Consequential Cash Choice Experiments: Provision Rules and Decision Support for Restoration of NROCs Ecosystem

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Abstract

Investigating incentives, through valuation context and questions, that motivate respondents to reveal their true values for environmental good under consideration has been a long-standing area of research in stated preference literature. A large number of previous non-market valuation studies have focused on various dimensions of valuation questions and context and have investigated how these dimensions affect the incentives to answer truthfully. An importnat, but relatively less-explored, area is the incusion of a provision rule, by which environmental good under investigation will be provided, and how this affects participants' incentives to tell the true values. Provision rules, that are made explicit to survey respondents, provide a connection between survey choices and actual outcomes. Advancements in Mechanism Design Theory have recently attracted researchers' attention on examining alternative provision rules using discrete choice experiments (DCE) and comparing preferences and tradeoffs across provision rules. Only very few studies,

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mostly in laboratory experiments, have attempted to examine the influence of the inclusion of a provision rule in elicited preferences and tradeoffs. Employing a split-sample approach, this study compares a single decision-maker's choice and a plurality vote provision rules in in-person choice experiments using real cash for actual implementation of ecosystem restoration project on the ground. A very preliminary conditional logit model results suggest that both rules produce statistically similar preference functions in terms of marginal values and tradeoffs between restoration attributes. Further analysis is yet to be conducted to ensure these preliminary results hold consistently using a Latent Class Model to incorporate preference heterogeneity for ecosystem restoration.

Key words: provision rules, real-money choice experiments, ecosystem restoration, decision-support tool

1 Introduction

Examining incentives, through valuation context and choices, that motivate respondents reveal their true values for environmental good under investigation, has been a long standing focus of stated preference literature beginning with Hoehn and Randall (1989). Most of previous non-market valuation studies have focused on understanding how different dimensions of valuation context and questions affect incentives to reveal true values of environmental good. However, very little is known about how survey participants respond to the valuation questions when there is an explicit rule or process described to them, by which their responses lead to a collective outcome for actual decision-making application. A rule or process, by which environmental good under investigation will be provided known as a provision rule, may present survey participants with certain incentives to respond to valuation questions. This aspect of incentive properties of discrete choice experiment approach has not been rigorously investigated. This study empirically compares marginal values and marginal tradeoffs between ecosystem restoration attributes focused on invasive plants management under two provision rules namely a single decision-maker's choice and a plurality vote. Two provision rules are submitted for investigation using a discrete choice experiment (DCE) approach involving binding choices of cash payments and actual implementation of ecosystem restoration projects on the ground.

An important aspect but not as much focused in stated preference literature is the examination of incentive properties of a provision rule, explicitly described to survey participants, by which the environmental good under consideration will be provided. A provision rule provides an explicit connection between survey choices and actual outcomes and is also considered an important term of exchange for participants to decide whether or not to purchase environmental good. A provision rule can also be thought as a process by which survey choices will be translated into a collective decision. When a provision rule is not explicitly described to respondents, uncertainty may arise about how their choices determine actual outcomes for decision-making context and thus may affect the incentives to truthfully reveal their values. Incentive properties of choice questions have long been investigated, but very little is known about the influence of such provision rules on elicited preferences. Inclusion of a provision rule in the choice survey may trigger certain incentives to motivate survey participants to respond to valuation questions one way or the other . For example, when participants are choosing between two alternative restoration plans in a single binary choice question, plurality vote provision rule, the alternative that receives the most votes wins, is incentive compatible as participants would do no better than voting for their most preferred option (Arrow et al 1993). However, when participants are choosing among three or more alternatives, plurality vote rule may no longer be incentive compatible as voting for the most preferred option may be less appealing for strategic or other reasons. This has been formally established in mechanism design theory (Gibbard 1973; Satterthwaite 1975; Moulin 1988). Mechanism design theory relates to designing a voting rule or mechanism to truthfully identify a consistent collective outcome, from a fixed set of alternatives, on the basis of voters' privately held preferences. An incentive compatible rule or mechanism, in Mechanism Design Theory, is the one in which individuals have no other incentives than truthfully revealing privately held preferences. Based on mechanism design theory, a single decision-maker's choice rule is incentive compatible as each individual involved has an equal likelihood of being a single decision maker whose choice will be the collective outcome for the group at least in theory as it mimics the case of a dictatorship rule. While plurality vote is generally incentive compatible in a binary choice situations, it is no longer incentive compatible in a multinomial choice situations, choosing among 3 or more alternatives, at least in theory. This study empirically compares Single decision-maker's choice, an incentive compatible provision rule with a plurality vote rule, which is not generally incentive compatible with multinomial choice situations. Almost all previous discrete choice experiment studies have ignored this aspect of incentive compatibility of the approach and very little is known about how these elicited preferences are affected by different provision rules, if any.

