, one who values the future, will accept a lower rate of return. The difference being that the future oriented person perceives less difference between present and future costs and benefits than does the present oriented person.

The calculative person takes Schelling's approach to the market world. Costs and benefits acknowledged are narrowly economic and monetary. Their consideration is for the goal of self-regarding maximization of utility. From social and moral incentives one derives neither costs nor benefits. Finally, future values are highly discounted so as to have almost negligible present value.

**Ethical rationality**

Ethical or moral rationality is based on moral theory. There are many theories but all aim to provide principles or norms of right behavior and of valuation. Principles of right behavior guide actions and thoughts. Theories of valuation set standards and guidelines as to what states, things, or properties are intrinsically valuable. The value can be either of a moral or nonmoral value. Moral value expands the class of things to which one has a moral obligation.

There are two general approaches to moral theory, the difference is the importance of the effect of the action. Consequentialist or teleological theory judges value on the result of the action, whether or not it produces or maintains something which has been defined to be valuable. Deontological theories assess the rightness of the action based on qualities inherent in the action itself. Out of
moral theory flow normative ethics. Ethics have been traditionally human-centered or at least heavily human oriented, valuation based on its relationship with man. This leads to a predominately economic or utility based value.\textsuperscript{3} Advances in ecology demonstrating the interdependence of man and nature render the economic approach untenable if man is dependent upon parts of nature for which there is no economic value. It is from this dependence that the call for a new environment ethic springs.

A new ethical theory rejecting the anthropocentric view of traditional ethical theories in favor of an ecocentric (nature-centered) approach, accords man the status of "just another species," then seeks to determine values and standards for human behavior. This new environmental ethic must define what is to be valued. It is here that the road forks for types of environmental or conservation ethics. There are three basic positions which lie along a continuum from an ecocentric ethic to an anthropocentric attitude. Along the same lines, the continuum moves from the intrinsic value of nature to an ascribed value of nature (see Figure 4).

\begin{figure}[h]
\centering
\begin{tabular}{ccc}
<table>
<thead>
<tr>
<th>Ethical position</th>
<th>Ethical Preservationist</th>
<th>Ethical Conservationist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecocentric ethic</td>
<td>Valuation basis of nature</td>
<td>Ascribed</td>
</tr>
<tr>
<td>Conservation attitude</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{3}Although utilitarian theory does not limit valuation to economic utility, this has been the historical paradigm.
At the left end of the spectrum are the ethical preservationists,\(^4\) ecocentrists who, due to the interdependence of all living and non-living forms and systems, conclude that all of nature is intrinsically valuable. As such, all of nature is ascribed moral worth. In the middle are the ethical conservationists. While remaining anthropocentric, they acknowledge the full range of value in nature from its instrumental to existence value. These ethical conservationists call for a new normative ethic based on environmental needs and the obligations nature incurs upon man. Finally, on the right are the conservationists. The distinction between this group and the former is the call for an ethic. This last group calls only for a reexamination of the implication of traditional ethics as it relates to the environment.\(^5\)

In addition to generally guiding behavior, Thompson (1990, 149-150) lays out three logical, formal requirements of an "ethic": consistency, nonvacuity, and decidability. Consistency necessitates that all things alike in important respects be judged equally valuable. Nonvacuity requires that not all situations or things count as equally valuable; otherwise, there is no basis upon which to choose one course of action over another. Thirdly, a decision must be made. It must be possible to distinguish what is valuable and what is not.

The "intrinsic," ecocentric valuation of nature by the preservationists leads to many definitions and schema (see Leopold 1966, Routley and Routley 1980, Taylor 1986). Generally these schema suffer from generality and vagueness; thus, violating the resolvability requirement. For example, Leopold

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\(^4\)The labeling of these groups was inspired by Pearce and Turner, p.228-230.
\(^5\)Off the scale to the right are the exploiters. This group sees nature as a resource to be used and conquered. They can be seen as the foil for the rest of the spectrum.
(1966), author of the seminal preservationist work *Land Ethic*, values that which maintains, "integrity, stability, and beauty of the biotic community" (262). Yet, by not defining terms nor outlining a ranking scheme his standards are rendered vacuous in application.

Conservation ethicists, while still calling for a new environmental ethic, take a different approach. Rather than an ethic starting from scratch based on a novel, ecocentric valuation, this ethic is based on traditional, anthropocentric ethical theory extended and expanded to include environmental impacts and obligations. The moral community is expanded to include sentient animals. The difficulty with this approach is in the third requirement of decidability. Without an explicitly ranking the species, there is no guidance in difficult cases, for example, what is the moral decision when the needs of a dog and a cat, cow, or dolphin come into confrontation? There is no way to choose between them as equal members of a moral community.

Finally, there are those who do not call for an ethic. H.J. McCloskey explains this position: "[T]here is no need for a specifically ecological ethic to explain our obligations toward nature...[E]cology bears on ethics and morality in that it brings out the far-reaching, extremely important effects of man's actions, that much that seemed simply to 'happen' is due to human actions that are controllable, preventable, by man and by men, and hence such that men can be held accountable for what occurs" (McCloskey 1983, 31). Here man's needs come first but must be balanced against the immediate and long-term consequences.

There are several assumptions which one can make about the positions which a conservationist will hold. First, the future will be less discounted. The consequentialist assumption coupled with acknowledgment of environmental
impacts requires one to take responsibility for one's actions which impact into the future as if they are cumulatively impacting the present. As a result, conservationists take seriously their inter-generational, inter-temporal obligations. Secondly, in line with the interdependent nature of all life, a conservationist accepts a communal responsibility for environmental protection. Finally, a conservationist derives moral or conscience benefits from environmentally sensitive behavior; thus, she will act accordingly even when the economic incentives favor environmentally damaging behavior.

Collective rationality

"A public good, roughly speaking, is a good that can be produced only by collective action, but its production benefits people regardless of whether they join in the collective effort. Such collective action as is necessary to provide public goods is collectively rational in a straightforward sense. Even so, it is not individually rational for people to voluntarily to do their part to secure a collectively rational outcome" (Schmidz 1991, 1, emphasis in original).

Collectively rational refers to the ability of a group to be "goal-oriented" toward ends which benefit the whole.

Basic ideas about collective rationality revolve about the role of individuals. Should individual rationalities be aggregated for a social preference? Or is social rationality distinct from individual rationality? Adam Smith (1937) professes the aggregation of individual preferences, that all people

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6 A standard against which one can evaluate social preferences is pareto optimality. A pareto optimal outcome is one where no one person can be made better off without making another person worse off. In terms of social choice a pareto optimal choice is one where if everyone prefers apples to oranges then society prefers apples to oranges. Its importance is that society should choose that solution in which everyone is best off as a whole.
working for their "own gain," inadvertently but surely, will be "led by an invisible hand to promote... the public interest" (1937, 423). There are, however, problems with this theory. Arrow's general impossibility theorem show that summation of preferences across individuals leads to a cycle where the result varies with the choice of vote order, i.e., is in essence random (Plott 1976, 97-98). Plott (1976) explains that the transfer of individual preferences to collective preferences is a "classic fallacy of composition," and claims that the whole idea of social preferences "must go" (109).

