ABSTRACT

SUNG, JOO-KYUNG. Understanding Winter Visitation to Yellowstone National Park Using Revealed and Stated Preference Modeling. (Under the direction of Daniel J. Phaneuf.)

This research provides information needed to help resolve winter management issues at Yellowstone National Park (YNP) and also addresses methodological issues in non-market valuation. The first essay examines the effect of the temporary plan on heterogeneous snowmobile riders and guide service providers both theoretically and empirically. I find theoretically that this policy benefits guided tour providers by increasing their producer surplus and rents. Snowmobile riders are worse off because snowmobile entries are restricted and the price of a snowmobile trip increases. I estimate the demand for snowmobile entries into YNP using a variation of the method for a recreation RUM model. I find that the estimate of avoiders' consumer surplus loss from the restriction on snowmobile access is $290,000 for a winter season.

The second and third essays estimate winter visitors' preferences and welfare impact of snowmobile policy changes at YNP using choice experiment data. The two essays, however, incorporate different pieces of data to model preferences and examine the values of additional information collected in the choice experiment questions. The extra information provides interesting insights on visitors' behavior. I find that the detailed information makes differences in welfare measures but the rankings of different policies' impact are unaffected.

Understanding Winter Visitation to Yellowstone National Park Using Revealed and Stated Preference Modeling

by

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DEDICATION

To Mom and Dad

BIOGRAPHY

Joo-Kyung Sung was born in South Korea on July 28th, 1979. After graduating from Berlin-Potsdam International School in 1999, Joo-Kyung came to the U.S. for college education. She attended Southeast Missouri State University, where she received her Bachelor of Science degree in Economics in 2002. She then moved to Raleigh, North Carolina to pursue Ph.D. in Economics. Joo-Kyung married SungJae Yoo on May 26th, 2007 in Seoul, Korea and they are expecting a baby boy in April, 2008.

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CHAPTER 1

INTRODUCTION

To preserve natural wonders of the U.S. such as Yosemite Valley, the geysers of Yellowstone, the Giant Sequoia trees, and Mount Rainier, the federal government designated these areas as national parks, starting with Yellowstone in 1872. National parks not only preserve cultural and historical heritage and wilderness but also provide a variety of recreation opportunities. Visitors to national parks can enjoy many kinds of activities including wildlife viewing, learning, hiking, camping, picnicking, cross-country skiing, mountain climbing, swimming, white-water rafting, and snowmobiling. Most activities are non-consumptive and are enhanced by wilderness and healthy wildlife populations. These activities are, however, congestible: one person's activities crowd other peoples' activities and therefore reduce the benefits received from their own activities (Turner, 2000).

Some activities, especially those involving motorized vehicles, impose externalities on other visitors. 'Flight'-seeing by aircraft, personal watercraft (often called jet-skis) in rivers and lakes, snowmobiles and motor bikes in some parks create noise, water, and air pollution. For example, visitors to Grand Canyon National Park can take an air tour to view the scenery. These flights generate noise and disturb other visitors on the ground. Jet skis, which are allowed in many national parks, recreation areas, and seashore water bodies, not only generate noise but also discharge small amounts of gasoline and oil directly into the water. Another example is snowmobiles, which are allowed in 28 national park managed areas and create noise and air pollution that disturb the wilderness and interfere with non-motorized activities such as wildlife viewing and cross-country skiing. Snowmobiles also have an effect on wildlife migration and can threaten wildlife populations in the parks. For example, snowmobile noise and trail grooming push bison out of the parks, where they can become a nuisance to surrounding agriculture. Because there is a risk to livestock outside of the park from the transmission of brucellosis from bison, the Montana Department of Livestock haze bison back inside park boundaries. They also capture, test for exposure to brucellosis, and ship animals to slaughter if they test positive.

These examples suggest there are multiple and occasionally competing uses of public lands in general and national parks in particular. Two types of conflicts have arisen from these competing uses: tension between the wilderness preservation and visitor use missions of the parks, and tensions between different types of park visitors.

1.1. POLICY ISSUES

In 1987 Congress asked the Federal Aviation Administration (FAA) to regulate flights over the Grand Canyon National Park. Unfortunately, the FAA has been unable to get the National Park Service (NPS) and air tour operators to agree on a workable plan. The NPS, however, did ban jet skis from most national park water bodies and placed restrictions on their use at national recreation areas and seashores where they are allowed. Once motorized recreation is allowed, the business and customer constituencies make it difficult to phase out the activity unless it directly threatens human health or the environment as in the jet ski case. It seems that it would be easier to prevent establishment of motorized activity from the start. For example, Rocky Mountain National Park officials and the Colorado congressional delegation worked with the FAA and others to put in place a ban on tour planes and helicopters over the park to prevent establishment of such a tour industry (Loomis, 2002).

There exist multiple competing uses of park resources among the visitors and the conflicts between them can become serious. How can these competing activities be managed efficiently in a national park? The current situations in Grand Canyon and Yellowstone National Parks demonstrate that it is difficult to find compromise solution to these conflicts. Turner (2000) developed a model for managing multiple activities in a national park using the theory of club goods[1]. He assumes that the benevolent social planner maximizes society's welfare, accounting for both visitors' and non-visitors' preferences, to find the socially efficient allocation of park resources. He illustrates that since different activities lead to different direct and external (the increase in congestion and impact on wilderness) costs, they should be regulated individually. One way to regulate activities individually is with tolls that differ by activities. Tolls should be higher for activities with high direct and external costs. Turner shows that once the efficient toll on each activity is imposed, there is no need for an entrance fee and that for an activity to be prohibited in the park there should be private substitutes available outside the park. However, in order to apply his theory in practice, a considerable amount of information is required. Park managers need the following information in order to reach an efficient decision.

- Effects of an activity on congestion of the same activity
- Effects of an activity on congestion of the other activities
- Effects of wilderness protection on congestion of each activity
- Effects of park size on congestion of each activity
- Effects of each activity on wilderness
- Effects of park size on wilderness

[1] A club good is a good that is excludable, nonrival and congestible such as recreation activities in national parks.

- Value of effects on direct park costs of each activity
- Value of effects on direct park costs of park size
- Value of effects on visitor enjoyment of congestion of each activity
- Value of effects on visitor enjoyment of wilderness
- Value of effects on visitor enjoyment of park size
- Value to public at large of wilderness

1.2. CASE STUDY: YELLOWSTONE NATIONAL PARK

This research focuses on Yellowstone National Park (YNP) as an example of multiple and competing uses of public land. YNP was established in 1872 and welcomes over 3 million visitors on average per year. YNP is home to thousands of active thermal features, including the famous Old Faithful Geyser. It is also known for the spectacular Grand Canyon of the Yellowstone. Yellowstone provides wilderness and an open refuge for wildlife, including grizzly bear, elk, American bison, moose and wolf. In addition to YNP, the Greater Yellowstone Area (GYA) includes the Great Teton National Park (GTNP) and the John D. Rockefeller, Jr., Memorial Parkway. The GYA parks are ideal for various recreational activities such as snowmobiling, cross-country skiing, downhill skiing, hiking, and wildlife viewing. The vast majority of visitors come to YNP during summer season, and about 140,000 people visit in winter. Over 60% of winter season visitors ride snowmobiles, and an average of 765 snowmobiles entered YNP each day prior to the 2003-04 season. During the busiest holiday weekends, as many as 1,500 machines enter the park each day (Mansfield *et al*., forthcoming).

The multiple and partially competing uses of the parks have resulted in conflicts between visitors. Supporters of snowmobiles claim that snowmobiles provide not only recreational excitement but also a safe and convenient mean of transportation to experience the park's winter scenery. A visitor to YNP called snowmobiles a "great way to be able to see the landscape" (*USA Today*, February 16, 2006). Snowmobiling is also important for snowmobile manufacturers and a handful of Yellowstone gateway communities (*The Economist*, July 7, 2001). However, snowmobiles have contributed to crowding, noise, bumpy roads, and exhaust fumes in the park, which impose costs on visitors who would like to enjoy other activities such as wildlife viewing and cross-country skiing. Snowmobiles also disturb the wilderness ambience, threaten the wildlife population in the park, and impose potential health and safety risks. A number of park employees have complained that snowmobiles, which smell like "raw gasoline and fermented manure" and make a loud noise like "a forest of chain saws", made them ill and caused them to wear masks (*The Washington Post Magazine*, 2002). Since the snowmobile conflict at YNP involves various stakeholders such as snowmobile enthusiasts, traditional recreationists, environmentalists, local businesses, snowmobile industry, and politicians, the debates over snowmobiles have been controversial and confusing.

1.3. HISTORY OF WINTER USE

Over the past 15 years several proposals and counter-proposals have been suggested as potential management plans for winter visitation to solve the conflict surrounding the use of snowmobiles in the GYA parks. The Winter Use Plan in 1990 allowed access to the GYA parks by recreational snowmobile riders. In 1997, the Fund for Animals initiated a lawsuit against the National Park Service (NPS), alleging the failure of NPS to conduct adequate analysis under the National Environmental Policy Act (NEPA), to consider the impact of winter use on threatened or endangered species, and to evaluate the effects of trail grooming on wildlife and other park resources. This lawsuit was settled, and the NPS was required to conduct an Environmental Impact Statement (EIS). The EIS resulted in a Record of Decision (ROD) which was signed on November 22, 2000. This new rule, published in the Code of Federal Regulations on January 22, 2001, outlined a plan to phase out snowmobiles in the parks. On December 6, 2000, the International Snowmobile Manufacturers Association filed a lawsuit asking for the ROD to be set aside. The lawsuit was settled on June 29, 2001 with requiring NPS to conduct a Supplemental Environmental Impact Statement (SEIS).

In March 2002, NPS published a proposed rule in the Federal Register to generally delay for one year the phase-out of snowmobiles in the parks under the January 2001 snowmobile regulations. This “delay rule” was finalized in November 2002, and it allowed additional time to complete the SEIS. This rule allowed continued snowmobile use through the end of 2003-04 winter season with no other restrictions. On December 11, 2003, the NPS published a new final rule which required strict daily limit on the number of snowmobile, but on December 16, 2003, a judge in Washington DC ordered the NPS to implement the January 2001 rule which bans snowmobiles from the parks. In February 2004, a Wyoming federal judge re-opened and restated his original ruling that the 2001 NPS rule to phase-out snowmobiles was invalid. He also ordered NPS to allow more snowmobiles into the parks. This created confusion among YNP gateway communities, park staff, and snowmobile riders. Thus, NPS developed a temporary winter use plan, which was finalized in November 2004. This plan imposed daily limits on snowmobiles in YNP and GTNP and required all snowmobiles be part of a commercially guided group. Under this plan, snowmobiles are also required to meet NPS best available technology (BAT) requirements. The NPS is currently considering new final regulations to replace the temporary winter use plan. This sequence of lawsuits, court decisions, and agreements to this point is summarized below.