Recent advancements in mechanism design theory have attracted researchers' attention on empirically examining the marginal values and tradeoffs in discrete choice experiments under alternative provision rules. To the authors' best knowledge, Taylor et al. 2010 is the only study that compared marginal values under alternative provision rules using private and public goods and concluded that including a provision rule may reduce bias in WTP estimates but found no significant difference in value estimates across provision rules. Collins and Vossler 2009 also examined provision rules using 2-alternatives and 3-alternatives choice situation in induced value laboratory experiments and found a statistically significant but a modest degree of bias towards selecting the status-quo option. Using a split-sample approach, this study utilizes a field application for the development of a decision support tool for land managers for prioritizing ecosystem restoration projects focused on managing invasive plants to compare two provision rules namely a single decision-maker's choice and a plurality vote rules. These rules are compared in terms of marginal values and marginal tradeoffs using trichotomous (three alternatives in each choice set or question; Plan A, Plan B and Neither Plan) choice questions. The choice survey involved a mix of hypothetical and binding choices which have real monetary consequences and each provision rule determined an actual ecosystem restoration project to implement on the ground and actual payment by participants to deliver the selected project. Our study is contributing to the literature in following ways. Firstly, our study involved consequential decisions meaning survey participants actually paid, through research grant money given to them, for the project determined as group outcome based on provision rule and involved actual implementation of these selected projects on the ground. Secondly, our study involved examining two provision rules using 3-alternatives choice situations, which is a common elicitation format, of which single decision-maker's choice is established as an incentive compatible rule to compare marginal values and tradeoffs with plurality vote rule which is not generally incentive in 3-alternatives choice situations. Thirdly, our study utilizes an efficient design approach using state-of-the-art experimental designs. Fourthly, our study covers a larger set of attributes in choice questions incorporating both binding and hypothetical choices covering an extended range of levels of attributes.

The paper is organized as follows. Section 2 discusses the theoretical framework to analyze stated choices in relation to mechanism design theory. Section 3 details the field experiment. Section 4 presents the results of hypothesis tests. Section 5 concludes and discusses the implications of the results.

2 Discrete Choice Experiments and Provision Rules

We employ a discrete choice experiment approach asking survey participants a series of choice questions, each consisting of three alternative ecosystem restoration projects: Project A and B that differ in terms of levels of restoration attributes and no action alternative. We model participants' responses to ecosystem restoration choices using a standard economic model, the Random Utility Model-RUM (McFadden 1974). In the RUM, a participant evaluates a set of alternatives in a choice set or a choice question and chooses the one that gives her or him the highest utility. Specifically, each participant faces a set of alternatives A and evaluates each alternative in terms of utility received from component attributes of the alternative given by $U_j = v(X_j, P_j) + \epsilon_j$, where X_j is a vector of component attributes associated with alternative j, and P_j is the cost to buy the alternative j and $\epsilon_j$is a random component of participant's utility. A participant chooses alternative k if and only if $U_k > U_j$; $j, k \in A, j \neq k$. Assuming a distribution for the random component or ϵ term of participant's utility function, corresponding econometric model can be estimated, which allows us to make probabilistic statement about how probably an alternative is expected to be chosen. The empirical model employed in this article will be described later.

Now we examine single decision-maker's choice rule and how this rule may influence their responses to the choice questions. This provision rule involved randomly choosing a choice question among binding questions and also randomly choosing a single decision-maker whose response on the randomly selected question determines the group outcome after all participants finished responding to the choice survey. Survey participants actually paid, from the research grant money provided to them, for the selected group outcome to be actually implemented on the ground. Single decision-maker's choice is an incentive compatible rule as each participant has an equal chance of being the single decision-maker whose choice on a randomly drawn binding question will determine the collective outcome. This rule theoretically represents the case of dictatorship [3]. Given that a participant is chosen as the single decision-maker, she or he has no incentives to misrepresent v_j in each question as the participants have to follow through their choices or decisions. So we would expect that survey participants reveal their true v_j in each choice question under this rule.