He turns to a social rationality distinct from the individuals who compose the society: social welfare functions. These functions are analogous to individual utility functions, outlining the variables which affect social choices. The classic Bergson-Samuelson social welfare function is;

$$W = W(z_1, z_2, ..., z_n),$$

where $W$ is the value of the function and $z_i$'s represent the variables which affect social welfare (Mueller 1989, 373). This function assumes society should maximize its welfare as an individual maximizes her utility.

Collective rationality springs from two possible sources: one, an aggregation of the individuals or, two, a distinct axiomatic choice mechanism. Ideally, public policy should represent social preferences seeking to maximize social welfare. While the policy selected is itself a social choice, as a given it can provide direction to individuals making decisions about personal behavior having collective impacts. Hardin (1968) suggests "mutual coercion, mutually agreed upon," as the basis of commons regulating public policy.

In the discussion of the commons, collective rationality leads to an escape from the tragedy of the commons. In a larger sense this whole paper discusses
one path to collective rationality. A model of the interaction of individual and collective rationalities, distinct yet related phenomena, will help structure this discussion (see Figure 5). Public policy structures the interactions of individuals. This interaction is the basis of society. The way in which these relationships develop ultimately determines collective rationality (collective action) or collective irrationality (collective failure). The relationship between individuals and the collective, on a common resource issue such as refuse, is direct. The aggregation of individual behavior is the collective behavior, as such, I turn to Smith's aggregation of individual preferences but without his invisible hand. Rather there is a visible hand of public policy which links individual and collective rationality, so that the individually rational is also the collectively rational. A policy which does not link the individual to the collective will not be collectively rational.

![Figure 5. Collective rationality model](image.png)
Because collective goods are available to all, it may be necessary to establish the link by appealing to private benefits, i.e., use Olsonian selective incentives. In a sentence, public good provision must be in society's private interest.

In the discussion of rationalities, two basic distinctions have been made, individual and collective, and within individual, economic and ethical. The individual/collective distinction embodies the tension which creates the tragedy of the commons. Escape lies in the linkage of the individual to the collective. In the analysis which follows the individuals are analyzed in terms of their rationalities, but the standard for success will be in terms of the collective rationality of an aggregation of individuals. Thus each rationality, individual and collective, has a separate role in this paper, individual rationality guides decisions within a policy structure and collective rationality is a standard to evaluate the effectiveness of the policy itself.

**Propositions**

The above discussion of rationalities coupled with the analysis of refuse reduction as a collective action problem modeled using game theory leads to several propositions about the various policy impacts. These propositions include the anticipated results of changes in the cost/benefit structure resulting from the policy strategy. Along the policy continuum, as the incentive to recycle increases so the participation in the program is expected to increase.

Those using a calculative rationality are expected to be the last to participate. These citizens will require options very biased toward recycling. Conservationists will be more likely to participate than the calculative citizens, requiring the opportunity to recycle rather than strong economic incentives.
As this suggests, the type of policy will impact the two rationalities differently. Policies which utilize voluntary approaches, without pricing system changes (voluntary drop-off centers and curbside collection), shift conservationists from the latent to fully privileged groups, while calculative citizens remain in the latent group. Other policies, which internalize the externalities through either a change in the pricing system for solid waste collection (volume based rate) or a penalty price (mandatory separation with curbside collection) will shift individuals from membership in the latent groups to fully privileged groups.

In the model formulation in the following section, there will be four games which build on the basic two person games. Games which model repeated encounters and n-person groups in voluntary curbside policy will result in shifting the structure to privileged groups. Also, a model of the situation where the two rationalities interact. Using game theory to analyze the basic policy strategies allows me to hypothesize how the policies are expected to impact real communities facing the real problem of landfill depletion. These models will be the foundation for the empirical study of refuse reduction policy.
Measurement of costs and benefits

There are two general categories of both costs and benefits: public and private. Public costs and benefits are analogous to public goods, in that they are nonrival and nonexcludable. The characteristic most relevant is nonexcludability. A public benefit available to one member of the community is available to all. A public cost is divided among all members of a community. Private costs and benefits are neither shared nor divided with anyone. Each is enjoyed or borne by the individual in toto.

Comparison of costs and benefits is the basis of the decision making process. Therefore, it is the relationship between the numbers which is important rather than the exact numbers themselves. I begin with this statement because the numbers used in this analysis do not represent any single unit. The costs reflect the price of garbage collection, the cost of gasoline to drive to the recycling center, and the time and effort required to separate trash. Benefits can include the extended life of the landfill, a clear conscience, or prestige in the neighborhood. As Olson states, "To say that rational decision-making maximizes 'expected utility' says...that decision makers take all of their objectives, material and intangible, selfish and altruistic, into account" (1987, 206; emphasis in original).

The public benefit of any one person recycling is set at 5. If any policy structure encourages or makes possible an increased amount of recycling per
person, then the public benefit also increases. Private benefits considered relate to one's feelings about recycling. For some it is assumed that doing something about the environment, reducing future public costs, and doing the right thing all increase the personal benefit of recycling. For others it is the prestige in the neighborhood or status as a recycler which are private benefits (this is relevant only in the repeated game).

Table 1. Costs and benefits for recycling policy games

<table>
<thead>
<tr>
<th></th>
<th>Private Costs</th>
<th>C(mnp)</th>
<th>C(np)</th>
<th>Public Benefits</th>
<th>Private Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Game 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>calculative</td>
<td>10</td>
<td>1</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>conservationist</td>
<td>10</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td><strong>Game 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>calculative</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>conservationist</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td><strong>Game 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>calculative</td>
<td>8</td>
<td>2</td>
<td>40</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>conservationist</td>
<td>8</td>
<td>3</td>
<td>40+1</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td><strong>Game 4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>calculative</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>conservationist</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td><strong>Game 5 (Game 4)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>calculative</td>
<td>6</td>
<td>2</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>conservationist</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td><strong>Game 6 (Game 2)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>calculative</td>
<td>7</td>
<td>2</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Game 7 (Game 2)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>calculative</td>
<td>7</td>
<td>2</td>
<td></td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
The costs of recycling are private. The exception being when no one participates, this could necessitate a new landfill which represents a public cost. Across policies, private costs vary by the required time and effort to recycle. Across rationalities, these costs vary by futures discounting. Mutual non-participation costs, $c(mnp)$, that is when no one participate, represent the discounted future public costs plus any present penalties for such behavior. Government intervention in the siting of a new landfill and, possibly, the reclamation of the present landfill represent future public costs. When no one participates the probability that these events come to fruition increases, hence, the non-zero cost of mutual non-participation.

A table of the costs and benefits for the seven games is presented in Table 1. The discussion of the exact values is included in the individual games. It is included here for reference and summary purposes.

**Recycling policy games**

The general recycling story involves two citizens both with the opportunity to recycle or not to recycle. As is generally common with public goods, the cost of cooperation is greater than the benefits of any one person’s participation would accrue to herself, hence, the need for cooperative behavior. For each policy two game matrices are created: first calculative, then conservationist. The payoffs (rather than the ordinal rankings of the collective action games) are calculated from the costs and benefits. In each cell, the left-hand (or first entry) value belongs to the row player (person 1) and the right-hand (second entry) value belongs to the column player (person 2).
Games 1, 2, 3, and 4, are the four policies in game form. Games 5, 6, and 7, are variations on the original policy games. Game 5 is volume based pricing with both rationalities in the same encounter. Game 6 is a repeated version of voluntary curbside collection, while, Game 7 is the same game involving an n-persons group. These last three games are attempts to expand the model to more realistic assumptions.