- A 1997 lawsuit by the Fund for Animals against the National Park Service (NPS) for NEPA violations which forced NPS to conduct an environmental impact statement (EIS) on the impact of snowmobiles in the parks.
- Announcement in 2000 of rules outlining a phase-out of snowmobiles
- A lawsuit in December 2000 by the International Snowmobile Manufacturers Association asking that the phase-out rules be nullified.
- Establishment in December 2003 of rules limiting the daily numbers of snowmobiles that can enter the GYA parks, followed by federal court actions challenging this rule in favor of both more and less restrictive access policies.
- Development of a temporary winter use plan imposing daily limits on snowmobiles and requiring all snowmobiles to be in a commercially guided group and to meet the best available technology

1.4. OBJECTIVES OF DISSERTATION

My dissertation has two broad objectives. One is to provide information needed to help resolve winter management issues at YNP. An efficient solution to this conflict requires a thorough understanding of the costs and benefits to different types of park visitors of changes in management plans. Various non-market valuation methods can be used to examine non-market values for park visits and attributes of the park. Among these I will focus on two methods: travel cost models for valuing park days at baseline conditions; and choice experiment models for understanding the importance of park attributes in visitors' decisions and values for park visits.

The second objective is to address methodological issues in non-market valuation. I will use several recent econometric and data combining innovations to improve inference from the two non-market valuation methods. In particular, I will adopt Murdock's (2006) approach to handle unobserved site characteristics in travel cost models. I will also estimate choice experiment models with a richer specification of the opt-out option, and provide an improved approach to welfare analysis using respondents' subjective assessment of the current trip as individual-specific baseline utility. Lastly, I will adopt a discrete-continuous framework to estimate both the choice of trip type and its length in days using Bayesian procedures.

The 2002-03 winter survey data, which will be described in the next chapter, provides the base information needed to pursue these two objectives. My research will contribute to the policy debate involving YNP by providing additional information about how visitors will react to the alternative winter plans and also complement the existing non-market valuation methodology.

The rest of this dissertation is structured as follows. The next chapter describes the survey and the resulting data. Chapter 3 examines the effect of the temporary plan on heterogeneous snowmobile riders and guide service providers both theoretically and empirically using a modified Random Utility Maximization Model (RUM) method. Chapter 4 and 5 estimate winter visitors' preferences and welfare impact of snowmobile policy changes at YNP using choice experiment data. The two chapters, however, incorporate different pieces of data to model visitors' preferences and examine the values of additional information collected in the choice experiment questions.

CHAPTER 2

SURVEY AND DATA

Researchers at RTI International, with support and funding from NPS staff, surveyed visitors to Yellowstone and Grand Teton National Parks during the 2002-2003 winter season. The survey was designed to enable a benefit-cost analysis of the alternative winter management plans under consideration by NPS. The alternatives this survey considered are

- a ban on snowmobiles,
- a cap on the number of snowmobiles allowed in each day and a requirement that snowmobiles be on a guided tour, and
- a cap on the number of snowmobiles allowed in each day but no requirement for guided tours.

Visitors to YNP were sampled throughout the season at all four entrances (East, West, North and South) open during the winter. The sampling goal was to create a probability-based sample that could be weighted to reflect the true population of winter visitors to YNP. The survey took place in two phases. First, visitors were intercepted in the park according to the sampling rate and asked three short screening questions as follows.

1. On this trip, are you staying away from home overnight?
___ Yes, I am staying away from home overnight on this trip
___ No, I am here on a day trip

2. Are you snowmobiling in the park during this trip [if visitor is in a wheeled vehicle]?
___ Yes
___ No

3. If you are riding a snowmobile on this trip, is this trip the first time you have ridden a snowmobile?
___ Yes, this trip is my first time on a snowmobile
___ No, I have ridden a snowmobile before

Name:
Address:

The main survey was then mailed to the visitors who provided their name and address. There were four versions of the main survey:

- Local, experienced snowmobile rider
- Non-local, experienced snowmobile rider
- Local, all others
- Non-local, all others

The answer to the screening questions determined which of four versions of the survey was sent to the respondents. Locals include visitors who were on a day trip, and non-locals are those who were on an overnight trip. An experienced snowmobile rider is a person riding a snowmobile in the park the day he was intercepted who is not a first-time rider. All others include people not riding a snowmobile in the park or first-time snowmobile riders. The survey contains four sets of questions: questions about the visitor's recent trip including activities, the area he visited, and expenditures; questions about previous year's winter recreation (2001–2002); stated preference choice experiment and stated behavior questions; and demographic questions.

Overall, 92 percent of the visitors approached in YNP provided their contact information, and 80 percent of the mailed surveys were returned. The total number of respondents is 1,552. The sample can be divided into four groups depending on the survey version they filled out: locals (23.39%); non-locals (76.61%); experienced snowmobile riders (40.46%); and all others (59.54%). Respondents can also be grouped into snowmobile riders (56.88%) and non-snowmobile riders (43.12%), where riders include both experienced and first-time snowmobile riders.

2.1. RECENT TRIP BEHAVIOR

About 30 percent of the respondents stated that they visited the parks on a day trip, and the other 70 percent were multi-day trip takers[2]. There are more one-day trip takers among all others (35.5%) than among experienced snowmobile riders (20.6%). Also, non-snowmobile riders (41.22%) took more single day trips than snowmobile riders (20.46%). Table 2.1 describes information on individuals' recent trips to the GYA parks and the surrounding areas. The average length of a multiple day trip was almost 5 days. Visitors spent most of their days outside the GYA parks, with about 2 days spent inside YNP. About 20 percent of the sample owns a snowmobile, and 65 percent of the snowmobile owners own the 2-stroke engine snowmobiles. Only 5 percent owns a 4-stroke engine snowmobile, which produces less noise and air pollution.

The most popular primary activity of snowmobile riders' recent trip was, not surprisingly, snowmobiling. However, only 10 percent of riders indicated their recent snowmobiling experience involved a commercially guided tour. Non-riders' most popular primary activity was cross-country skiing (39%). Snowcoach tour of park sights (16%), driving tour of park sights in a car (12%), and downhill skiing (11%) followed cross-country skiing as primary activities.

The survey asked visitors to describe a typical day on their recent visit using nine attributes that describe the parks' condition (appendix A). Table 2.2 presents the attributes and levels of attributes used and summary statistics of respondents' answers. Once

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[2] Respondents were asked to indicate whether they were on a day trip or a multiple-day trip. This "trip length" variable was used to count the number of day trippers and multiple day trippers. If I calculate the same statistics using the information on how many people filled out the Local version of the survey, 23.39% of the sample were on a day trip and 76.61% on a multiple-day trip.

respondents described their most recent trip using these attributes and levels, they were offered an alternative trip consisting of fixed levels of the attributes and the option of not visiting. Then, they were asked whether they would prefer the trip they just took, the alternative trip, or whether they would stay home. The alternative trip's characteristics are as follows:

- Activity - snowmobile;
- Entrance - Yellowstone West entrance,
- Tour - unguided,
- Snowmobile traffic at the entrance - low
- Snowmobile moderate level of snowmobile traffic at the most crowed area - moderate,
- Snow condition - smooth,
- Noise level - moderate,
- Level of exhaust emissions - noticeable, and
- Cost per person for day - $100.

The survey also asked respondents what they would change about a feature of their recent trip if they could (table 2.3). About 44 percent of the respondents reported that they would not change anything about their recent trip. However, 14 percent of snowmobile riders would like to have a smoother road surface, and 15 percent of non-riders wanted to see fewer snowmobiles in the parks. Both groups would like to change the level of exhaust emissions. This suggests that snowmobiles impose externalities not only on non-snowmobile riders but also on other riders.

The survey asked about the number of trips to GYA parks respondents took so far during 2002-2003 winter season and about any additional trips they plan to take during the rest of that season. Table 2.4 summarizes this information. Both experienced snowmobile riders and all others anticipated they would visit and stay in the GYA parks for about 6.5 days, but experienced riders allocated that time more to days in YNP and all others more to days in GTNP.

2.2. REVEALED PREFERECE QUESTIONS

The experienced snowmobile version of the survey listed 52 snowmobile sites in Idaho, Montana, and Wyoming with a map showing these locations (appendix B). These 52 sites represent the set of snowmobile riding alternatives that would be available to potential YNP and GTNP visitors. Survey respondents were asked to provide information on the number of trips they made during the 2001-2002 winter season to the sites included in the choice set. There are 628 people who answered the experienced snowmobile version of the questionnaire, and 307 of them indicated that they visited at least one of the snowmobile sites in the choice set during the previous winter season. Table 2.5 provides a summary of the visits to the 10 most frequently visited sites. The most visited site is YNP with 304 observed visits, and overall experienced snowmobile riders took an average of 6.53 trips per year.

The "all others" version of the survey asked respondents about their winter trips for cross-country skiing, snowshoeing, hiking, and camping in winter 2001-2002 (appendix C). They were given a map with 36 counties surrounding YNP and GTNP and asked to list counties they visited and the number of trips they made in these counties during the last winter season. There were 924 people who filled out the "all others" version, and only 262 of them indicated they visited at least one county among the choice set during the previous winter season. They took an average of 13.46 trips per year, and the median is seven trips per year. Teton County in WY is most frequently visited by all others, and YNP and GTNP ranked the fourth.

2.3. CHOICE EXPERIMENT QUESTIONS

The choice experiment questions, also referred as the conjoint questions, asked respondents to choose between two hypothetical and experimentally designed trips, where the trips were described by attributes related to activity and park conditions (appendix D). If one of the hypothetical trips was chosen, respondents were asked to indicate the number of days they would spend on the chosen trip. The nine attributes presented in table 2.7 were used to describe the trip and park conditions, but only seven of them varied in any given pair of trips to reduce respondents' cognitive burden. There were six choice questions per respondent. Respondents were also given the option of not visiting (the opt-out option). If the opt-out option was selected, she was asked a follow-up question about what she would most likely do instead. The choices were:

- Stay at home: I would not travel to the GYA
- Travel to the GYA to snowmobile outside the parks
- Travel to the GYA to cross-country ski outside the parks
- Travel to the GYA to downhill ski at Big Sky or one of the ski areas near Jackson Hole
- Other

Table 2.8 shows the percentages of each choice chosen by respondents. About a half of the respondents chose the not-visit option, and snowmobile riders, especially experienced snowmobile riders are the more likely to opt out (60.44%). Among the snowmobile riders who chose the opt-out option, about 40 percent answered they would visit other sites in the GYA to continue snowmobiling. For non-snowmobile riders, cross-country skiing (58.59%) was the most likely activity to do when they opted out. "Stay-at-home" was a popular option for both snowmobile riders (38.80%) and non-riders (16.67%).

2.4. STATED BEHAVIOR QUESTIONS

There are three sets of stated behavior questions for alternative management proposals (appendix E). Each respondent was presented with a single management plan and asked how this proposal would impact his current trip and also trips over the entire season. The attributes that described winter use plans here correspond to the stated choice experiment questions. For the question that asked about the effect of a policy change, i.e. banning snowmobiles, on respondents' current trip, the following four options were given:

- My visit would not have been different
- I would have stayed fewer days → how many fewer days? _______
- I would have stayed more days → how many more days? _______
- I would not have visited the park

To obtain information on the impacts of different management plans on visits over the entire season, respondents were presented with the following four options:

- No change in total visits
- I would visit less often → I would take _______ fewer annual trips
- I would visit more often → I would take _______ more annual trips
- I would not visit Yellowstone and Grand Teton National Parks.

Impacts of the different management plans on the recent trip and on the total visits are presented in tables 2.10 and 2.11, respectively. The largest change comes from the proposal of banning snowmobiles and the smallest change comes from just capping the numbers of snowmobiles. Under the ban, 85 percent of experienced snowmobile riders say they would not visit the park whereas 16 percent of all others say they would increase the number of days they spend in the parks.