Now we examine plurality vote in case of 3 or more alternatives and how this rule may influence participants' responses to the choice questions. This provision rule involved selecting a project that receives the most votes on a randomly chosen binding choice question. Our study involved asking participants trichotomous choice consisting of two alternative restoration projects and no plan alternative. It has been long established in the literature that a plurality vote rule in a binary choice situation is incentive compatible mechanism (Arrow et al. 1993). However, when 3 or more alternatives are involved, plurality vote rule is not generally incentive compatible as voting strategies may depend on subjective beliefs about the distribution of preferences within the voting group. For example, participants interested in high public access allowing for dogs and horseback riding may strategically vote for alternative with medium access or their second best alternative to avoid getting their least favored alternative (low or no public access) if they believe the alternative with high public access has less chance of being favored by the most people. Theoretically, plurality vote rule in case of 3 alternatives choice situations is not incentive compatible as there may be strategic or other reasons that might motivate participants to misrepresent their values. So we would expect that participants may not reveal their true value v_j if they believe that misrepresenting may be in their best interest.

[3] We used the term "single decision-maker's choice", which essentially bears the properties of a dictatorship rule in mechanism design theory to avoid any negative notion in decision-making context. This rule may not be practically very appealing but we set up this rule as a "base rule" to compare preferences with plurality vote rule which is not generally incentive compatible with the situation of 3 or more alternatives.

3 A field application to NROC's ecosystem restoration

3.1 Study context, area, and survey development

This study was one of the components of larger project entitled ”Orange County Invasive Management (OCIM)”. The natural science component of the project was aimed at assessing the effectiveness of alternative invasive plants control or management techniques on restoration of native habitats. This study was the social science component of the project attempting to assess public values and priorities of ecosystem restoration attributes and incorporate such values and priorities into future restoration prioritization. Combining these two components, the larger project aims at developing a decision support tool for prioritizing future ecosystem restoration decisions by relevant land managers or environmental managers. Our study area is the Nature Reserve of Oragve County (NROC), a 37,000 acres large protected open space or nature reserve in southern California established in 1996 to restore native habitats and natural processes.

The research team began developing survey instrument for final field experiments with interviews with ecosystem restoration experts from the NROC and Irvine Ranch Conservancy (IRC) an other local conservation groups involved in ecosystem restoration activities in the city of Irvine, California. Experts' interviews helped us develop a set of attributes that could be potentially relevant to ecosystem restoration choices. We employed a series of 7 focus groups (Johnston et al. 1995) to develop, revise and pretest survey instruments for overall clarity, relevancy, and comprehensiveness of ecosystem restoration choices and general instructions. We identified a total of 7 ecosystem restoration attributes namely restoration effort, habitat and bird species focus, size of restoration, public access, trained volunteers, likelihood of success, and cost to the respondents (Table 1). We developed a choice survey entitled ”Ecosystem Auctions for Decision Support (EADS): Economic Choices for Ecosystem Restoration for Environmental Decision-Making in the Nature Reserve of Orange County (NROC), California”, which consisted 3 sections. First section asked participants about their general attitudes towards ecosystem restoration, their perspectives on involving volunteers or public access, and incorporating public values and priorities in future restoration decisions by relevant stakeholders like local land or environmental managers. These likert-scale type of questions involved asking participants about their degree of agreement about statements on a 7 point Agree-Disagree scale. Second section presented participants with a series of ecosystem restoration choices along with information, instructions on provision rule to be employed to determine group outcome of restoration project to implement on the ground, and examples on restoration choices. Second section also included a subsection that asked participants follow-up questions after they answered choice questions on a 5 point likert-scale of how often they answered choice questions one way or the other. Third section asked participants about their socio-demographic background to help interpret our results.

Table 1: Variables and descriptions

Attributes	Variables and Descriptions
Neither Plan	**DN** The dummy variable (=1) for the neither restoration project; else (=0) for Project A or Project B.
Restoration Effort	**HEFF** Dummy variable representing a high restoration effort i.e., project restores 0-30% native plants cover upto 51-75 % (=1) ; (=0) if project restores 30-50 % native plants cover upto 51-75 %.
Habitat and Bird Species Focus	**CACTUS** Effects-coded variable (=1) representing restoration actions on Coastal Cactus Scrub, which supports *Cactus Wren* , may support *California Gnatcatcher*; (=0) if restoration on Native Grassland which supports other native wildlife; (=-1) if restoration on Coastal Sage Scrub which supports *California Gnatcatcher*
	NGRASS - Effects-coded variable (=1) representing restoration actions on Native Grassland; (=0) if restoration on Coastal Cactus Scrub (CCS); (=-1) for base habitat category which is Coastal Sage Scrub (CSS)
Public Access	**HPA** Effects-coded variable (=1) if restoration in an area that allows a high public access (running, hiking, mountain biking with designated areas for dogs and horse-back riding); (=0) in an area that allows a medium public access (running, hiking, and mountain biking) ;(=-1) for base category allowing a low public access