**Game 1--General Recycling Game--Voluntary drop off centers**

The general game of recycling uses a community with voluntary drop off centers. The benefits of voluntary reduction are, say 5, to each person; while its costs are 10 for each individual. If no one participates, then each individual bears the costs of her non-participation which due to discounting remain small, say 1. The payoff matrix, Figure 6, develops as follows: if both recycle then each earn their own and each other's benefits minus their cost of participation, that is, 

\[(n \times b) - c \text{ or } (2 \times 5) - 10 = 0.\]

If only one recycles, then the recycler receives the benefits of her effort minus her own cost which is 

\[(1 \times 5) - 10 = -5;\]

meanwhile, the nonrecycler gets the benefits of the others effort minus her cost or 

\[(1 \times 5) - 0\text{ or }5.\]

Finally, if both choose not to recycle, then both forfeit any benefits and pay the costs of mutual non-participation, which is 

\[(0 \times 5) - 1 = -1.\]

In this general game, the dominant strategy is to not recycle. For person 1, if person 2 recycles, not recycling yields the larger payoff \(5 > 0\). If person 2 does not recycle, not recycling is still better for person 1 because -1 is greater than -5. The cell which represents the solution to the game is marked with an asterisk (*)


### Figure 6. Game 1: calculative rationality (public benefits=5, private costs=10, costs of mutual non-participation (cmnp)=1) *solution*

<table>
<thead>
<tr>
<th>Person1</th>
<th>recycle</th>
<th>don't recycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>recycle</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Person2</td>
<td></td>
<td>-5, 5</td>
</tr>
<tr>
<td>0, 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>don't recycle</td>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td>5, -5</td>
<td></td>
<td>-1, -1</td>
</tr>
</tbody>
</table>

The rationality assumption above is strictly calculative. If one uses a conservation rationality, the individuals' costs and benefits change. Consistent with its long-term oriented consequentialist assumptions, this attitude requires one to place more value on the future impact of not recycling. Thus, the cost of non-participation increases due to the discounting of likely, although uncertain, future events and to the guilt one may feel for nonparticipation. The costs of non-participation is 1. Mutual non-participation is the individual costs of 1 plus the mutual costs of one, mentioned in the calculative game, for a total of 2. While the costs of participation do not change, the individual also will receive private benefits as a result of the moral satisfaction of having done the "right thing." Assume these private benefits, available only to the recycler, are say, 3. Thus in addition to the public benefit of 5 to each player, the recycler can receive an extra 3 for a total of 13. The new game matrix is in Figure 7.
With the introduction of the private benefits, the payoff matrix changes. If both recycle, then each earns both the mutual public benefits plus the individual private benefit minus the costs of participation, which is \((2 \times 5) + 3 - 10 = 3\). If only one recycles then the recycler receives her public and private benefits minus the costs of participation or \((1 \times 5) + 3 - 10 = -2\). The nonrecycler gets the other's public benefits minus her costs of participation \((1 \times 5) - 1 = 4\). If neither recycles then each pays the price of mutual noncooperation, \((0 \times 5) - 3 = -3\).

In this matrix a dominant strategy does not exist. The solution is determined by finding the Nash equilibrium point(s). Beginning with cell a in Figure 7, where both recycle, both players would prefer to not recycle if her opponent recycles, hence, both recycling is not a Nash equilibrium point. In cells b and c, begin with the recycler, she would not want to switch from recycling because her payoff would decrease, neither would the non-recycler would not want to start recycling. Both are Nash equilibria since neither player unilaterally will change strategies. Finally, we turn to cell d. When neither recycles, each would prefer, unilaterally, to switch to a recycling strategy in
order to receive increased benefits. The Nash equilibria cells are marked with an asterisk (*).

**Game 2--Voluntary curbside collection**

Voluntary drop off centers provide opportunity to recycle but no real incentives to do so. The next policy within the recycling policy spectrum of incentives is voluntary curbside collection. This policy has two significant characteristics. First, curbside collection reduces the costs of recycling, no longer is it necessary to drive to the center, to use that time and energy. Also, what to recycle is the individual's decision, there is no penalty for recycling incorrectly or incompletely. Secondly, it becomes possible for everyone in the neighborhood to know who is and who is not recycling. While unimportant in a single encounter model, this social aspect can impact the repeated situation.

There are, however, costs associated with curbside collection. There must be separate storage containers and area for recyclables. On the whole the time and effort reduction, lowers the costs of participation to say, 7. When no one participates the cost of mutual non-cooperation increases to 2 to cover the additional fixed costs of recycling. As before, the public benefits of recycling are 5 (see matrix, Figure 8).

Both players' dominant strategy is to not recycle. When the other player recycles, the first is better off not recycling (5 > 3). If the other player does not recycle, then the first is at least as well off by not recycling (-2 = -2). The addition of a voluntary curbside service has not altered the decision solution of those citizens motivated strictly by the economics of the situation, although it could if the costs and benefits were different (see summary below).
As earlier, when the rationality assumptions of the game are changed then the payoff matrix and solution to the game change. For conservationists, the public benefits of participation are 5. The private benefits of moral satisfaction in recycling remain at 3. There are two sources of costs for non-participation. The first is the guilt due to not recycling, as in Game 1. 1. The costs of mutual non-participation, as for the calculative person, cover the fixed costs of the recycling program, 2. The total costs for mutual non-participation for the conservationist is thus, 3. The payoff matrix is in Figure 9.

Figure 8. Game 2: calculative rationality (public benefits=5, private costs=7, costs of mnp=2) *solution

<table>
<thead>
<tr>
<th></th>
<th>recycle</th>
<th>don't recycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>recycle</td>
<td>a: 3,3</td>
<td>b: -2,5</td>
</tr>
<tr>
<td>Person1</td>
<td>c: 5,-2</td>
<td>d: -2,-2</td>
</tr>
<tr>
<td>don't recycle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The dominant strategy changes to recycling. The importance of this solution is that each individual is now a privileged group, that is, each individual will recycle, or provide the public good, no matter what the other player does. When the dominant strategies are to cooperate, each person is a privileged group, hence, the structure is called Fully Privileged.