Table 2.1: Information on Visitors' Recent Trip

	Overall	Experienced Snowmobile Riders	All Others	Snowmobile Riders	Non-Snowmobile Riders
Days spent in GYA	4.9	5.03	4.93	4.92	5.09
Days spent in YNP	1.97	2.14	1.83	2.14	1.68
Days spent in GTNP	0.94	0.53	1.3	0.60	1.58
Days spent outside the parks	4.2	4.6	3.85	4.21	4.18
Own a snowmobile	20.88%	41.72%	6.71%	33.94%	3.74%
2-stroke engine snowmobile	65.57%				
A fuel-injected 2 stroke engine snowmobile	27.05%				
4-stroke engine snowmobile	5.74%				
Don't know	1.64%				
Rented a snowmobile on trip	73.78%				
2-stroke engine snowmobile	55.73%				
4-stroke engine snowmobile	34.83%				
Don't know	9.44 %				
Years riding a snowmobile		12.56 years			

Table 2.2: A Typical Day of the Most Recent Trip to GYA Parks

Features of Trip	Respondent's Trip	Overall	Experienced Snowmobile Riders	All Others	Snowmobile Riders	Non-Snowmobile Riders
Activity	Snowmobile	56.44%	97.58%	27.88%	96.67%	1.87%
	Snowcoach tour	12.03%	0.32%	20.16%	1.03%	26.99%
	Snowcoach Shuttle to ski or Snowshoe	2.71%	0.32%	4.37%	0.11%	6.24%
	Drive car to sightsee, ski or snowshoe	26.11%	1.45%	43.23%	1.26%	59.91%
Entrance	Yellowstone West near West Yellowstone, MT	45.42%	63.59%	32.96%	62.49%	22.53%
	Yellowstone East near Cody, WY	4.08%	7.44%	1.78%	6.90%	0.31%
	Yellowstone North near Gardiner, MT	16.33%	4.05%	24.75%	4.95%	31.48%
	Yellowstone South near Flagg Ranch	16.26%	19.26%	14.21%	20.37%	10.80%
	Grand Teton Moose entrance near Jackson Hole, WY	14.48%	2.91%	22.42%	2.76%	30.25%
	Grand Teton Moran entrance near Flagg Ranch	2.76%	2.27%	3.11%	2.19%	3.55%
Guided tour?	Yes	22.15%	11.79%	29.22%	15.61%	30.93%
	No	77.85%	88.21%	70.78%	84.39%	69.07%
Snowmobile traffic at the entrance	High	5.67%	3.41%	7.25%	3.70%	8.40%
	Moderate	18.83%	23.90%	15.29%	23.35%	12.52%
	Low	46.60%	58.70%	38.17%	59.54%	29.00%
	I did not see any snowmobile	28.91%	13.98%	39.30%	13.41%	50.08%
Level of snowmobile traffic at the most crowded area	High	9.70%	7.61%	11.16%	8.51%	11.37%
	Moderate	27.84%	34.47%	23.22%	34.37%	18.80%
	Low	43.65%	55.83%	35.17%	55.29%	27.80%
	I did not see any snowmobile	18.80%	2.10%	30.44%	1.84%	42.02%

Table 2.2 (continued)

Features of Trip	Respondent's Trip	Overall	Experienced Snowmobile Riders	All Others	Snowmobile Riders	Non-Snowmobile Riders
Condition of snow on road surface	Bumpy and rough for all or most of the trip	6.13%	5.35%	6.69%	4.73%	8.10%
	Bumpy and rough for some of the day	40.09%	35.82%	43.14%	41.22%	38.41%
	Smooth	53.77%	58.83%	50.17%	54.04%	53.48%
Noise level	Loud	5.75%	1.31%	8.82%	1.86%	11.08%
	Moderate	19.93%	19.31%	20.36%	21.46%	17.72%
	Low noise	74.31%	79.38%	70.81%	76.68%	71.20%
Level of exhaust emission	Very noticeable	5.34%	1.95%	7.70%	3.36%	8.04%
	Noticeable	30.57%	30.41%	30.69%	32.06%	28.55%
	I did not notice	64.09%	67.64%	61.61%	64.58%	63.41%
Cost	(per person for day)	$ 98.57	$ 124.74	$ 79.96	$ 129.08	$ 55.68
Choice	Your Trip	82.54%	82.00%	82.92%	79.70%	86.64%
	Trip B	14.38%	16.20%	13.12%	18.67%	8.49%
	Not Visit	3.08%	1.80%	3.96%	1.63%	4.87%

Table 2.3: Things Respondents Would Like to Change about Their Recent Trip

	Overall	Experienced Snowmobile Riders	All Others	Snowmobile Riders	Non-Snowmobile Riders
Number of other visitors	1.16%	0.96%	1.30%	1.13%	1.19%
Number of other snowmobiles	7.99%	1.59%	12.34%	2.49%	15.35%
Number of other cars	0.52%	0.32%	0.65%	0.34%	0.75%
Noise level	3.35%	2.87%	3.68%	2.94%	3.87%
Smoother road surface	10.31%	13.54%	8.12%	13.80%	5.66%
Level of exhaust emission	5.80%	5.73%	5.84%	6.56%	4.77%
Cost	5.41%	7.96%	3.68%	7.69%	2.38%
Other	18.43%	18.79%	18.18%	19.12%	17.44%
I would not change anything	44.20%	46.02%	42.97%	43.89%	44.56%

Table 2.4: Information on Visitors' Overall Trips during 02-03 Winter Season

	Overall	Experienced Snowmobile Riders	All Others	Snowmobile Riders	Non-Snowmobile Riders
Number of days in GYA so far	5.63	5.73	5.55	5.39	5.98
Additional days to GYA	0.89	0.79	0.97	0.68	1.22
Anticipated total number of days in GYA	*6.52*	*6.52*	*6.52*	*6.07*	*7.20*
Number of days in YNP	2.05	2.29	1.88	2.21	1.81
Additional days to YNP	0.63	0.35	0.82	0.34	0.98
Anticipated total number of days in YNP	*2.68*	*2.64*	*2.7*	*2.55*	*2.79*
Number of days in GTNP	1.44	0.64	1.98	0.68	2.46
Additional days in GTNP	0.92	0.28	1.35	0.32	1.69
Anticipated total number of days in GTNP	*2.36*	*0.92*	*3.33*	*1.00*	*4.15*

Table 2.5: Top Ten Most Visited Sites to Experienced Snowmobile Riders

Site Name	Observed Visits
Yellowstone/Grand Teton National Parks, WY	304
West Yellowstone, MT	298
Continental Divide Togwotee, WY	210
Big Springs Area Trails, ID	156
Bozeman/Big Sky, MT	98
Ashton Area Trail, ID	96
Continental Divide Gros Ventre, WY	74
Bear Tooth, WY	58
Wyoming Range Afton, WY	55
Snowy Range, WY	54

Table 2.6: Top Ten Most Visited Sites to All Others

Site Name	Observed Visits
Teton, WY	1191
Gallatin, MT	466
Park, MT	436
Yellowstone/Grand Teton National Park, WY	425
Teton, ID	215
Jefferson, MT	127
Carbon, MT	122
Bonneville, ID	105
Fremont, ID	94
Fremont, WY	58

Table 2.7: Attributes and Levels for Choice Experiment Design

Attributes	Levels
Activity	▪ Snowmobile ▪ Snow coach tour ▪ Snow coach shuttle to cross-country ski or hike ▪ Drive car to auto-tour, cross-country ski, or hike
Entrance where trip starts	▪ Yellowstone West near West Yellowstone, MT ▪ Yellowstone North near Gardiner, MT ▪ Yellowstone South near Flagg Ranch ▪ Grand Teton National Park
Guided tour or not	▪ Guided tour ▪ Unguided tour
Daily snowmobile traffic at the entrance where you started	▪ I did not see any snowmobiles near the entrance where my trip started ▪ Low, 200 or fewer snowmobiles (typical North and East Entrances on all days and South Entrance on most weekdays and weekends) ▪ Moderate, 300 to 600 snowmobiles (typical West Entrance on weekdays and South Entrance on busy holiday weeks) ▪ High, 800 to 1,500 snowmobiles (typical West Entrance on a holiday or crowded weekend)
Snowmobile traffic at most crowded part of trip	▪ I did not see any snowmobiles on my most recent trip ▪ Low, 200 or fewer snowmobiles (very uncrowded days at Old Faithful) ▪ Moderate, 300 to 600 snowmobiles (typical Old Faithful on less crowded weekdays and weekends) ▪ High, 800 to 1,500 snowmobiles (typical Old Faithful on a holiday and busy weekends or weekdays in late January and February)
Condition of snow on the road or trail surface for all or most of the trip	▪ Smooth ▪ Bumpy and rough
Highest noise level experienced on trip	▪ Low noise, occasional ▪ Moderate, you would need to raise your voice to talk to someone standing next to you, noise like a busy city street ▪ Loud, standing next to the road you could not converse with someone standing next to you, noise level similar to standing next to a gas-powered lawn mower or a busy highway
Exhaust emission levels	▪ I did not notice any exhaust emissions ▪ Noticeable for some of the trip ▪ Very noticeable for most or all of the trip
Total cost for day per person	▪ Varied according to whether the trip was a car trip or unguided or guided tour.

Table 2.8: Percentages of Alternatives Chosen by Respondents

Choice	Overall	Experienced Snowmobile Riders	All Others	Snowmobile Riders	Non-Snowmobile Riders
TRIP A	25.26%	20.36%	28.62%	22.18%	29.38%
TRIP B	20.78%	19.20%	21.86%	19.78%	22.11%
Not Visit	53.97%	60.44%	49.52%	58.04%	48.51%

Table 2.9: Respondents' Opt-Out Behavior

Opt-Out Choice	Overall	Experienced Snowmobile Riders	All Others	Snowmobile Riders	Non-Snowmobile Riders
Stay Home	31.03%	39.70%	23.23%	38.80%	16.67%
Snowmobile in GYA	27.30%	42.32%	13.80%	40.16%	3.54%
Cross-Country Ski in GYA	21.81%	1.87%	39.73%	1.91%	58.59%
Downhill Ski in GYA	19.86%	16.10%	23.23%	19.13%	21.21%

Table 2.10: Effects of Different Management Plans on the Recent Trips

	Cap on Number of Snowmobiles	Cap on Number of Snowmobiles and Guided Tour	Ban on snowmobiles
Overall population			
Visit unchanged	76.60%	56.12%	40.54%
Decrease days	1.33%	3.29%	2.68%
Average decrease in days	*0.43*	*1.18*	*1.46*
Increase days	4.79%	5.67%	11.89%
Average increase in days	*1.64*	*1.85*	*3.62*
Not visit	17.29%	34.92%	44.89%
Experienced Snowmobile Riders			
Visit unchanged	63.82%	44.09%	10.32%
Decrease days	1.97%	4.79%	3.87%
Average decrease in days	*0.38*	*1.14*	*3.1*
Increase days	1.32%	1.60%	0.65%
Average increase in days	*1.81*	*0.69*	*0.17*
Not visit	32.89%	49.52%	85.16%
All Others			
Visit unchanged	85.27%	72.22%	51.13%
Decrease days	0.89%	1.28%	2.26%
Average decrease in days	*0.50*	*1.29*	*0.56*
Increase days	7.14%	11.11%	15.84%
Average increase in days	*1.95*	*2.39*	*3.92*
Not visit	6.70%	15.38%	30.77%
Snowmobile Riders			
Visit unchanged	67.62	45.41	11.42
Decrease days	1.90	4.59	4.84
Average decrease in days	*0.56*	*1.13*	*2.10*
Increase days	2.86	2.43	1.73
Average increase in days	*1.33*	*0.88*	*0.69*
Not visit	27.62	47.57	82.01
Non-Snowmobile Riders			
Visit unchanged	87.95	78.29	67.86
Decrease days	0.60	0.57	0.65
Average decrease in days	*0.2*	*1.4*	*0.11*
Increase days	7.23	12.57	21.43
Average increase in days	*2.54*	*4.22*	*1.88*
Not visit	4.22	8.57	10.06