Table 1 - continued from previous page

Attributes	Variables and Descriptions
	(for research with permits and guided tours only)
	MPA Effects-coded variable (=1) if restoration in an area that allows a medium public access (running, hiking, and mountain biking); (=0) in an area that allows a high public access ;(=-1) for base category allowing a low public access
Trained Volunteers	**VOLUN** Dummy variable (=1) if restoration project involves trained volunteers in addition to restoration professionals ;else(=0)
Likelihood of Success	**HLOS** Dummy variable (=1) if restoration project has high likelihood of success due to easy access for maintenance and / or surrounded by native landscape; else(=0)
Size of Restoration	**SIZE** Continuous variable representing size of candidate restoration site in acres
Cost to you	**PRICE** Continuous variable representing the payment required from economics experiment participants to implement the project on the ground

3.2 Efficient design of ecosystem restoration choices

We employed an efficient design approach, a design that yields data enabling estimation of the parameters with lowest possible standard errors, using a software specifically built for producing experimental designs for discrete choice models called Ngene version 1.1 . We utilized priors on parameters of ecosystem restoration attributes from focus group data in producing final efficient design. The efficient design used five discrete ecosystem restoration attributes namely restoration effort, habitat and bird species focus, public access, trained volunteers, likelihood of success, and two continuous attributes namely size of candidate restoration site and cost to the participants (Table 1). Our efficient design process was unique that incorporated the available binding choice questions with hypothetical choices intended to expand the range of attributes considered in the choice survey. This design process produced a total of 14 choice questions, among which 6 questions represent binding choices. These binding choices were distinguished from hypothetical choices and were explicitly labeled as *"Feasible Projects in 2012, Choice—"*. In each choice question, binding or hypothetical, participants were asked to evaluate three ecosystem restoration plans: Plan A and Plan B which differ in terms of levels of restoration attributes and No Plan (no action) alternative (Figure 1). A total of 14 questions were efficiently blocked into two blocking orders of 7 questions each to avoid any ordering effects that could produce noises in our analysis. In addition, we also designed a fifteenth choice question, using regular orthogonal design that has 3 restoration plans (A,B and C) and no action alternative, that strives to identify each respondents motivation relative to preferences for certain types of attributes such as general ecosystem restoration, volunteers involvement, or public access. This question is specially intended to identify whether there is a strategic motivation or reason for respondents to misrepresent their preferences under the provision rules examined. Each participant is asked to respond to 15 restoration choices in total.

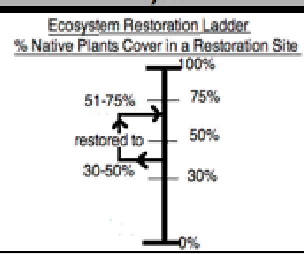
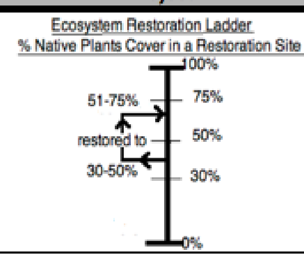
Project Attributes	Project A	Project B	Project C
Restoration Effort			Neither of these projects. I choose to keep **my $150 for my other priorities rather than paying my cost** for either Project A or B.
Habitat and Bird Species Focus	Restoration in **Cactus Scrub,** supports **Cactus Wren**, and often **California Gnatcatcher**	Restoration in **Coastal Sage Scrub,** supports **California Gnatcatcher**	
Size of Restoration	**1** acre	**2** acres	
Public Access	Area allows **access** for **running, hiking and mountain biking**	Area allows **access** for **running, hiking, mountain biking, with designated areas for dogs and horse-back riding** when ecologically feasible.	
Trained Volunteers	**No**, project **does not involve** trained volunteers in addition to restoration professionals	**No**, project **does not involve** trained volunteers in addition to restoration professionals	
Likelihood of Success	**High** due to **easy access** for maintenance and / or **surrounded by native landscape**	**High** due to **easy access** for maintenance and / or **surrounded by native landscape**	
Cost to You	I will pay **$40**, from my **$150.**	I will pay **$90**, from my **$150.**	I keep my **$150.**
HOW WOULD YOU VOTE? (CHOOSE ONLY ONE)	☐ **I vote for PROJECT A**	☐ **I vote for PROJECT B**	☐ **I vote for PROJECT C**

Figure 1: An example ecosystem restoration choice

3.3 Provision rules

Participants were encouraged to evaluate each restoration project in terms of what each project might or might not accomplish, how it matters to them, whether it is worth the money cost to them , and how their vote might influence the group outcome. Participants were also encouraged to treat the personal budget of $150 provided to them as their own money out of their pocket. After presenting example choice question and how the group outcome will be chosen based on provision rule described, participants were asked to respond to 15 choice questions. Participants were also told that 6 out of 14 choice questions (except the final 4-option question) presented are labeled as *"Feasible Projects in 2012, Choice—"* and one choice question will be randomly chosen out of those 6 to implement the provision rule, single decision-maker's choice or plurality vote and they are required to pay for the project determined by the rule.