**Game 3--Mandatory curbside collection**

<table>
<thead>
<tr>
<th>Person1</th>
<th>Person2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>recycle</td>
<td>don't recycle</td>
</tr>
<tr>
<td>recycle</td>
<td>a 4, 4</td>
<td>b -2, -34</td>
</tr>
<tr>
<td>don't recycle</td>
<td>c -34, -2</td>
<td>d -42, -42</td>
</tr>
</tbody>
</table>

Figure 10. Game 3: calculative rationality (public benefits=6, private costs=8, fine=40, costs of mnp=2) *solution

Mandatory recycling gains currency in communities where the need to recycle is greatest. By mandating recycling the community uses economic incentives to attempt to force individuals to recycle. The incentive used here is a fine for not recycling. The fine is levied for not recycling. The increased pressure on each individual to remove all (or all of certain) recyclables or else be fined raises the individual effort of recycling above that of the voluntary curbside program. It will not however equal to the drop off center's effort as, it is collected at one's curbside and once the process is learned it will require only slightly more effort than the voluntary curbside collection. The individual cost of
mandatory recycling will be say, 8. The cost of nonparticipation will be the price of the fine for non-participation. The fine needs to be large enough to ensure that everyone will want to participate, let's say five times the individual cost of participation, that is, 40. The public benefit of recycling increases as the volume of unseparated trash per person will decrease when all, even difficult and unobvious items, recyclables are removed. The benefits change from 5 to 6. The payoff matrix is in Figure 10. The dominant strategy for both is to recycle, making the game Fully Privileged.

<table>
<thead>
<tr>
<th></th>
<th>Person2</th>
</tr>
</thead>
<tbody>
<tr>
<td>recycle</td>
<td>*</td>
</tr>
<tr>
<td>don't recycle</td>
<td>c: -35, 1</td>
</tr>
</tbody>
</table>

Figure 11. Game 3: conservation rationality (public benefits=6, private benefits=3, private costs=8, fine=40, costs of np=1, costs of mnp=3) *solution

Using conservation rationality, the major change in benefits is the addition of private benefits, still 3. The guilt attendant to non-participation adds to the fine level, increasing the cost of mutual non-participation from 40 to 43. The payoff matrix, Figure 11, includes the same cost of participation as calculative rationality. The solution to the game is, for the first time, the same for both rationalities.
Game 4--Voluntary curbside collection with volume based pricing

None of the preceding policies explicitly uses price changing incentives. Volume based pricing means that one's garbage bills reflect the amount of unseparated garbage one sends to the landfill. By increasing the amount of recyclables one decreases the amount of "regular" trash and thus one's garbage bill. This savings indirectly reduces the cost of voluntary recycling. Thus where the cost of recycling is 7 for voluntary curbside collection, that same collection with volume based pricing is 6. The benefits of recycling and the cost of mutual non-cooperation remain the same. The game matrix is in Figure 12.

<table>
<thead>
<tr>
<th></th>
<th>recycle</th>
<th>don't recycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>recycle</td>
<td>a: 4,4</td>
<td>b: -1,5</td>
</tr>
<tr>
<td>don't recycle</td>
<td>c: 5,-1</td>
<td>d: -2,-2</td>
</tr>
</tbody>
</table>

Figure 12. Game 4: calculative rationality (public benefits=5, private costs=6, costs of mnp=2) *solution

This game structure is similar to the drop off center for conservationists. Neither game has a dominant strategy and therefore the solution is found using Nash equilibria. The equilibria is when only one person recycles. This collective action structure is the chicken game. The combination of volume based pricing and the conservation rationality shifts the game from two Nash equilibria to a dominant strategy of recycle. And the Chicken game becomes a Fully Privileged game (see Figure 13).
Figure 13. Game 4: conservationist rationality (public benefits=5, private benefits=3, private costs=6, costs of np=1, costs of mnp=4) *solution

|       | Person2
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>recycle</td>
<td>don't recycle</td>
</tr>
<tr>
<td>Person1</td>
<td></td>
</tr>
<tr>
<td>recycle</td>
<td>a</td>
</tr>
<tr>
<td>don't recycle</td>
<td>c</td>
</tr>
</tbody>
</table>

Game 5--Game 4 with both rationalities

No town or community has a homogeneous decision-making process. Some members of the community are calculative while others are conservationists. The result is a game (see Figure 14) which is no longer symmetric and in which each player must consider the other's rationality as well as strategy choices before choosing a strategy.

In the search for a solution, if either has a dominated strategy, then that strategy option is eliminated and the other player chooses her best response to the remaining strategy. This process is called iterated dominance. From person 1's point of view, knowing that person 2 is calculative she determines whatever she (person 1) does, person 2 will do the opposite. This means, person 2 has no dominant strategy, and, neither of person 2's strategies can be eliminated.

Consider person 2's thoughts, she calculates that person 1 has a dominant strategy to recycle. Person 2 reasons that her best response to person 1 recycling is to not recycle. Thus, the solution is for the conservationist (person 1) to recycle and the calculative person 2 to not.
Game 6--Game 2 in a repeated situation

This repeated game is built on Game 2 with calculative rationality. Game 2 was chosen because of its Prisoner's Dilemma structure, the basis of most collective action problems. The repeated situation adds the time dimension to the discussion. When discussing time-valuations, one immediately considers discounting. The discount rate is \( r \) and is derived from the formula: \( r = 1/(1+i) \), where \( i \) is the interest rate. The costs and benefits of this game are the same as Game 2.

In the nonrepeated games discussed earlier, there were two strategy options: to recycle or not to recycle. Now that the players interact more than once there is the possibility of changing that strategy during the play. There are an infinite number of ways to vary the strategies; but in this analysis, I choose to use one varying strategy choice: tit-for-tat. In tit-for-tat (tft), the player recycles on the first encounter, on all following encounters, the player matches the behavior of her opponent in the previous round. The strategy was developed by Anatol Rapoport for a computer tournament of strategies for repeated Prisoner's...
Dilemma sponsored by Robert Axelrod (1984). Of the submitted strategies, tit-for-tat won the tournament, that is, while it did not beat the competition (tying is its best hope) it remained close in total payoff, and because the tournament was scored so that close counted, tit-for-tat beat the other strategy entries (Dixit and Nalebuff 1991, 107). Because it appears to be the "best" varied strategy, I use only this varying strategy. The other two strategy choices also take on a temporal dimension. If one chooses the recycle strategy, then this is the strategy used in all following encounters. The same is true for not recycling, this is the strategy of choice for the entire time of the repeated encounters.

In a three by three matrix, the solution is sought using an iterated dominance approach (see Figure 15). This matrix is symmetric, so a strategy which is dominated for person 1 is also dominated for person 2. To read each cell, the top entry (slightly to the left of the cell) belongs to person 1, and the lower entry (slightly to the right of the cell) belongs to person 2. The payoffs are read as follows, when person 1 and person 2 use tit-for-tat each receives 3 on the first encounter and a discounted 3 thereafter, hence 3+(3/1-r). Let's begin with person 1 and compare tit-for-tat (tft) with recycle. These two strategy choices yield the same payoffs, however, the source of the payoffs is different. If person 1 uses tft while person 2 uses don't recycle, she receives -2 on the first encounter as the only recycler and a discounted -2 thereafter for the mutual non-participation. When person 1 recycles and person 2 does not, then she receives -2 on the first encounter and thereafter as the only recycler. Neither strategy choice dominates the other.

Next to compare not recycling to recycling (or tft since they are equivalent), for person 1. If person 2 does not recycle, then the payoffs are the
same for either strategy: -2 on the first encounter and -2 thereafter. For a recycling person 2, person 1 will prefer to not recycle \((5+(5/1-r))>3+(3/1-r))\). When person 2 chooses tit-for-tat person 1 needs to calculate which payoff is larger. To solve the equation she needs to determine the value of \(r\) for which one cell is larger than the other. Assuming that recycling is larger, the equation is as follows:

\[
3r(1-r) > 5 + (-2/1-r)
\]

\[
r > 3/8
\]

When \(r>3/8\), recycling yields the larger payoff. Again there is no dominant strategy. Next is the search for a Nash equilibrium(a).