Table 2.11: Effects of Different Management Plans on Total Visits

	Cap on Number of Snowmobiles	Cap on Number of Snowmobiles and Guided Tour	Ban on snowmobiles
Overall population			
Visit unchanged	68.92%	51.93%	36.95%
Decrease days	3.78%	6.79%	8.31%
Average decrease in days	*0.63*	*1.08*	*1.07*
Increase days	9.73%	7.52%	16.78 %
Average increase in days	*1.40*	*1.65*	*2.89*
Not visit	17.57%	33.76%	37.97%
Experienced Snowmobile Riders			
Visit unchanged	74.89%	65.38%	45.45%
Decrease days	3.65%	5.56%	7.27%
Average decrease in days	*0.75*	*1.62*	*1.17*
Increase days	13.70%	14.96%	21.82%
Average increase in days	*1.6*	*2.23*	*3.08*
Not visit	7.76%	14.10%	25.45%
All Others			
Visit unchanged	60.26%	41.80%	12%
Decrease days	3.97%	7.72%	11.33%
Average decrease in days	*0.55*	*0.79*	*0.85*
Increase days	3.97%	1.93%	2%
Average increase in days	*0.8*	*0.31*	*0.43*
Not visit	31.79%	48.55%	74.67 %
Snowmobile Riders			
Visit unchanged	64.90	42.93	13.43
Decrease days	4.33	7.88	11.66
Average decrease in days	*0.55*	*0.85*	*1*
Increase days	3.85	2.72	2.83
Average increase in days	*0.91*	*0.69*	*1.38*
Not visit	26.92	46.47	72.08
Non-Snowmobile Riders			
Visit unchanged	74.07	70.29	58.63
Decrease days	3.09	4.57	5.21
Average decrease in days	*0.75*	*1.7*	*1.19*
Increase days	17.28	17.71	29.64
Average increase in days	*1.59*	*2.21*	*3.18*
Not visit	5.56	7.43	6.51

CHAPTER 3

THE ALLOCATION OF SNOWMOBILE ENTRANCE RIGHTS AND GUIDE SERVICES IN YNP

3.1. INTRODUCTION

Yellowstone National Park (YNP) is an ideal place for various recreational activities such as snowmobiling, cross-country skiing, snow-shoeing, hiking, and wildlife viewing. The vast majority of visitors come to YNP during the summer season, and about 140,000 people visit in the winter. Over 60 percent of winter visitors ride snowmobiles, and an average of 765 snowmobiles entered YNP each winter day prior to the 2003-2004 season. During the busiest holiday weekends, as many as 1,500 machines enter the park each day (Mansfield *et al*., forthcoming). Because snowmobiles contribute to crowding, noise, bumpy roads, and exhaust fumes in the park, which impose costs on visitors who would like to enjoy preserved nature, there have been conflicts between visitors.

Beginning with the 2004-2005 winter season, snowmobile policies in YNP have been guided by a Temporary Winter Use Plan, which allows 720 snowmobiles per day in the park: 400 through the West Entrance, 220 through the South Entrance, 40 through the East Entrance, 30 through the North Entrance, and 30 at Old Faithful. The plan also requires all snowmobilers to be part of a guided trip and all snowmobiles to meet the best available technology (BAT) requirement. One can imagine several possible rationing mechanisms for distributing the daily allowed 720 snowmobile permits to YNP visitors. They include: first-come first-served (or rationing by waiting), lotteries (random drawings), auctioning, and grandfathering. For each of these allocation mechanisms, permits could either be transferable after allocation or not.

Under the current management plan, all of the daily permitted snowmobile entries are allocated to commercial guides and visitors must contact one of the guiding companies to obtain an access to the park, implying that guiding companies have the potential to earn rents due to entry restrictions. Guiding companies must acquire permits from the NPS to provide guided tours in YNP, and these are issued through a competitive bidding process. The NPS issued a prospectus for proposals for the operation of snowmobile guiding service at the park in July 2003[3]. The prospectus identifies five principal and one secondary selection factor that the potential bidders must (or may) address for their offer to be responsive to the prospectus. They include:

1. Describe your environmental plan for the protection, conservation, and preservation of resources of the park's natural resources.
2. Describe your safety plan and the rate schedule.
3. Describe your past performance and expertise in providing the same or similar services.
4. Include detailed information about your company's financial status.
5. State the franchise fee you offer as a percentage of the gross yearly revenue
6. Secondary selection factor: describe environmental management programs and activities that will protect the park's resources further.

Those questions are fairly simple, but they require months of research and writing (Swanson, Augusts 2006). Some guiding companies pay tens of thousands dollars to have full financial audits done in order to show the NPS a clean bill of financial health (Loomis, September 2006). Hundreds of pages of environmental and safety protocols are written up. Those proposals are sent to the NPS and are evaluated by a team of NPS staff. For each

[3] The 2003 NPS rule was designed to allow 950 snowmobiles per day (80% commercially guided; 20% non-commercially guided).

selection factor, the NPS assigns a score that reflects the merits of the proposal under that selection factor in comparison to the other proposals received. The NPS will select the proposal with the highest total point score as the best proposal. Pre-existing concessioners that had performed satisfactorily during the term of their concession contract were determined to be preferred offerors, and if they submitted a responsive offer they had the right to match a better offer. Based on personal communication with NPS staff, there were 35 companies that bid for authorization in response to the 2003 prospectus.

The 2003 NPS rule was overturned by the courts in December 2003, and the prospectus was thrown out. The park has been operated under a temporary winter use plan since then, and the existing snowmobile guides were authorized to continue providing tours in the park. All authorized companies are currently paying three percent of their gross yearly revenue as the franchise fee, which is the minimum annual franchise fee. When the NPS finally has a long-term winter use plan, a prospectus similar to that developed in 2003 will be issued, and guiding companies must prepare and submit their proposals again in order to continue doing their business.

During the 2005-2006 winter season there were eight guiding companies serving the West entrance, 12 in the South entrance, one in the North entrance, and one in the East entrance. Snowmobile entry permits were allocated to each park entrance based on historic use. For example, 400 snowmobile entries were allocated to the West Entrance, and the eight authorized operators were each allocated 50 snowmobiles per day. If a concessioner chooses to operate with fewer snowmobiles than allocated, they can request approval of the NPS to sell a portion of their allocation to another authorized concessioner[4]. Table 3.1 shows the numbers of snowmobiles allocated to guiding companies at each entrance. It can be noted that the West entrance has the largest allocation of snowmobiles because it is historically the main entrance for snowmobiles. The 2002-2003 winter visitor survey data confirms that the West entrance is the most popular to snowmobile riders (see table 3.2). Rates for guide services are not set by the NPS but are based on comparison with like services provided by the private sector. Before the Temporary Plan, the guide service fee ranged roughly from $17 to $25 per person. In the 2005-2006 winter season, the overall guide fee increased and ranged from $25 to $50 per person.

In this chapter, I develop theoretical models of the demand for snowmobile trips to YNP and for guide services and analyze the welfare effects of the Temporary Winter Use Plan on heterogeneous snowmobile riders and guiding companies. I also estimate the aggregate demand for snowmobile trips using 2002-2003 winter visitor survey data, which contains information on the number of trips respondents made to YNP and other snowmobile sites during the previous year (2001-2002). The estimated demand curve is used to assess the overall effect of the policy change on YNP snowmobile riders.

[4] A west Entrance concessioner's daily allocation is 50 snowmobiles. On a given day, for example, this concessioner might only utilize 45 of its daily allocation. The concessioner is then authorized to let another concessioner use his extra five allocations. Concessioners are allowed to reimburse one another for a "referral" or "reservation" fee when utilizing one another's snowmobile allocation for the day. Regulations prohibit any transfers of contract rights or privileges as a result of the contract. The NPS does not get involved in the referral fee; the concessioners work this out among themselves. The guide is required to notify the entrance station staff how many snowmobiles he/she has from each company.

3.2. A THEORETICAL MODEL

3.2.1. The Derived Demand for YNP Entries

Assume that a guided snowmobile trip to YNP is produced by two inputs, using fixed-proportions: one entry (E) and one unit of guide service (G) constitute a trip (T). According to NPS regulations, a snowmobile rider must first arrive at one of the entrances of YNP and have a guide to enter the park and ride a snowmobile. A guided tour includes ten people, implying that one-tenth of a single guide's service is needed for each visitor. For simplicity, I will assume that a YNP snowmobile trip is made up of one entry and one guide service: $T = min\ (E, G)$. Following Friedman's handles, blades and knives analysis (Friedman, 1976), in equilibrium, the price of an YNP trip (P_T) will equal the sum of prices of an entry (P_E) and a guide service (P_G). This condition becomes a derived demand for entries when one takes as given the supply of guide services and the demand for YNP trips. Figure 3.1 shows the derived demand for YNP entries, $D_{E,}$ as the vertical difference between the demand for trips, D_T, and the supply of guide services, S_G. The demand for trips is itself a derived demand with transportation costs vertically deducted from a raw demand curve.

3.2.2. Heterogeneous Preferences for Guided Tours

Snowmobile riders have heterogeneous preferences towards guide services, and these can be divided into three categories: guided tour lovers, guided tour avoiders, and guided tour neutrals. Guided tour lovers are people who prefer to have professional guides when they take a snowmobile trip in Yellowstone. This type of visitor is likely to be an inexperienced rider or one visiting YNP for the first time. Experienced guides are knowledgeable about snowmobiling and the park and can assist visitors in exploring and enjoying the park more thoroughly. Guided tour avoiders are those who would prefer to take independent snowmobile trips. These visitors are likely to be experienced riders who are familiar with YNP and enjoy speed. If a guided tour neither adds nor detracts utility from snowmobile riders, this kind of visitors can be categorized as a neutral.

Figure 3.2 illustrates the preferences over guide services and park entries for guided tour lovers, avoiders, and neutrals. The utility of guided tour lovers increases as guide services and entries increase, which means that both commodities are "good" and more is preferred to less. For guided tour avoiders, guide services are a "bad" in which less is preferred to more. The utility decreases for guided tour avoiders when guide service increases. If a guided tour is a neutral commodity, consumers are indifferent to the level of guide services, but prefer more entries to fewer.

3.2.3. Welfare Effects of Policy Change: Who Loses and Who Gains?

Prior to the 2004-2005 winter season, there was no limit on the number of snowmobile entries into YNP and no guided tour requirement. During this time, guided tour lovers took snowmobile trips to Yellowstone with commercial guides while avoiders and neutrals[5] took independent snowmobile trips without guides. According to the 2002-2003 winter survey, about 10 percent of riders took guided tours prior to when they were required to do so. Figure 3.3 illustrates two demand curves for snowmobile trips (D^{G}_{T} and D^{WOG}_{T}) and an aggregate demand curve (D_E) for entries, which is the horizontal sum of the first two demand curves. In the guide avoider market segment, which includes both guided tour neutrals and avoiders, the demand for entries is equal to the demand for trips because they do not take

[5] Guide neutrals will choose not to take a guided tour because guide services have a positive price.

guided snowmobile tour. In the guide lover market segment, the demand for entries is the derived demand illustrated in figure 3.1.