In order to examine whether participants respond consistently to the choice questions under alternative rules conveying different incentive structures, two sub-samples were presented with the exact same information, example choices, choice questions and other questions except the description of provision rule used. Exact same powerpoint presentations, except the description about the provision rule used, were made to corresponding subsamples before they complete choice survey. The following is an excerpt from the instructions of plurality vote rule:...

*...**Section 2.1: Determining the group outcome at the end of tonights workshop***

*Once everyone has finished responding to all choice questions, **one choice question** number **will be selected randomly** from the group of choice questions labeled as **Project Feasible in 2012, Choice-..** . Each participants response on this choice question will be counted as **a vote** . The project that gets **the most votes** will be chosen as **the group outcome** of tonights decisions and will be implemented in this (2012/2013) NROC field season. **Your payment** will be determined based on the **group outcome** chosen according to **majority vote (or plurality vote)** rule as described above.*

As single decision-maker's choice rule involved two stages of random processes namely picking a binding choice that counts and a single decision maker whose response on that binding choice is determined as the group outcome. Here is how this single decision-maker's choice rule was described to the participants of corresponding subsample:

*...**Section 2.1: Determining the group outcome at the end of tonight workshop***
Once everyone has finished responding to all choice questions,
one choice question** number **will be selected randomly** from the group of choice questions labeled as **Project Feasible
***in 2012 Choice-..** ,.One **Survey ID number** will also be selected randomly. The project,*
***chosen by the person holding the randomly selected Survey ID number on the randomly selected choice question**, will be chosen as the group outcome of tonights decisions and will be implemented in this (2012/13) NROC field season.*
***Your payment** will be determined based on the **group outcome** chosen according to **randomly chosen single decision-makers choice** as described above.*

Follow-up questions about how they made their choices also involved asking about how often their responses were influenced by the fact that plurality vote or single decision maker's choice rule is employed to determine the group outcome. Those questions were also modified to represent the corresponding provision rule used.

Before asking participants to respond to choice questions, they were presented with the information about restoration attributes included in the choices. A powerpoint presentation was made to inform participants about the project in general and detailed information on ecosystem restoration attributes, example choice question, provision rule involved to determine the group outcome. Participants were told that they have been provided with a personal budget of $150 to make decision with in each choice question. Participants were also reminded that any money left after paying for the restoration project can be taken home to spend on utility bills, family gifts, and donations to charities or any other purposes important to them.

3.4 Field experiment participants and administration

Participants for field experiments were voluntarily recruited through local environmental organizations namely Nature Reserve of Orange County (NROC), Irvine Ranch Conservancy (IRC), Back to natives restoration, Laguna Greenbelt, Newport Bay Conservancy, Laguna Canyon Foundation, Friends of Harbor, Beaches and Parks, Sea and Sage Audubon Society in southern California. An email invitation was sent to the potential participants through email lists of these organizations and individuals were asked to indicate which of the two nights they could participate in (May 16 and 17, 2012). The email invitation described the economics experiments as **Ecosystem Restoration Decision-Making Workshop** to better convey the purpose of the events. At least two rounds of email invitations were sent. The first night of the field experiments involved a plurality vote provision rule and the second night involved the single decision-maker. For both nights, all individuals who agreed to participate were gathered in an educational facility of Orange County Parks at the Peter and Mary Muth Interpretive Center. The research team did a powerpoint presentation on a brief introduction of larger project called Orange County Invasive Management (OCIM) of which are the economics experiments to estimate values of ecosystem restoration to incorporate into a decision support model for relevant stakeholders for future restoration prioritization. The powerpoint presentation also informed participants about what types of questions including examples, they expect to see in the survey to complete after the presentation. A detailed information about the ecosystem attributes included in restoration choices was presented along with the provision rule used to determine the group outcome. A brief question-answer session was allowed to clarify on the general questions about the survey without leading participants in one direction or the other. At the end of each night, the final group outcome was chosen based on the provision rule used and the outcome was announced and participant were informed that the selected project is going to be implemented by our collaborative partners namely NROC and IRC.