Beginning again with cell a. Person 1 compares her payoffs in cells a, d, and g. Of these no cell is better than a, Person 1 will not change. Person 2 compares her payoffs in cells a, b, and c, again cell a is at least as good as the rest, our first Nash equilibrium point. Next to cell b, person 1 compares cells b, e, and h, cell h has the highest payoff, person 1 will shift, this is not a Nash equilibrium. In cell e person 1 will again shift to cell h. Cell c represents person 1 tft and person 2 not recycling. Actually, if person 2 does not recycle then all strategy choices for person 1 are equal (cells c, f, and i). Now we need to analyze these cells from person 2's perspective. For person 2 when person 1 does tft, she would prefer to also tft or recycle (cells a or b), hence cell c is not an equilibrium point. If person 1 recycles, then not recycling is person 2's best strategy, thus cell f is a Nash equilibrium point, due to symmetry in the matrix, cell h is also a Nash point. Finally, the last cell, cell i. This is where both players do not recycle, and this was the solution to the single encounter game.
Figure 15. Game 6: calculative rationality in repeated game (public benefits=5, private costs=7, costs mnp=2) *solution

For both players all do not recycle payoffs are equivalent so there is no cell that either player would rather be in, given that the opponent is not recycling. The conclusion then is that there are four Nash equilibria points, cells a (tft, tft), f and h (one recycles, one does not), and cell i (neither recycles).

The solution to this game is indeterminate. It is impossible to guess which potential solution will chosen by real players. There are several factors which could influence the citizens. Because the citizens are interacting with each other over time social incentives may play a role. Some citizens may want to establish a reputation as a "good citizen" (recyclers), others may want to keep up with the neighbors and follow their lead (tit-for-tat strategy choosers), others may live in a community without much interaction and social incentives play no role (maybe not recyclers).
The game may have had a more useful solution if the costs and benefits had been different. In this game, the unusual situation of having the single recycler payoff and the mutual non-participation payoff being the same led to the equivalence of the strategy choices for player 1 when player 2 did not recycle. If the single recycler received a more negative payoff (or the costs of mutual non-participation was closer to zero) then the two equilibria where one recycles and one does not would not be Nash equilibria.

**Game 7--Game 2 with n persons**

Extending the game to more than 2 persons, more closely reflects the interactions of a community. In order to analyze such a game one considers five situations: where no other persons participate, where some number \(j\) minus one participate, \(j\) participate, \(j\) plus one participate, and where everyone else participates. This should reflect any possible combinations of persons interacting. As was Game 6, this game is based on Game 2, using the same costs and benefits. As usual, the search for a solution begins with an exploration for a dominant strategy (see Figure 16, Sandler 1992). In this case, not recycling is larger by 2 for every combination except if no one else participates, in which case, the two are tied. The dominant strategy is to not recycle. Introducing a larger number of people into the game has not changed the outcome, as in the 2 person game the solution is not recycle, as all players will reason to the same conclusion, we have not escaped the Prisoner's Dilemma. The citizens have remained in their latent group.
Summary of Propositions

For the policies, it was anticipated that both mandated curbside collection and volume based pricing would create privileged groups regardless of the rationality. The privileged group would result from voluntary approaches including curbside collection and drop off centers for conservationists, leaving the calculative citizens in their latent state. When the two rationalities anticipate each other’s actions, the expectation was for the conservationist to recycle and the calculative citizen to let her while she did not recycle. For the special games, repeated play and n-person, different results were expected. In both cases, examined only under calculative rationality, the voluntary curbside collection was expected to shift individuals into cooperation.

On the whole the expectations were borne out fairly well. For a summary of the results see Table 2. The summary table includes the game solutions, their structure, and the end game group membership. The recycling game is assumed
to be a Prisoner's Dilemma, the impact of the incentives is measured in terms of movement towards Fully Privileged games and membership.

As expected conservationists will generally recycle as long as it is possible and certainly when it is at all convenient. The impact of incentives on the calculative persons mirrors the strength or pointedness of the incentives. As expected mandatory recycling shifted even these self-maximizers to independent collective action. What did not happen though, was the same shift to fully privileged for volume based pricing. Instead an privileged group situation where one person recycles was created.

For the special games the solutions were not as anticipated. For the n-person game, there was no shift from Prisoner's Dilemma. The repeated game yielded an indeterminate solution, either both use tit-for-tat and therefore recycle, or both don't recycle, or one recycles and one does not. Even thought, Volume based pricing did not shift as was expected. It offers an example of the importance of the price. If the price change could have created a large enough decrease in the individual's costs the game would have shifted to Fully Privileged. The conclusion for a town considering the implementation of price changes, is for them to examine the prices and be certain they are affecting the intended results. In the case of volume based pricing, the marginal rate for each additional bag needed to be large enough that it becomes worth the individual effort to reduce the amount of trash. At the same time, there needs to be enough revenue for the managing company or agency to cover the long term costs.
Table 2. Results

<table>
<thead>
<tr>
<th>Game solutions</th>
<th>Calculative</th>
<th>Rationality</th>
<th>Game Structure</th>
<th>End Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Calculative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Game 1</td>
<td>no recycling</td>
<td>one recycles</td>
<td>Prisoner's Dilemma</td>
<td>latent</td>
</tr>
<tr>
<td>Game 2</td>
<td>no recycling</td>
<td>both recycle</td>
<td>Prisoner's Dilemma</td>
<td>latent</td>
</tr>
<tr>
<td>Game 3</td>
<td>both recycle</td>
<td>both recycle</td>
<td>Fully Privileged</td>
<td>fully privileged</td>
</tr>
<tr>
<td>Game 4</td>
<td>one recycles</td>
<td>both recycle</td>
<td>Chicken</td>
<td>privileged</td>
</tr>
<tr>
<td>Game 5</td>
<td>conservationist recycles</td>
<td>--</td>
<td>privileged</td>
<td></td>
</tr>
<tr>
<td>Game 6</td>
<td>indeterminate</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Game 7</td>
<td>no recycling</td>
<td>--</td>
<td>Prisoner's Dilemma</td>
<td>latent</td>
</tr>
</tbody>
</table>

While all the policy strategies could be used to effectively promote refuse reduction through recycling, not all are equally likely to do so. From this fact, a number of hypotheses flow from the game solutions.

1. Voluntary approaches will lead to less refuse reduction than will mandatory or price changing approaches.

2. Voluntary curbside collection will lead to a greater reduction in landfilled cubic yardage than voluntary drop-off centers.

3. Whereas the success of a volume based system would depend upon the price chosen, this price should make the benefits of recycling (including cost savings) greater than the cost of participation.