Without any restrictions on the number of snowmobile entries, there will be Q^G_0 of snowmobiles entering with guides and Q^{WOG}_0 of snowmobiles without guides. From the 2002-2003 winter visitor survey, approximately 10 percent of visitors took a guided tour, which means that on an average day about 76 snowmobiles entered the park with guides ($Q^G_0 = 76$). The total number of snowmobiles is, then, Q_0 ($= Q^G_0 + Q^{WOG}_0$) when there are no regulations. Riders pay the zero price for entries in both markets and pay P^0_G if they choose to have a guide. Consumer surplus for guide lovers is the area below the demand for trips and above the price riders must pay for a trip, P^0_T, and the producer surplus of guide service providers is the area above the supply curve and below the price of guide services, P^0_G. Consumer surplus for independent snowmobile riders is the whole area below the demand for trips (D^{WOG}_T).

I will examine consequences of a policy change, which occurred in the 2004-2005 winter season when the NPS set a limit of the number of snowmobiles and imposed a guided tour requirement. Under this policy, all snowmobiles must be guided by commercial guides. Among the three kinds of snowmobile riders, guide avoiders are now least likely to visit YNP, shifting the demand for trips to the left in the guide avoider market segment as it is presented in figure 3.4.

Demands for snowmobile trips for avoiders with and without the guide requirement are $D^{WG'}_T$ and D^{WOG}_T, respectively. Another way of interpreting this consequence is that guide avoiders' willingness to pay for YNP trips decreases when the guided tour requirement is in place because they obtain disutility from guide services. Riders who drop out of this market are likely to go to other snowmobile trails where there is no guided tour requirement. The aggregate demand for snowmobile trips with guides is the sum of demands for trips from two different markets ($D_T = D^G_T + D^{WG'}_T$).

Now, Q_1 ($=Q^G_0 + Q^{WG'}_0$) is the number of snowmobile riders who desire to enter the park with commercial guides if no fee is charged for entering the park. If Q_1 is less than the allowed number of snowmobiles in YNP, Q', then the limit does not bind, and all of Q_1 will enter the park with guides. The price of guide services will be P^1_G, and the producer surplus will increase because P^1_G is greater than P^0_G, which is the price of guide services prior to the regulation. If Q_1 is, however, greater than Q', then the limit is binding and the price of guide service will be P'_G, which is greater than P^0_G but less than P^1_G. When the limit is binding, guide service providers, who ration entry permits, can charge P'_E to snowmobile riders. This means that riders now must pay P'_T ($=P'_G + P'_E$) per entry because only a limited number of snowmobiles can enter and the demand for entry is larger than the limit. It can be noted that the supply curve (S'_G) becomes vertical at Q' because only authorized guiding companies can provides guided visits.

The welfare change for guide service providers is the sum of the change in producer surplus and the rent. The price of guide services is P^0_G prior to the restriction, but with a binding limit on the number of snowmobiles, the price of guide services increases to P'_G, which means that producer surplus increases. In addition to the increased producer surplus, guiding companies gain entry rents. The potential size of the rents is $P'_E \times Q'$, but guided tour operators must pay a certain percentage of their revenues to the NPS according to their contracts. It is also believed that the bidding process is costly, which further reduces the rents.

3.3. DATA

Among four sets of questions included in the survey, I will focus on the revealed preference questions, which asked visitors about their previous year's winter recreation for this chapter. The experienced snowmobile version of the survey listed 52 snowmobile sites in Idaho, Montana, and Wyoming with a map showing these locations (appendix B). These 52 sites represent the set of snowmobile riding alternatives that would be available to potential YNP visitors. Survey respondents were asked to provide information on the number of trips they made during the 2001-2002 winter season to the sites included in the choice set. There are 617 people who answered the experienced snowmobile version of the questionnaire, and 377 of them indicated that they visited at least one of the sites in the choice set during the last winter season. More details about the data can be found in section 2.2

3.4. MODEL ESTIMATION

Because I do not have information on the supply side of guide services, it is not possible to estimate the supply curve and do a full analysis of the welfare changes for guiding companies and snowmobile riders. It is, however, possible to estimate the demand for snowmobile entries into YNP and to calculate snowmobile riders' welfare change from limiting the number of snowmobile entries using the revealed preference data. For this I need to construct the snowmobilers' demand for entry. To estimate the demand curve, I need information on each visitor's willingness to pay to enter YNP, which can be evaluated via a Random Utility Maximization (RUM) model.

The RUM model I employ is a travel cost model that considers the choice among sites as a function of characteristics of available sites. These characteristics include the price of arriving at the sites (both explicit and implicit travel costs) as well as attributes of each site. The utility a person receives for a visit to site j is defined as:

$$u_j = v_j + \varepsilon_j, j = 1,...,J, \tag{3.1}$$

where v_j is the observable component of utility and ε_j is a random error, which is unobservable to the researcher. On a given choice occasion the probability an individual chooses to visit site j is the probability that u_j is greater than u_k for all $k \neq j$. If the errors are independently and identically distributed with a type I extreme value distribution, the probability of an individual visiting site j is given by:

$$pr(u_j \geq u_k) = \frac{\exp(v_j)}{\sum_{k=1}^{J} \exp(v_k)}. \tag{3.2}$$

The willingness to pay for access to site 1 can be calculated as:

$$WTP_1 = -\delta^{-1}\left(\ln \sum_{k=2}^{J} \exp\left[v_k\right] - \ln \sum_{k=1}^{J} \exp\left[v_k\right] \right), \tag{3.3}$$

where v_k is the deterministic component of utility for alternative k, and δ is the marginal utility of income. The price elasticity of the probability of visiting site 1 can be computed as:

$$E_{1p_1} = \delta \cdot p_1 \cdot (1 - P_1), \tag{3.4}$$

where P_1 is the probability of choosing site 1, p_1 is the travel cost, and δ is the price coefficient.

It is not possible from the researcher's perspective to observe all the characteristics of the sites that are important in individuals' decision making. If there is correlation between the observed regressors and the error, coefficients on the observed characteristics are potentially biased (Berry, 1996). In recreation demand, when unobserved characteristics of sites are not properly modeled, there may be correlation between the travel cost variable and unobserved site characteristics, which results in biased estimates of the travel cost parameters.

Murdock (2006) uses the method of Berry (1996) and Berry, Levinsohn and Pakes (BLP) and proposes a variation of the method for a recreation RUM model. This model successfully addresses unobserved characteristics of the sites and assures unbiased estimates of the price parameter by including a full set of alternative-specific constants with the travel price parameter. Model estimation takes place in two stages. In the first stage, a full set of alternative-specific constants and the travel distance parameters are estimated via maximum likelihood. Because a full set of alternative-specific constants are estimated in the first stage along with the price parameter, the unobserved characteristics are poured into the constants. In the second stage, estimated alternative-specific constants are regressed on the observed site characteristics via OLS to find out their effects on individuals' choices.

To estimate unbiased WTP for entries to YNP, I utilize Murdock's first stage estimation and specify the utility a person *i* receives from visiting site *j* as:

$$u_{ij} = \alpha_j + \gamma \cdot price_{ij} + \beta \cdot price_{ij} \cdot guided_i + \varepsilon_{ij} . \qquad (3.4)$$

This model can be applied to snowmobile riders' revealed preference data, which contains information on the number of trips respondents made to 52 available sites. The total number of respondents who filled out the experienced snowmobile riders' version of the survey is 617 (the full sample), and they took 2,081 trips. The RUM model requires calculation of the travel cost for each person in the sample to all available snowmobile sites, which requires a consistent distance-based measure of travel cost. Visitors from east of the Mississippi River, however, are more likely to use forms of transportation other than driving. In addition, visitors from east of the Mississippi River come to the Greater Yellowstone Area (GYA) on multiple purpose trips, where snowmobiling in YNP is just one of the several trips and may not be the primary purpose. The travel cost model breaks down when we cannot assume that the activity of interest is at least the primary reason for travel. I argue, therefore, that it is reasonable to include in the sample only people living west of the Mississippi River those who are most likely to drive to the GYA for the primary purpose of snowmobiling in the park (the restricted sample). The number of respondents included in the restricted sample is 377 who took 1,750 trips. To analyze the sensitivity of the results to the exclusion of respondents east of the Mississippi, I run the RUM model with both the full and restricted samples.

Travel cost includes the round trip travel cost and the opportunity cost of driving time. The round trip distance and travel time between each person's zip code and each of the 52 sites is calculated using *PCMiler*. The travel cost is calculated based on the following formula:

$$\text{Travel cost} = \$0.49 \times \text{distance} + (1/3)*(\text{income}/2000) \times \text{time}. \qquad (3.5)$$

The $0.49 is the average operating costs for gas, oil, maintenance, and tires in 2000 according to the American Automobile Association. The opportunity cost of driving time is the estimated travel time provided by *PCMiler* times one-third of the wage rate for each respondent, which is calculated by dividing income by 2,000 working hours in a year. Income is calculated using the midpoint of the household income ranges included in the survey. For missing income values, the median of those included in the sample ($30,000) is used.

Among the 52 snowmobile sites, the survey data indicate that 50 sites were visited at least once and 45 sites were visited more than twice. Because two of the sites are not visited, I include 49 (50-1) rather than 51 (52-1) site-specific terms. Snowmobile riders not only have 52 snowmobiling sites listed in the survey as a choice set but also have an option of not visiting any sites. To allow respondents to have a stay-at-home option, one more alternative specific constant is added, and the price of this option is zero.

The RUM is estimated with price, price-guide interactions, and 50 alternative-specific constant variables. I, then, evaluate the welfare loss from eliminating YNP as an available snowmobile site in the choice set using the estimation results, which gives the willingness to pay for an entry to Yellowstone for each person in the sample. After calculating the willingness to pay for each respondent, I rank them top to bottom, which represent a demand curve for entries for the sample. To evaluate the welfare changes for site closure for snowmobiling or the entry restrictions, the demand curves for trips are required. For guide avoiders, demands for entries and for trips are identical. Information on the supply side of guide services is, however, needed to derive the guide lovers' demand curve for trips because they value guided tour as a part of their snowmobile trip. The lack of data on guide services precludes estimation of guide lovers' demand for trips.

To scale up the sample demand curve to an aggregate demand curve, I need information on how many actual visitors are represented by a sampled visitor. Prior to the 2004-2005 winter season, an average of 765 snowmobile riders entered YNP per day, and during the busiest weekend day, approximately 1,500 riders came to the park. The data indicate that 10 percent of them took a guided tour, and, therefore, it can be claimed that about 1,350 and 630 guide avoiders visited the park on a weekend day and a weekday respectively. Because the sample was created to reflect the true population of winter visitors to YNP, I can assume that a respondent in the restricted sample (N_R=377) represents about four weekend and two weekday visitors.

3.5. RESULTS

Tables 3.3 and 3.4 present the RUM results with the full and restricted samples. The price variables are significant and negative as anticipated in both samples. The price elasticities of the probability of visiting YNP for guide lovers and avoiders with the restricted sample are -1.4873 and -2.4025, indicating that guide lovers are less price elastic than avoiders. The mean of guide lovers' willingness to pay (WTP) to keep the park open for snowmobiling is higher than avoiders' WTP (see table 3.5). Apparently guide lovers see YNP as a unique place and, therefore, see fewer substitutes and have a higher WTP to have access to the park in the winter.