4 Empirical Model

The empirical model employed here is based on a random utility framework (McFadden 1974) which assumes that utility a participant i receives from an alternative j represented by U_{ij} is composed of a deterministic component v_{ij} and a random component ϵ_{ij}. It is assumed that participants evaluate a set of alternatives in a choice set or choice question and choose the alternative that provides them with the highest utility. A participant i chooses an alternative k over another alternative j if and only if:

$$U_{ik} = v_{ik}(X_{ik}, \beta) + \epsilon_{ik} > U_{ij} = v_{ij}(X_{ij}, \beta) + \epsilon_{ij} : j, k \in A, i \neq k.$$

where U_{ik}, U_{ij} represent the utilities received from alternative k and j which is composed of the the utilities received from component attributes $v_{ik}(X_{ik}, \beta)$ and $v_{ij}(X_{ij}, \beta)$ and random components ϵ_{ik} and ϵ_{ij} respectively unknown to the analyst. β is a vector of parameters to be estimated. Assuming that random component of participant's utility is distributed independently and identically (IID) with Type 1 Extreme Values across alternatives and participants, a basic conditional logit model can be estimated which allows us to make probabilistic statement about how liklely an alternative j is expected to be chosen by participant i given by following expression:

$$P_{ij} = \underline{exp^(\mu X_{ij}\beta)} \sum_j (exp^(\mu X_{ij}\beta)$$

where μ is a scale parameter which is inversely proportional to error variance σ^2_ϵ expressed as:

$$\mu = \pi over \sqrt{6\sigma^2_\epsilon}$$

In fitting a basic conditional logit model, the error varaince is assumed to be constant usually set to 1 for practical estimation purposes as it can not be separately identified from vector of utility parameter β. The assumption of constant variance has been questioned especially while comparing utility parameter vectors across two different datasets as this assumption might mislead the hypothesis testing. The scale parameter μ can be allowed to have unequal error variance and can be parameterised as $exp(S_i\omega)$ where ω is a vector of parameters indicating the influence of decision rules treatment or participant characteristics S_i. We used *clogithet* STATA program to fit a heterskedastic logit model (Hole 2006) given as:

$$P_{ij} = \underline{exp^(\mu_i X_{ij}\beta)} \sum_j (exp^(\mu_i X_{ij}\beta)$$

A robust Lagrangean Multiplier (LM) test for heteroskedasticity (i.e., $\omega = 0$) using decision rule dummy as a variable in S_i will inform us whether participants have unequal error variances due to decision rule treatment.

A final consideration in modeling the choice data in our application is to incorporate heterogeneity in preferences for ecosystem restoration actions. The authors expect to identify different groups of participants likely distinguished by their preference functions similar within group and distinct across such groups. Assigning each participant in their likely group or class is a latent process called Latent Class Model (LCM) appraoch where group or class membership is expressed as logistic probability based on their socio-demographic characteristics given as: $P_{ic} = exp^(S_{ic}\gamma) \sum_c (exp^(S_{ic}\gamma)$

Then, conditional probability of a participant i choosing an alternative j in class c is given by: $P_{ij|c} = exp^(\theta_c X_{ij}\beta_{c)} \sum_c (exp^(\theta_c X_{ij}\beta_c)$ where θ_c is a scale parameter normalized to 1 for one of the classes for identification and β_c is a class-specific utility function. Finally, the joint probability that a participant i is in class c and chooses an alternative j is given by the product of P_{ic} and $P_{ij|c}$ given as:

$$P_{ijc} = P_{ic} * P_{ij|c} = exp^(S_{ic}\gamma) \sum_c (exp^(S_{ic}\gamma) * exp^(\theta_c X_{ij}\beta_{c)} \sum_c (exp^(\theta_c X_{ij}\beta_{c)}$$

A LatentGold 4.5 with Syntax module was used to estimate a scale-adjusted (by decision rule dummy) Latent Class Model.

5 Results

5.1 Descriptive statistics

A total of 43 participants (of 57 sign ups) actually took part in field experiment under plurality vote (PVOTE) provision rule, whereas 38 participants (of 53 sign ups) actually showed up for single decision-maker's choice (SDMC) treatment. All participants in both treatments completed all 14 choice questions and a final 4-alternatives choice question. Average frequency of choosing Project A (32.55 % in PVOTE and 33.08 % in SDMC), Project B (53.15 % in PVOTE and 51.50 % in SDMC) and Neither Project (14.28 % in PVOTE and 15.41 % in SDMC) is approximately consistent across provision rules. Table 2 reports summary statistics for socio-demographic characteristics of participants in the two field experiments. Also we conducted a chi-squared test of independence between the subsamples for categorical variables and two-sample t-test between the means of continuous variables and concluded that none of the variables are significantly different between two decision rules treatment at the traditional 10 % level of significance.