4. Mandatory curbside collection and a correctly priced volume based pricing system should have the same landfill reduction impact.
ANALYSIS AND FINDINGS

In the previous section games were constructed and analyzed. Based on those results hypotheses for policy impact were generated. Data with which to test these hypotheses should become available as Iowa's municipalities and counties carry out the mandates of the 1987 GPA and 1989 WR-RA. These policies mandate a 25% reduction in landfilled waste by 1994 and a 50% reduction by 2000, over then next few years. However, due to the time lapse between mandating, and planning, piloting, and implementing programs is short, the data currently available is often inadequate for serious statistical analyses. Additionally, many towns and communities have not kept complete records to date and are not required to submit "their numbers" to the state until 1994. Thus; the plethora of anticipated data is not yet available.

One town for which data is available and which has used two of the four policy strategies of this paper is Waverly, Iowa. Waverly uses its own sanitation trucks it keeps track of the cubic yardage sent to the landfill, while other towns, which contract with private companies, often do not keep the same detailed records. Waverly has gone through various planning and implementing stages since the 1989 WR-RA. Refuse reduction planning started with a citizen organizing board in November 1989. Beginning in January of 1990, yardwaste was removed from the general collection. The following year, January 1991, the voluntary drop-off center was opened. Then in January 1992 a volume based pricing system was introduced followed in March of that year with a voluntary curbside collection program. Since the major policy changes usually were instituted on the first of the year, comparing calendar years, rather than fiscal
years (July through the following June) is appropriate. The cubic yardage for each year, by month, is listed in Table 3. As with the 1989 law, I use 1988 as the baseline year.

Comparing the complete years to each other, 1989 shows virtually no change over 1988. This supports the idea that a mandate, state or otherwise, is not an effective tool, in and of itself, for collective action. Beginning January 1, 1990, the WR-RA mandated the removal of yard waste from the landfill waste stream. Most of the fifteen percent difference between 1988 and 1990 can be attributed to the program to the yard waste removal. In January 1991, Waverly began its own refuse reduction policy, using the first policy discussed in this paper, voluntary drop-off centers. This policy cut the landfilled cubic yardage another eight percent. Comparing the first six months of 1992, after the introduction of volume based pricing and subsequent voluntary curbside collection, the 1988 levels were cut by thirty-eight percent thus far. This puts Waverly over the 1994 mandated levels, well on its way to the 2000 goal.

In order to test the significance of these cuts, I used a paired t-test, pairing the months of the year to control for seasonal variations. As outlined above, 1990 and 1991 differed significantly from 1988 (p=0.0155 and p=0.0077, respectively). However, 1991 (voluntary drop-off center) was not significantly different than 1990 (yard waste removal) as seemed apparent. In April 1991, there was a surge in landfilled waste, due to a city-wide "Clean up Waverly Day," city trucks collected anything the citizens put on the curb at no extra charge. In 1991, it was announced that this would be the last year that such a day would be sponsored. It may be that the citizens responded by cleaning out all the "big stuff," in any case it may be appropriate to recompare the two years without
April. Additionally, January 1991 was the first month of the drop off center. The large decrease in volume may be a result of the novelty of the center. Without January and April, 1991 is significantly different than 1990 (p=0.0359). In order to assess the impact of the 1992 rate based change, I compare 1992 to 1991. Given that January and April of 1991 appear to be outlying values, there remain only four months to compare. While this small sample comparison is inconclusive, the resulting impression is that the volume based pricing system indeed is leading to less landfilled refuse than the voluntary drop off center approach alone (p=0.0075).

The results of the games suggest that the actual price determines the success of the volume based system. When the new system was introduced the garbage collection rate was $6.95 per month, this changed to $5.00 per month plus $1.00 per bag. However, if the volume based system had not been introduced, the city would have increased the fixed rate to $9.60 per month. Using this value instead of the seven dollars seems the more appropriate comparison, a household can put out four and a half bags for the same cost as the fixed rate system. The important figure is the dollar per bag. The question is if this is a large enough cost savings that some households will view the effort of voluntary curbside recycling as worth the dollar per bag not placed on the curb. Given this limited sample, the suggested answer is yes. While these conclusions are not generalizable beyond Waverly, they do point to some positive and anticipated changes resultant from the various policies.

The results indicate, contrary to my anticipation, that the voluntary drop off center does significantly reduce the amount of refuse going to the landfill.

\(^7\)The city responded to an increase in the landfills tipping fees.
The voluntary approach does appear to have some success in Waverly. There are at least two explanations for this: the citizens of Waverly may have a conservation ethic, the costs of recycling at a drop off center may be less than I anticipated. On top of the impact of the drop off center, the rate based system plus the voluntary curbside collection led to a significant decrease in refuse going to the landfill. This result was anticipated.
### Table 3. Waverly, Iowa. Solid Waste Landfill Disposal, Cubic Yardage.

<table>
<thead>
<tr>
<th></th>
<th>1987</th>
<th>1988</th>
<th>1989</th>
<th>1990(^a)</th>
<th>1991(^b)</th>
<th>1992(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>990</td>
<td>1025</td>
<td>1120</td>
<td>630</td>
<td>722</td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>1000</td>
<td>985</td>
<td>910</td>
<td>870</td>
<td>674</td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>1290</td>
<td>1120</td>
<td>1090</td>
<td>860</td>
<td>745</td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>1325</td>
<td>1335</td>
<td>835</td>
<td>1110</td>
<td>755</td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>1430</td>
<td>1585</td>
<td>1240</td>
<td>905</td>
<td>810</td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>1100</td>
<td>1350</td>
<td>1065</td>
<td>915</td>
<td>790</td>
<td></td>
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<td>July</td>
<td>1490</td>
<td>1115</td>
<td>1015</td>
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</tr>
<tr>
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<td>1270</td>
<td>1065</td>
<td>980</td>
<td></td>
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<tr>
<td>September</td>
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<td>1310</td>
<td>1195</td>
<td>895</td>
<td>905</td>
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<tr>
<td>October</td>
<td>1400</td>
<td>1435</td>
<td>1470</td>
<td>1025</td>
<td>1000</td>
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</tr>
<tr>
<td>November</td>
<td>1206</td>
<td>1165</td>
<td>1110</td>
<td>995</td>
<td>880</td>
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<td>December</td>
<td>975</td>
<td>1125</td>
<td>1045</td>
<td>945</td>
<td>950</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14465</td>
<td>14505</td>
<td>12285</td>
<td>11020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% diff, 1988</td>
<td>0.00</td>
<td>0.28</td>
<td>-15.07</td>
<td>-23.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paired t-value (to '88)</td>
<td>-1.09</td>
<td>2.47</td>
<td>2.86</td>
<td></td>
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<tr>
<td>p value</td>
<td>0.85</td>
<td>0.02*</td>
<td>0.01*</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Paired t-value ('91 to '90)</td>
<td>0.91</td>
<td>1.22</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>p-value</td>
<td>0.19</td>
<td>0.13</td>
<td></td>
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</tr>
<tr>
<td>Paired t-value ('91 to '90 without April)</td>
<td>2.04</td>
<td>5.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-value</td>
<td>0.04*</td>
<td>0.01*</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Average</td>
<td>1205.42</td>
<td>1205.42</td>
<td>1208.75</td>
<td>1023.75</td>
<td>918.33</td>
<td>749.33</td>
</tr>
<tr>
<td>Stand. Dev.</td>
<td>199.46</td>
<td>151.41</td>
<td>194.34</td>
<td>113.54</td>
<td>116.10</td>
<td>48.59</td>
</tr>
</tbody>
</table>

\(^a\) January 1, 1990--Yardwaste removed.