The results with the full sample, however, suggest that guide lovers are more price elastic than avoiders, which is the opposite of the results with the restricted sample. The inconsistency could come from the fact that the vast majority of guide lovers (77%) in the full sample did not visit any sites in the previous year. Because guide lovers from the east coast are not likely to make a trip in the previous year, they appear to be very price elastic. On the other hand, about 41 percent of guided tour lovers in the restricted sample visited at least one site in the previous year, which is a better mix of guide lovers who did and did not choose to make any trips. This suggests that it is more reasonable to include only people from the west of the Mississippi River in the sample – people who are most likely to drive to the park and to have a single purpose trip (snowmobiling at the park).

The sample demand curves for YNP entries for guide lovers and avoiders are presented in figures 3.5 and 3.6. Guide avoiders' aggregate demands for trips for a weekend day and a weekday are presented in figures 3.7 and 3.8. If YNP is closed for snowmobiling, the estimates of the consumer surplus losses[6] for guide avoiders are $47,250 per day on the weekend and $22,050 per weekday. The current restriction on the number of snowmobiles allowed in the park does not affect the weekday entries because the limit is not binding, which suggests that there is no consumer surplus loss from the current policy during weekdays. On the weekend, however, the limit is binding, and there are consumer surplus losses of $9,630 per day. The overall consumer losses for an entire winter season[7] are estimated to be approximately $2,700,000 from banning entry to the park and $290,000 from the entry restriction actually adopted. These are lower bound estimates of snowmobile riders' consumer surplus losses because guide lovers welfare changes are not accounted for.

3.6. CONCLUSION

The conflict between snowmobile riders and conservationists in Yellowstone National Park started with a lawsuit by the Fund for Animals in 1997 and has not yet been settled. Since the 2004-2005 winter season, snowmobile policies in YNP have been guided by a Temporary Winter Use Plan, which allows 720 snowmobiles per day in the park. The plan requires all snowmobilers to be part of a guided trip and all snowmobiles to meet the best available technology requirement. All of the daily permitted snowmobile entries are allocated to 22 commercial guiding companies at the four entrances. This chapter examined the welfare

[6] This is calculated by the triangle area under the demand curve. $\Delta CS = (\$70*1350)*0.5 = \$47,250$.
[7] There are about 30 weekend days and 60 weekdays in a winter season.

effects of the policy change on the heterogeneous population of snowmobile riders and guide service providers theoretically and the impact of the policy specifically on guided tour avoiders using the 2002-2003 winter visitor survey data. To calculate the welfare effects of the policy change I estimated demands for entries into YNP using a modified Random Utility Maximization (RUM) model, which includes a full set of alternative-specific constants with the travel price parameter. The restriction on snowmobile access in YNP makes both guide lovers and avoiders worse off, and the estimate of avoiders' consumer surplus loss is $290,000 for a winter season.

The new regulation, however, makes guiding companies better off by increasing the number of guided tours demanded and by giving them access rights to the park. The size of their rents is decreased because guide service operators must pay three percent of their revenues to the NPS as a franchise fee and the bidding process to obtain authorization from the NPS takes both human and financial resources.

Table 3.1: Daily Snowmobile Entry Limits in Yellowstone National Park

Entrance	Number of Snowmobiles Allowed in the Park	Number of Guiding Companies	Snowmobiles per Company
West Entrance	400	8	50
South Entrance	220	12	Approx. 18
East Entrance	40	1	40
North Entrance	30	1	30
Old Faithful	30		
Total	720		

Table 3.2: Frequencies of Each Entrance Usages

Entrance	Snowmobile Riders	Non-Snowmobile Riders
West Entrance	66.10 %	39.54 %
East Entrance	10.45 %	1.84 %
North Entrance	3.95 %	44.83 %
South Entrance	19.49 %	13.79 %

Table 3.3: The RUM Results with a Full Sample (N_F=617)

Variable	Number of Visits	Coefficient	t-stat	WTP ($)
Price	N/A	-0.02039	-21.117	-
Price_Guide	N/A	0.00032	2.5814	-
Wallace Area Trails, ID	3	-	-	0.6168
Northern Idaho Trails, ID	20	2.0777	3.3555	4.2771
Grangeville Area Trails, ID	21	2.0975	3.3982	4.5306
North-Central Idaho Trails, ID	1	-1.0528	-0.9117	0.2096
Salmon/Challis Area Trails, ID	21	1.7464	2.8290	4.0117
Smith's Ferry Area Trails, ID	1	-1.0781	-0.9336	0.2065
Stanley Area Trails, ID	8	0.8594	1.2692	1.5539
Central Idaho Trails, ID	12	1.2243	1.8965	2.2950
South-Western Idaho Trails, ID	1	-1.2047	-1.0432	0.2021
South-Central Idaho Trails, ID	21	1.7084	2.7672	4.1726
Big Springs Area Trails, ID	156	3.5835	6.1452	30.2078
Ashton Area Trails, ID	95	3.0385	5.1787	17.9609
Eastern Idaho Trails, ID	50	2.4468	4.1144	9.2875
Bone Snowmobile Trails, ID	26	1.7752	2.9099	5.0051
Pocatello Area Trails, ID	30	1.8897	3.1189	5.7372
Bear Lake Area Trails, ID	36	2.0626	3.4303	6.9399
South-Eastern Idaho Trails, ID	7	0.4902	0.71014	1.3314
Kootenai Country, MT	3	0.1450	0.1776	0.6185
Flathead Valley, MT	5	0.5527	0.7568	1.0182
Haugan, MT	2	-0.4394	-0.4813	0.4083
Seeley Lake, MT	9	0.9403	1.4103	1.8056
Garnet, MT	3	-0.2207	-0.2703	0.5956
Lincoln, MT	11	1.1171	1.7149	2.2052
Kings Hill/Little Belts, MT	16	1.4833	2.3573	3.3005
Helena, MT	4	0.0336	0.0440	0.7963
Lolo Pass, MT	12	1.3097	2.0289	2.4274
Georgetown Lake, MT	12	1.1550	1.7890	2.3805
Wise River, MT	8	0.7079	1.0455	1.5629
Dillion/Polaris, MT	0	-	-	-
Wisdom/Jackson/Sula, MT	1	-1.3226	-1.1453	0.1958
Virginia City/Ennis, MT	5	0.1576	0.2157	0.9668
Bozeman/Big Sky, MT	97	3.1299	5.3372	19.2060
West Yellowstone, MT	305	4.2678	7.3530	61.5174
Cooke City/Silver Gate, MT	33	2.1309	3.5327	6.7533
Yellowstone/Grand Teton National Park, WY	354	4.4167	7.6145	72.2770
Bear Tooth, WY	58	2.5875	4.3676	11.9704
Continental Divide Togwotee, WY	207	3.7962	6.5236	40.0431
Continental Divide Gros Ventre, WY	74	2.7938	4.7409	13.8453
Continental Divide Dubois, WY	40	2.1464	3.5831	7.6423
Wyoming Range Kemmerer, WY	2	-0.8497	-0.9306	0.3839
Continental Divide Lander, WY	53	2.3890	4.0219	10.5656
Granite Hot Springs, WY	23	1.5847	2.5794	4.8425
Wyoming Range Alpine, WY	31	1.8863	3.1178	5.7501
Casper Mountain, WY	27	1.7726	2.9109	5.0595
Wyoming Ranger Kemmerer, WY	3	-0.4468	-0.5470	0.5944
North Big Horn Mountains, WY	28	1.8154	2.9863	6.0311
South Big Horn Mountains, WY	33	1.9546	3.2387	7.1551
Bear Lodge Mountain, WY	2	-0.8214	-0.8994	0.4581
Black Hills of WY, WY	0	-	-	-
Wyoming Range Afton, WY	55	2.4354	4.1038	11.7772
Snowy range, WY	55	2.3941	4.0326	12.2650
Sierra Madre Mountain, WY	1	-1.5404	-1.3337	0.2159
Opt-Out	-	2.4086	4.0566	-

Table 3.4: The RUM Results with a Restricted Sample (N_R=377)

Variable	Number of Visits	Coefficient	t-stat	WTP ($)
Price	N/A	-0.0046	-27.106	-
Price_Guide	N/A	0.0028	13.2100	-
Wallace Area Trails, ID	3	-	-	0.3253
Northern Idaho Trails, ID	5	2.6120	3.5396	3.7911
Grangeville Area Trails, ID	21	2.5841	3.5094	4.1107
North-Central Idaho Trails, ID	1	-0.5513	-0.4509	0.1740
Salmon/Challis Area Trails, ID	1	2.0996	2.8481	2.7378
Smith's Ferry Area Trails, ID	1	-0.5543	-0.4533	0.1735
Stanley Area Trails, ID	7	1.2976	1.6466	1.1121
Central Idaho Trails, ID	12	1.6181	2.1261	1.5869
South-Western Idaho Trails, ID	1	-16.313	-0.0069	0
South-Central Idaho Trails, ID	21	2.0068	2.7212	3.0273
Big Springs Area Trails, ID	123	3.4340	4.8310	13.1808
Ashton Area Trails, ID	81	2.9449	4.1254	8.7272
Eastern Idaho Trails, ID	50	2.5690	3.5731	5.6377
Bone Snowmobile Trails, ID	27	2.0044	2.7406	3.1460
Pocatello Area Trails, ID	11	2.0658	2.8381	3.5905
Bear Lake Area Trails, ID	14	2.2436	3.0985	4.3164
South-Eastern Idaho Trails, ID	7	0.6731	0.8419	0.8786
Kootenai Country, MT	3	-0.3122	-0.2554	0.1652
Flathead Valley, MT	4	0.8801	1.0198	0.6265
Haugan, MT	2	-0.0367	-0.0368	0.3159
Seeley Lake, MT	8	1.0441	1.3075	1.0186
Garnet, MT	3	-0.2895	-0.2902	0.2782
Lincoln, MT	9	1.5022	1.9622	1.5555
Kings Hill/Little Belts, MT	16	1.9508	2.6109	2.3052
Helena, MT	4	0.3737	0.43285	0.5460
Lolo Pass, MT	12	1.7429	2.2923	1.8133
Georgetown Lake, MT	12	1.5008	1.9730	1.6510
Wise River, MT	8	1.0268	1.3035	1.0472
Dillion/Polaris, MT	0	-	-	-
Wisdom/Jackson/Sula, MT	1	-0.9630	-0.7875	0.1329
Virginia City/Ennis, MT	4	0.1894	0.2193	0.4951
Bozeman/Big Sky, MT	88	3.1713	4.4456	9.8303
West Yellowstone, MT	225	4.0966	5.7881	25.6642
Cooke City/Silver Gate, MT	29	2.1938	2.9864	3.1169
Yellowstone/Grand Teton National Park, WY	289	4.3504	6.1535	33.7514
Bear Tooth, WY	57	2.8188	3.9299	7.3677
Continental Divide Togwotee, WY	199	3.9113	5.5221	21.6667
Continental Divide Gros Ventre, WY	70	2.9230	4.0897	7.5719
Continental Divide Dubois, WY	37	2.2642	3.1286	3.9435
Wyoming Range Kemmerer, WY	2	-0.6390	-0.6401	0.2270
Continental Divide Lander, WY	53	2.5242	3.5129	5.8073
Granite Hot Springs, WY	19	1.6444	2.2176	2.2772
Wyoming Range Alpine, WY	29	1.9192	2.6309	3.0291
Casper Mountain, WY	6	1.8989	2.5962	2.8939
Wyoming Ranger Kemmerer, WY	2	-0.6587	-0.6598	0.2491
North Big Horn Mountains, WY	27	2.1167	2.9006	3.7024
South Big Horn Mountains, WY	33	2.2334	3.0756	4.3122
Bear Lodge Mountain, WY	2	-0.5223	-0.5229	0.2683
Black Hills of WY, WY	0	-	-	-
Wyoming Range Afton, WY	55	2.6645	3.7113	6.7551
Snowy range, WY	55	2.5184	3.5021	6.3471
Sierra Madre Mountain, WY	1	-1.2735	-1.0407	0.1235
Opt-Out	335	1.0316	1.4268	-