Table 2: **Descriptive statistics across provision rules**

Socio-demographic characteristics		**Provision Rules PVOTE**	**SDMC**
Gender (MALE)	%Male	44.19	52.63
	%Female	55.81	47.37
Residents (HOMEOWN)	%Home Owners	67.44	68.42
	%Renters	32.56	31.58
Education (GRAD)	%Graduate degree	39.53	39.47
	%Undergraduate degree	60.47	60.53
Income (HINCOME)	%<75,000 a year	41.86	55.26
	%>75,000 a year	58.14	44.74
Donate to an environmental group (DONATE)	%Yes	62.79	63.16
	%No	37.21	36.84
Ever participated in a restoration project (PARTRES)	%Yes	58.14	73.68
	%No	41.86	26.32
Hiking most important activity (HIKER)	%Yes	55.81	44.74
	%No	44.19	55.26
Educational tour most important activity (ETOUR)	%Yes	55.81	44.74
	%No	44.19	55.26
Public access and volunteers most important aspect (PUBRES)	%Yes	30.23	34.21
	%No	69.77	65.79
Living around Orange County (RESYRS)	Years	27.30	31.22
		(16.65)	(16.92)

5.2 Conditional and Heteroskedastic Conditional Logit Model Results

In order to compare utility parameters across provision rules, we first estimated a conditional logit model (Model 1; Table 3) and conducted a Likelihood Ratio (LR) test of restriction on utility parameters interacted with a dummy variable representing a plurality vote treatment (PVOTE). This LR test suggests that the restriction is not statistically significant ($\chi 2 = 3.1204, p - value = 0.9784$). Conditional logit model results suggest that high level of restoration action, size of the candidate site, volunteers involvement in addition to restoration professionals, and high likelihood of success have significant positive contribution to participants' utility. However, type of native habitat to be restored and bird species involved did not have statistically significant impact on participants' utility functions. Although statistically insignificant, high level of public access reduces participants' utility and they seemed to have a favor for medium public access to the surrounding areas of restoration sites. The coefficient on the price is negative and significant as expected meaning more expensive projects reduce their utility *ceteris paribus*.

This conditional logit model assumes that the error variances are homoskedastic (equal across provision rules) and does not consider potential heterogeneity across participants. We then estimated a heteroskedastic conditional logit model (Hole 2006; DeShazo and Fermo 2002; Hensher et al 1999) [4] and found out that dummy representing a plurality vote rule is not a significant source of heteroskedasticity across provision rules. However, heteroskedastic conditional logit model (Model 2; Table 3) suggested that participants specific socio-demographic variables are significant contributors of unequal error variances across provision rules. This also suggests a need to model preference heterogeneity in our dataset.

5.3 Latent Class Modeling and Preference Heterogeneity

Ecosystem restoration choices involved various aspects of restoration activities such as level of restoration actions, acreage, habitat and bird species and public involvement in terms of access and potential volunteer opportunities. Although assigned to a random survey set, our participants had some knowledge and inclination for restoration activities in general. We expect to identify groups of participants with distinct preferences such as a group more focused on public aspects of restoration versus some other group. In order to incorporate heterogeneity in preferences for ecosystem restoration, we will employ a latent class model

[4] It is a heteroskedastic version of McFadden's conditional logit model

approach which estimates utility parameters for each class identified with distinct socio-demographic characteristics. We will employ a LatentGold Choice with Syntax version to estimate a scale-adjusted latent class model (classes will be allowed to have their own scale parameters as opposed to the assumption of homoskedastic error terms across classes).

Final consideration on analyzing restoration choices will be to look at final 4-options choice set and some follow up questions regarding how they responded choices on potential strategic manipulation of preferences across provision rules.