\(^b\) January 1, 1991--Drop off recycling center opened.
Summer 1991--Corrugated paper collection offered.

\(^c\) January 1, 1992--Volume based pricing started.
March 1, 1992--Voluntary curbside collection offered.

* Significant at 0.05 level.
DISCUSSION AND CONCLUSION

Refuse reduction policy attempts to structure a social situation where collective action could mediate the problem, but, as it is in no one's personal self-interest to participate, collective action does not develop. If policy is collectively rational, it will consider the individual rationalities of the community. When addressing environmental issues there are basically two rationalities, those who consider environmental impacts and those who do not: the conservationists and the calculative citizens. The policy which links individual and calculative rationality should lead to collective action; otherwise, it will lead to collective failure.

While the policies themselves result from collective choice, for the purposes of analysis I have assumed that the policies were given. These policies structure the interdependent decisions of society and can be modeled as games. Social action situations fit into three common games: Prisoner's Dilemma, Chicken, and Fully Privileged. In Prisoner's Dilemma no one contributes to the collective good, in Chicken at least one person contributes, and in Fully Privileged every person contributes. Loosely corresponding to these games is a group taxonomy developed by Mancur Olson (1971). The group in which all persons see their contribution to be negligible and unnoticeable, corresponding to Prisoner's Dilemma, is called the latent group. When at least one in the group participates, corresponding to Chicken, there is a privileged group. Finally, the situation where each contributes regardless of any other person's actions, both the group and the game are called Fully Privileged.
The propositions of this study anticipate that the use of incentives will change the social situations and therefore the games and therefore the group to which the citizens of the community belong. Specifically that incentives will shift individuals from latent, non-cooperating groups, to privileged where collective action develops, or fully privileged where it is in each person's individual interest to act collectively. Also anticipated is that the impact of these changes will vary within the community as the rationalities vary. Of the two, conservationists were expected to make the transition with less pointed incentives.

These ideas were supported in the game analysis. Assuming a calculative rationality voluntary approaches had no impact on recycling participation; however, under conservationist rationality some did indeed recycle. The more pointed incentive policies had the greater impact on calculative citizens. Although the expectation was that the two policies, mandatory curbside and volume based pricing, would have the same impact, they did not. The volume based pricing created a Chicken game instead of the Fully Privileged of the mandatory policy. This result points to the importance of the actual price. Towns and communities need to examine the impact of the price to be certain that it creates the desired impact.

In the game theoretic models selected for this study, I arbitrarily chose one set of values for the various costs and benefits. Of course, these are not the only possible values. In Table 4 the values which would shift any of the four games to Fully Privileged are presented. To read the table, the values listed in the game are listed in the “given” column. Given “calc” refers to the calculative rationality, and “cons” refers to the conservationist rationality.
Table 4. Price changes to shift games to fully privileged groups.

<table>
<thead>
<tr>
<th>Game</th>
<th>Voluntary Drop-off</th>
<th>Voluntary Curbside Collection</th>
<th>Mandatory Curbside Collection</th>
<th>Volume Based Pricing plus Voluntary Curbside Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Game 1:</td>
<td>Game 2:</td>
<td>Game 3:</td>
<td>Game 4:</td>
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<tr>
<td></td>
<td>Private costs</td>
<td>Private costs</td>
<td>Private costs</td>
<td>Private costs</td>
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<tr>
<td></td>
<td>10</td>
<td>5</td>
<td>8</td>
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<td>Public benefits</td>
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<td>5</td>
<td>10</td>
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<td>Private benefits</td>
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<td></td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

a "Given calc" refers to games under calculative rationality.
b "Δb" refers to the new benefit value which when combined with the other variables as given, changes the groups to fully privileged.
c "Δc" refers to the new cost value which when combined with the other variables as given, changes the groups to fully privileged.
d "Δcnp" refers to the new cost of non-participation, i.e., fine, which when combined with the other variables as given, changes the groups to fully privileged.
e "Given cons" refers to games under conservationist rationality.
In order to shift a game structure to another, either the costs or benefits must change (simultaneous changes are not included in the table). The "Δc" shifts the costs and the benefits remain as given, "Δb" changes the benefits while leaving the costs as given. For any of the calculative games, if the benefits are greater than or equal to the costs, then the game becomes Fully Privileged. For example, in the volume based pricing game 4, if the cost reduction had been to 5 (thus equally the public benefits of 5) instead of to 6 as in the game analyzed, the payoff would be as in Figure 17. Recycling is now the dominant strategy and both are in a fully privileged group.

For the calculative voluntary policies, in order to create fully privileged groups either the benefits must increase dramatically, doubling for the drop-off center, or the costs must decrease. The only way to increase the public benefits is to decrease the amount of trash per person. Even in the mandatory recycling policy, the benefit from decreased trash was assumed to increase by one. This type of change would require a major shift in approach. Either the citizens would have to decrease the generation of unrecyclable trash, or the municipality
would need consider alternate disposal methods, e.g., incineration. Shifting the purely voluntary approaches, while not impossible, is unlikely. If the community cannot increase the benefits, it may attempt to cut the costs. The costs are a function of the time and effort for recycling and the cost of garbage collection. Beyond picking the recyclables up with the other unseparated garbage, there is not much which can be done to reduce the time and effort costs of recycling. The government could subsidize the cost of garbage collection if one recycles, but this may not be fiscally possible.

The use of the penalty seems to be the most direct approach to changing the costs. Even if public benefits fall to zero, the penalty still shifts the citizen into the fully privileged group, the benefit of cost savings being the impetus to recycle. However, the use of penalties is effective, if and only if, the probability of being caught is high. As the probability of receiving the fine decreases, then so does the expected value of the penalty (expected value is the probability of being fined times the amount of the fine). If a fine system is to work, then the enforcement must be strict and certain. Assuming that the mandate to recycle is enforced strictly, then the fine need not be as large as the fine in this study. It should be large enough that the total costs are less than the benefits, for calculative rationality this happens when the fine is 3 and for conservationist rationality no fine is required, as they are already in a Fully Privileged game under voluntary curbside collection.

The mixed rationalities showed a Chicken structure, with conservationists recycling and calculative persons not. The calculative persons are free-riders, accepting the benefits from the conservationists without participating. Because the calculative persons know the conservationists will provide the public good,
they do not participate. Olson refers to this as the exploitation of the large by the small. The problem is that free-riders lead to a sub-optimal provision of the public good. As most communities are a mix of rationalities, it is important for them to address this problem, especially if their landfill situation is serious and complete participation is critical.