Table 3.5: Willingness to Pay and Price Elasticities for Access to YNP

			Overall	Guide Lovers	Guide Avoiders
Full Sample	**WTP ($)**	**Max**	134.1892	134.1892	122.1817
		Min	7.0090	36.7593	7.0090
		Mean	72.2770	75.7620	71.8382
		Median	77.5343	73.1782	77.7318
	Price Elasticities		-1.7902	-2.1226	-1.7483
Restricted Sample	**WTP ($)**	**Max**	120.72	120.72	69.59
		Min	0.20	53.89	0.20
		Mean	33.75	80.51	30.14
		Median	32.71	73.55	31.19
	Price Elasticities		-2.3369	-1.4873	-2.4025

Table 3.6: Consumer Surplus Losses from Site Closure and Entry Restriction

	Consumer Surplus Loss ($/day)	
	Weekend	**Weekday**
Site closure	47,250	22,050
Entry restriction	9,630	0

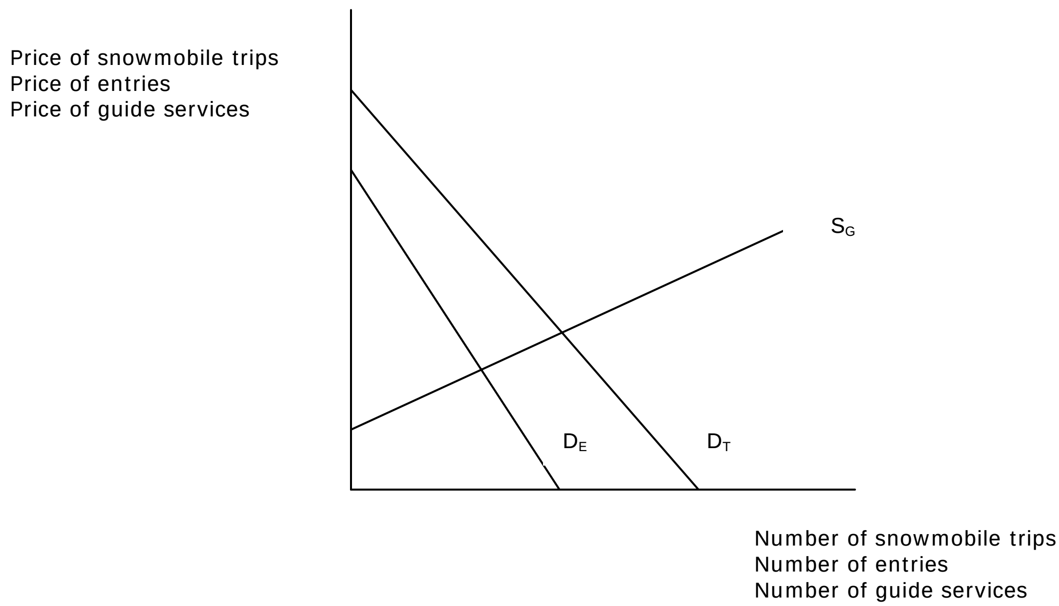

Figure 3.1: Derived Demand for YNP Entries

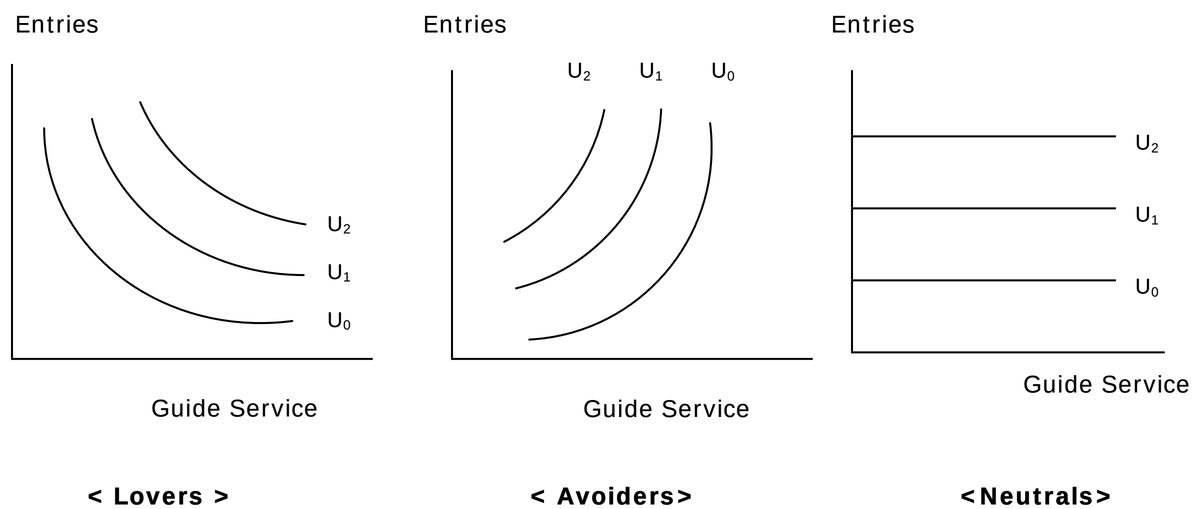

Figure 3.2: Preferences for Guided Tour Lovers, Avoiders, and Neutrals

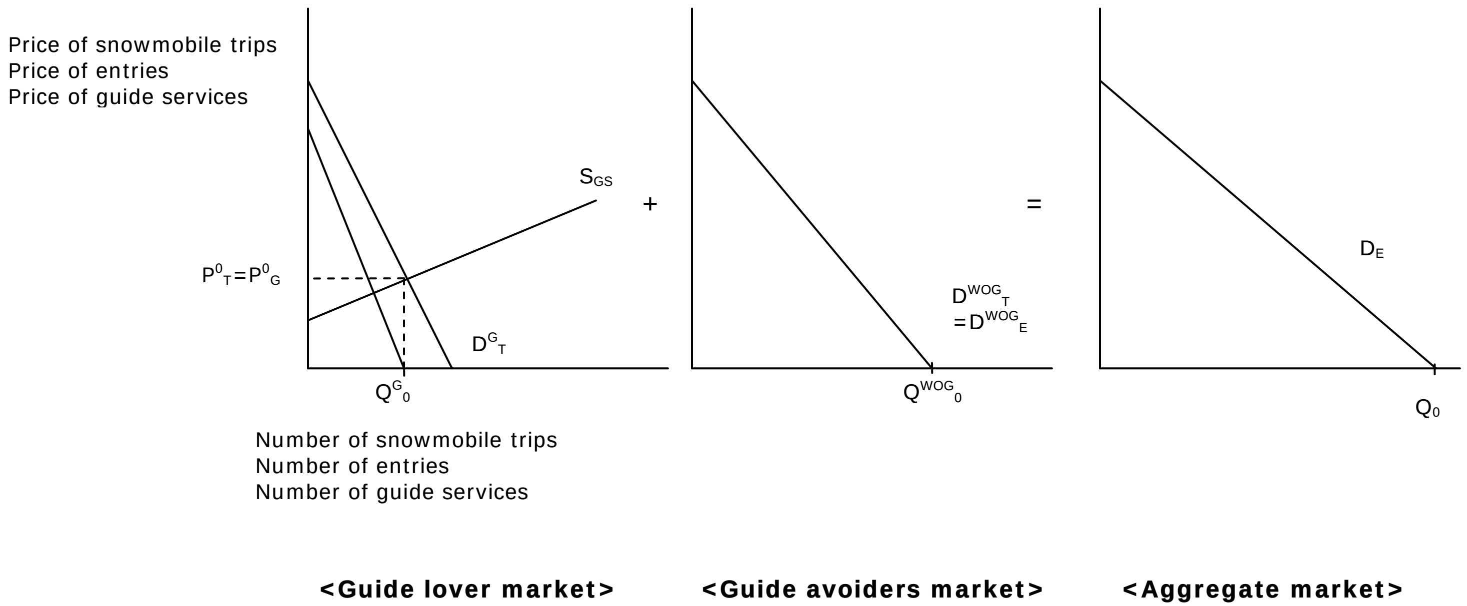

Figure 3.3: Guide Lovers and Avoiders Markets

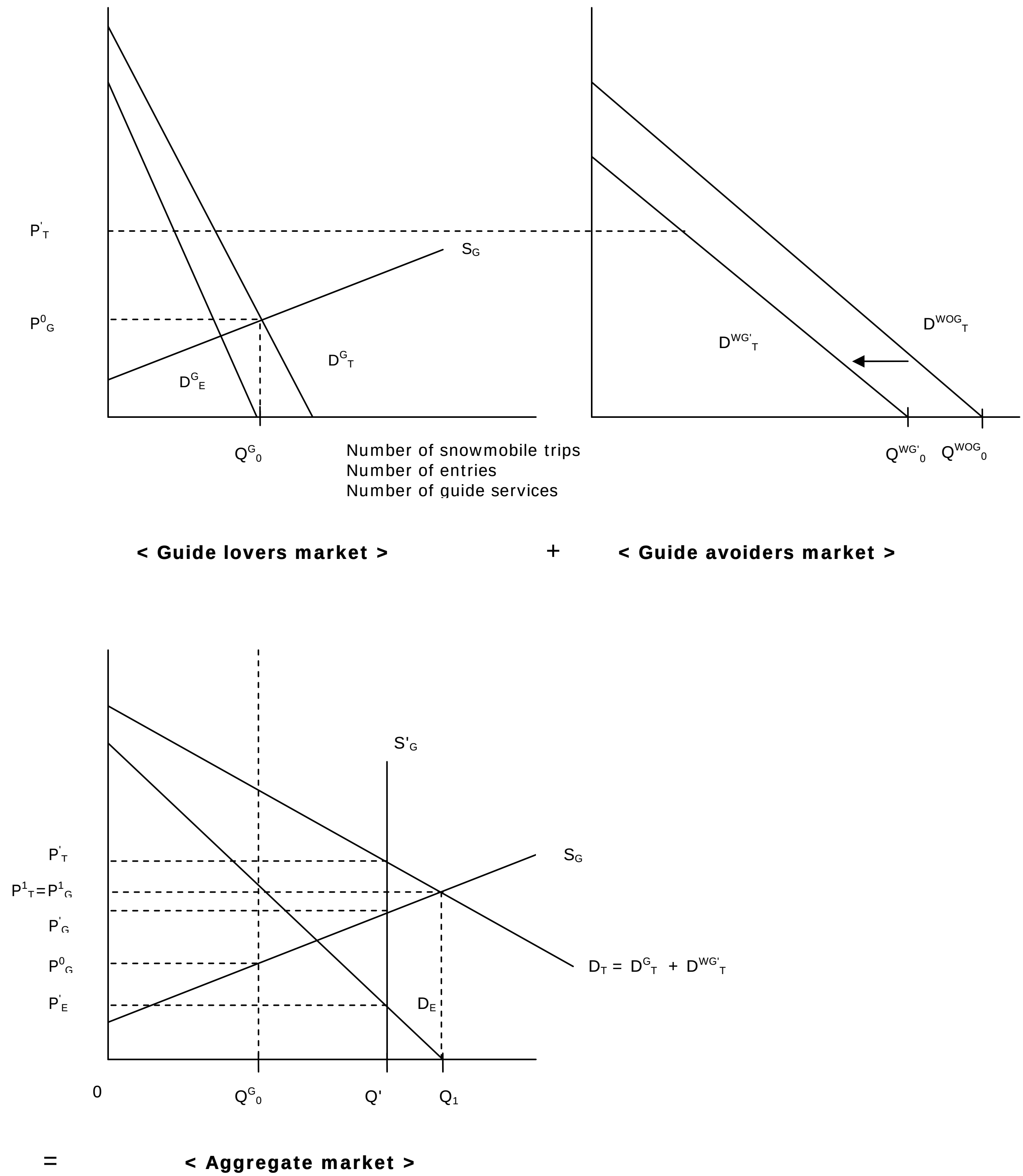

Figure 3.4: A Limit on the Number of Snowmobiles in the Park with Guided Tour Requirement