Variables		
	Model 1	**Model 2**
	Coefficient (s.d.)	Coefficient(s.d.)
PN	-2.8553***	-2.1889***
	(0.6656)	(0.5487)
HEFFORT	0.6131 ***	0.4236***
	(0.1208)	(0.1152)
CACTUS	-0.0056	0.00832
	(0.0825)	(0.05775)
NGRASS	0.0537	0.03408
	(0.1016)	(0.07286)
HPA	-0.1104	-0.0909
	(0.0873)	(0.0695)
MPA	0.1804 **	0.1322**
	(0.0843)	(0.06113)
VOLUN	0.4718 ***	0.3591***
	(0.1316)	(0.1076)
HLOS	0.7199***	0.5447***
	(0.1309)	(0.14501)
LN (SIZE)	0.627 ***	0.5598***
	(0.162)	(0.1419)
LN (PRICE)	-0.8173 ***	-0.6296 ***

	(0.1611)	(0.1434)
PN*PVOTE	-0.3475 (0.929)	0.2726 (0.6743)
HEFF*PVOTE	-0.0763 (0.1683)	-0.05411 (0.1231)
CACTUS*PVOTE	0 .0425 (0.1133)	0.04175 (0.0786)
NGRASS*PVOTE	0.0587 (0.1445)	0.0225 (0.1046)
HPA*PVOTE	0.001472 (0.1309)	0.02502 (0.09278)
MPA*PVOTE	0.0142 (0.1171)	-0.01741 (0.08271)
VOLUN*PVOTE	-0.00571 (0.1867)	-0.05298 (0.1362)
HLOS*PVOTE	0.2241 (0.1837)	0.05539 (0.1337)
LN (SIZE)*PVOTE	0.1102 (0.223)	-0.03598 (0.1636)
LN (PRICE)*PVOTE	-0.1139 (0.2272)	0.07104 (0.1699)
MALE	-	0.5078*** (0.1238)
RESYRS	-	-0.01225*** (0.003926)
DONATE	-	0.2076* (0.12309)
HIKER	-	0.4029*** (0.1234)
ETOUR	-	0.1914*

		(0.1234)
Log-likelihood	-1003.7075	-982.6907
No. of Choices	1134	1134
No. of participants	81	81

Robust standard errors are reported in patentheses. *, **, and *** indicate statistical significance at the 10 %, 5 %, and 1% respectively.

Table 3: **Conditional and Heteroskedastic Conditional Logit Models**

5.4 Discussion and Implications

This paper compares two provision rules namely a plurality vote rule and a single decision-maker's choice rule in terms of marginal values and tradeoffs under discrete choice experiment framework designed to assess public values and priorities of ecosystem restoration in the Nature Reserve of Orange County (NROC). Preliminary results and analysis suggest that the two rules did not produce significantly different preference functions and thus imply that participants responded consistently to choice questions under both rules. A single decision-maker's choice rule is an incentive compatible provision rule meaning participants do not have other incentives than choosing their most preferred alternative among 3-alternatives choice question format whereas a plurality vote rule may not bear the same incentives under 3-alternatives choice question format as choosing some other alternative than their most preferred alternative may be in their best interest for some strategic or other reasons. So we expect preference functions to be different under these two rules. These are theoretical predictions based on mechanism design theory. Our study is an empirical investigation comparing these two rules to assess whether these theoretical predictions hold under discrete choice experiment framework. Our preliminary results are in contrast to the expected outcome based on mechanism design theory but are in consistent with previous finding as in Taylor et al 2010. More rigorous analysis is yet to be done to further uncover insights into these results using a latent class model approach.

6 References

Arrow K, Solow R, Portney PR, Leamer EE, Radner R, Schuman H (1993) Report of the NOAA panel on contingent valuation. Federal Register 58: 4601-4614.

Collins JP, Vossler CA. 2009. Incentive compatibility tests of choice experiment value elicitation questions.Journal of Environmental Economics and Management 58 :226-235

DeShazo, J.R., Fermo, G., 2002. Designing choice sets for stated preference methods: the effects of complexity on choice consistency. Journal of Environmental Economics and Management 44, 123-143

Gibbard A (1973) Manipulation of voting schemes: a general result. Econometrica 41(4):587-601

Hensher, D., Louviere, J., Swait, J., 1999. Combining sources of preference data. Journal of Econometrics 89, 197-221

Hoehn, JP, Randall A (1989) Too many proposals pass the benefit cost test. Am Econ Rev 79: 544-551

Hole, A.R., 2006. Small-sample properties of tests for heteroscedasticity in the conditional logit model. Economics Bulletin 3, 1-14

McFadden, D. 1974. Conditional logit analysis of qualitative choice behavior. In Frontiers in Econometrics, ed. P. Zarembka, New York: Academic Press, 105.42

Moulin H (1988) Axioms of cooperative decision making. Cambridge University Press, Cambridge

Satterthwaite MA (1975) Strategy-proofness and arrows conditions: existence and correspondence theorems for voting procedures and social welfare functions. J Econ Theory 10:187-217

Taylor LO, Morrison MD, Boyle KJ. 2010. Exchange Rules and the Incentive Compatibility of Choice Experiments. Environmental and Resource Economics. 47:197-220