Since the n-person and repeated games are examined under calculative rationality, they also require that the benefits be greater than or equal to the costs in order to shift the game to Fully Privileged. In the analysis the repeated game yielded an indeterminate solution. There was the unusual situation where the costs of mutual non-participation and being the only recycler were identical. This yielded a constant payoff for one person when the other person did not recycle. In a strict Prisoner's Dilemma, these would not have been equal, the payoff for being the only recycler would have been lower, hence, the solution of one recycling and one not would no longer have been Nash equilibria. The remaining choice, between mutual tit-for-tat or not recycling, while no less indeterminate in itself suggests that both would want to use the same strategy choice. The key for the community would be to encourage recycling so that the citizens would try recycling first and then do what everyone else did (which was to try recycling). The implication is that public awareness of recycling possibilities and of public participation are keys to success in repeated situations.

Empirically, the effectiveness of public policy, even voluntary approaches, was demonstrated in the City of Waverly. If the citizens of Waverly were all calculative persons the voluntary drop-off center approach should not have a significant effect on the landfill tonnages, yet, it did. There are two
explanations, either some citizens have a conservation attitude and responded to
the opportunity to recycle, or the cost-benefit differential used in the analysis
was too large. Both of these could be explored in further research.

The impact of the volume based system is difficult to determine when the
policy has been in effect for such a short period of time. The preliminary data
suggest a significant improvement over the voluntary approach. The shift in the
pricing system seems to have created the desired effect. The decrease in refuse
to be landfilled could be a result of either the citizen's use of the voluntary
curbside collection opportunity, or the citizens could be dumping their trash in
other "free" manners. These include dumping trash in ditches or abandoned
areas, using business dumpsters, or burning the waste illegally. These options
bypass the system and may mask the true effect of the policy. Again, these could
be explored in a more thorough examination of municipalities and counties and
their refuse reduction policies. The remaining hypotheses could not be
empirically examined with the Waverly data. The comparison of the voluntary
approaches to each other and of the price changing approaches to each other will
have to be explored in a comprehensive empirically based study.

The purpose of this study was to examine the impact of incentive based
changes in recycling policy to reduce the refuse sent to landfills. The use of
recycling programs is one approach to shifting the waste stream away from
landfills. Although recycling has been a popular idea since the 1970s, it is not
until recently, with state mandated reductions in landfilled refuse, that it has
been available to most people on such a wide scale. The decision to recycle or not
is an individual decision based on the costs and benefits which one faces and on
the behavior of the other people in the community. Using game theory it was
possible to examine these interactions and make predictions about the decisions the individuals will make. The exploration of rationalities proved to be a worthwhile undertaking. Calculative rationality, simple and unambiguous, provided the launch point for the analysis. The introduction of a conservation attitude provided a foil for strict calculative approach and the preliminary evidence suggests some explanatory power for a conservationist rationality in recycling decisions.

The incentive based policy represents an alternate approach to local common resource problem study. The potential effectiveness outlined above, suggests that repricing may address the underlying cause of the problem, the mispricing of the environment. The price change forces the prices to be a “true reflection” of both the private and social costs of landfill usage. Additionally, voluntary incentive based policies offer an alternative to mandates. Because participation is voluntary, the citizens are presented with an increased menu of options. These may be slanted towards certain behaviors but the ultimate decision remains with the citizen. The hitch to this type of analysis is in the measurement of costs and benefits. Loosely, these can be derived from readily available data. However, in order to measure the moral costs and benefits or the discount rate for future environmental costs, more research will be needed.

Escaping the tragedy of the commons requires an approach to public policy which addresses the underlying forces at work. The causes include the rationalities of the participants and of the rules which structure the use of the commons. While not all commons issues are the same (Sandler 1992a), some also may be amenable to this type of analysis. With local governments facing shrinking budgets and growing responsibilities, it is important that they enact
policies which are both effective and cost-effective. Incentives may be the answer because they address some underlying causes of the problem and the behavior patterns that surround the problem. The policies can be self-enforcing, helping to minimize government expenditure. The results of this study indicate that as the structure of the rules, or public policy, changes to reflect the true cost of the landfill usage then individual users of the landfill will change their behavior accordingly.

The clarion call of thirty years ago, to get off the road of ease and environmental degradation and on to the road, "the one less traveled by," is still sounding. Today it is landfills, the filling of landfills, and the possible contamination of groundwater sources which threatens the environment. The solution is, as we all know intuitively, to work together, to establish an atmosphere encouraging such group or collective behavior. It seems as though, in addition to appealing to good hearts, attempting to close the gap between the private costs and social costs is a viable approach.
SUGGESTIONS FOR FURTHER STUDY

The hypotheses resulting from the game analysis of the policies are the primary results of this study. However, these hypotheses need to be tested empirically as the data becomes available. Iowa requires that the cities and corresponding landfills present plans for how they will reach the mandated reductions. In 1994, these plans need to be substantiated with numerical support to show that the planning areas have reached their goals. At that time, with the data base, it will be possible to do a more rigorous examination of the hypotheses presented here.

One question to be addressed builds on the Waverly example presented here. How do the various policies impact the waste stream? Using the analysis of the incentive structures presented above, it should be possible to test the predicted decreases in the waste stream. The municipalities would be the level of analysis. Other intervening variables which could be explored are the population of the municipality, its location as either an urban or rural area, possibly its location or region (North, South, East, or West) within the state itself, and the activeness of the citizenry on environmental issues. Some other variables to be considered would be the socio-economic characteristics of the municipality, such as, per capita income, average educational achievement and average age of the citizens, in addition to the size of the municipality.

From a random sampling of towns in Iowa certain information could be collected: 1) all historical and present ordinances dating to 1987, 2) municipal waste levels 1988-1994 (or whatever is available), 3) a basic history of the implementation process, including the dates of various dates in the plan, 4) type
of municipal government, and 5) some sense of the participation of the citizenry in the formulation and implementation of the programs. From the 1990 U.S. Census one could collect: 1) median income of citizen, 2) median age of citizenry, 3) town population, 4) urban/rural designation. Together, this would present a detailed picture of the varying impact of policies by town. At the same time, survey sampling could be used to measure a conservation ethic. Questions establishing an attitudinal scale could be used, mirroring the environmental ethic spectrum presented in this study.

Additional questions for further research grow out of this work. As stated the price, either volume rate or fixed rate, used can alter the impact of a policy on any given city. It may be possible to search an optimal price for the volume rate or for the fine level. A price which is either too high or too low introduces new problems. A rate increase too low to actually alter behavior would amount to little more than an indirect tax increase; while, a figure too large may be exploitative and again represent a revenue increase for the municipality (or private hauler) under the guise of an effective policy. Another related issue is the discount rate.

At least one publication has shown that people discount human lives at approximately the same rate that they discount money (Cropper and Portney 1992, 3). The question here would be at what rate do citizens discount environmental degradation? This is important for the repeated game and for determining the costs of non-participation and mutual non-participation. As the discount rates change, the costs and benefits required to shift the game to Fully Privileged will change. Understanding the relationship will enable
administrators and policy formulators to suggest changes in the price structure to reflect the impact of the discount rate.

As is common, more questions seem to flow from research than it answers. In this case new questions address the relationships among people, between people and their environment, and even citizens' fundamental views on right and wrong. Rather than approaching the community as a cohesive whole, it is necessary to understand it as a dynamic entity, respecting the importance of the individuals of which it is composed. This line of research can help policy formulators to see and understand the refuse problem in a new, truer light, thus enabling them to respond novel and effective ways.
REFERENCES