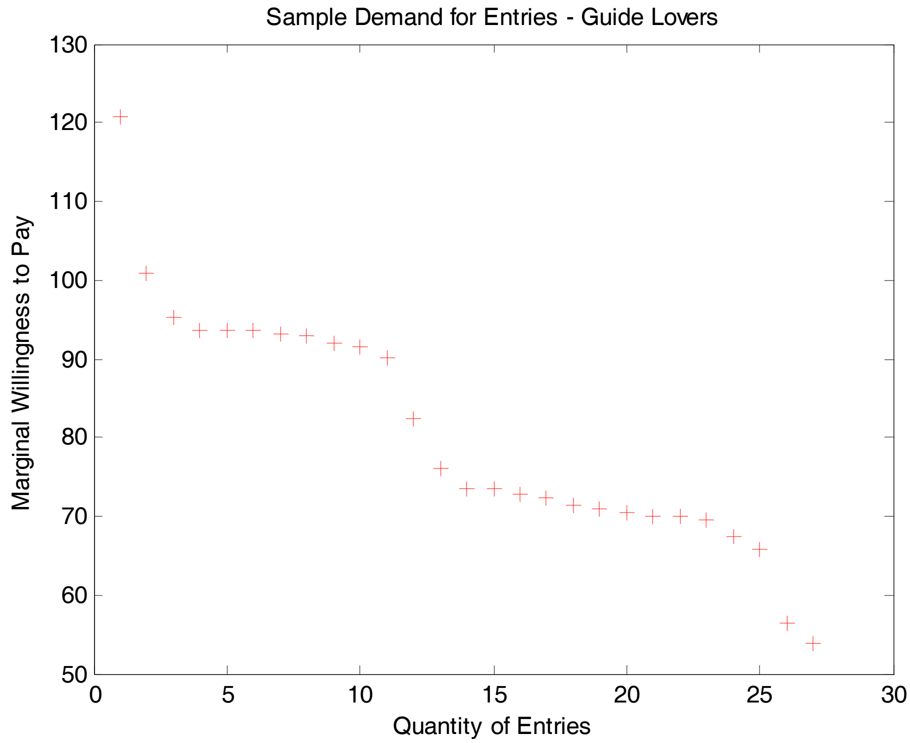

Figure 3.5: The Sample Demand for Entries for Guided Tour Lovers

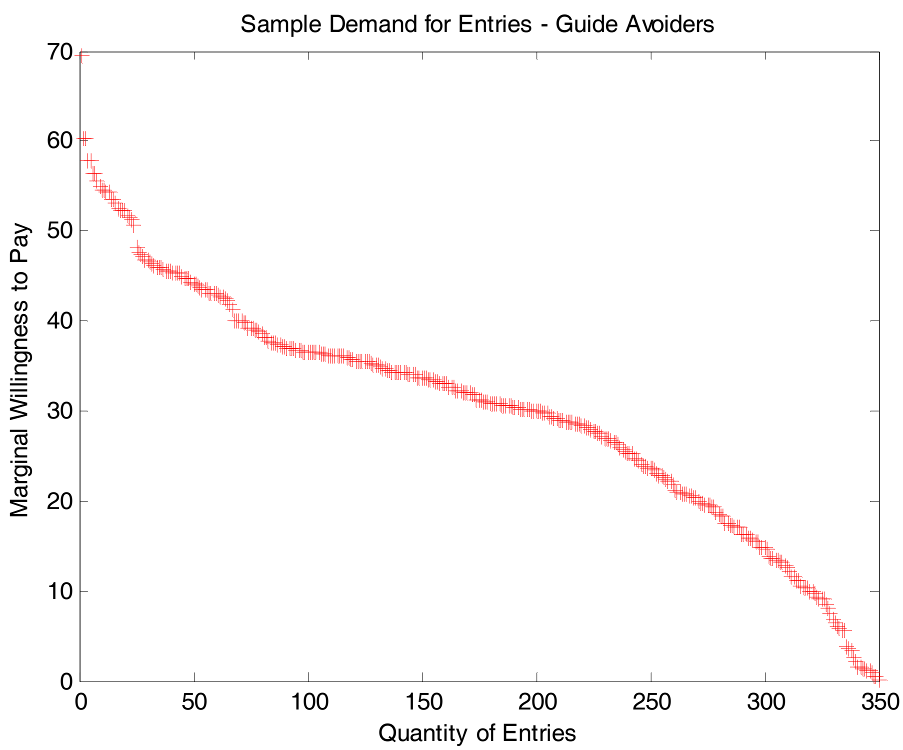

Figure 3.6: The Sample Demand for Entries for Guided Tour Avoiders

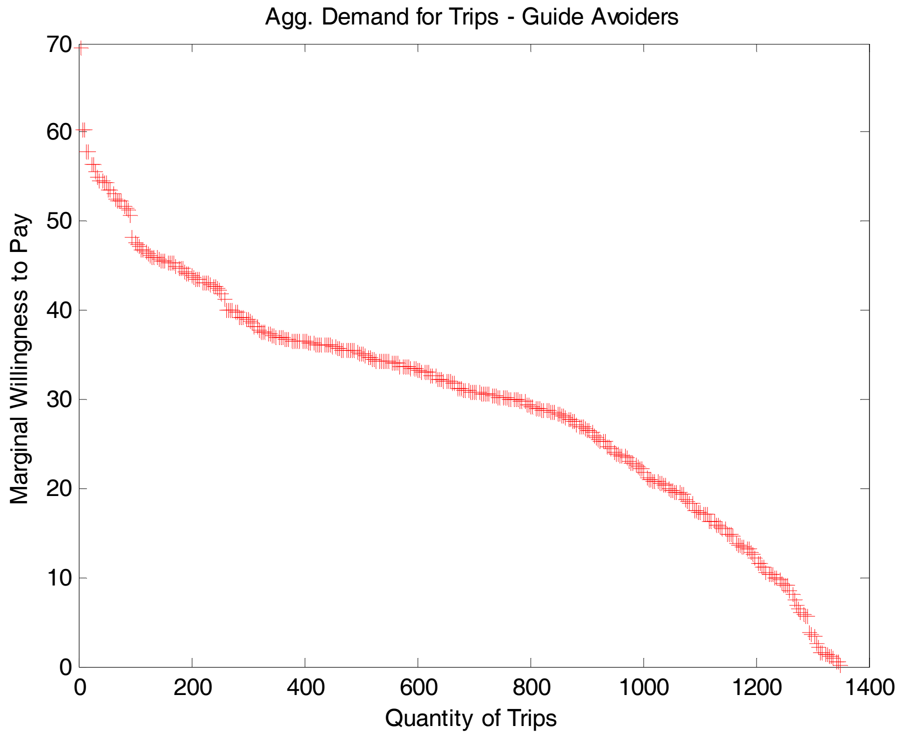

Figure 3.7: The Aggregate Demand for Trips for Guide Avoiders on the Weekend

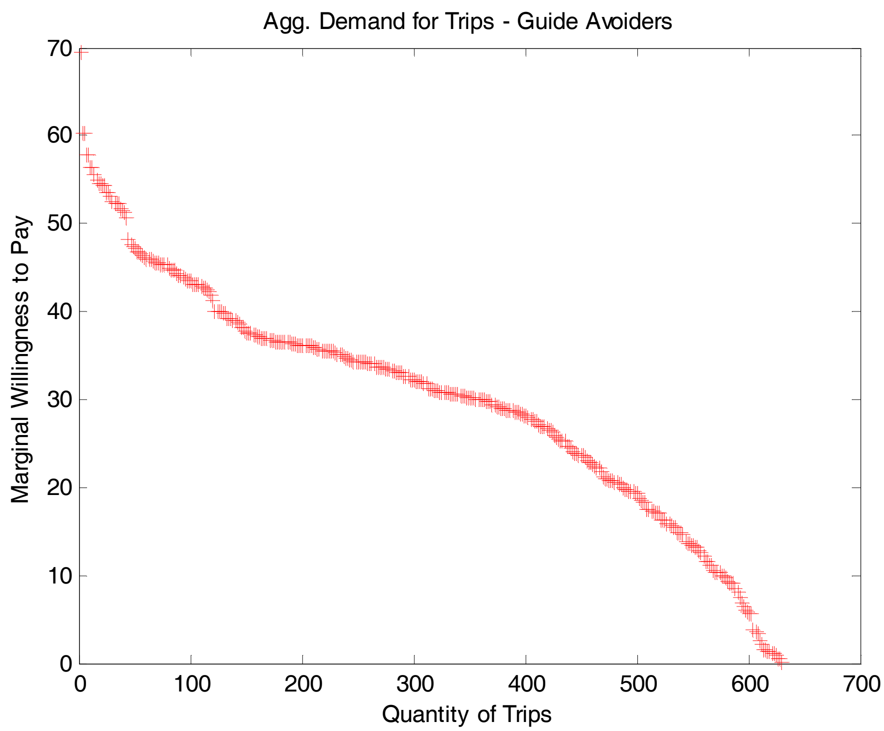

Figure 3.8: The Aggregate Demand for Trips for Guide Avoiders on a Weekday

CHAPTER 4

ARE THERE ANY ADVANTAGES IN COLLECTING DETAILED INFORMATION IN CHOICE EXPERIMENTS?

4.1. INTRODUCTION

Stated preference (SP) techniques are direct methods of non-market valuation that use survey data. Most economists would prefer to rely on revealed preference (RP) methods to value non-market goods. RP methods, however, require an identifiable link between the non-market goods and some subset of the market goods (Brown, 2003), which does not always exist. When the link is not present, economists can use SP methods to measure the value of non-market goods. Following contingent valuation, which is the oldest SP approach, a new class of SP methods has been developed: attribute-based methods. The objective of an attribute-based method SP study is to estimate economic values for a set of attributes of an environmental good (Holmes and Adamowicz, 2003), and such method includes rating, ranking, and choice experiments.

Choice experiments, which are also referred to as choice-based conjoint analysis, were originally developed in marketing research in the early 1970s and have since been widely used in transport research (Bryan and Dolan, 2004). They began to be used in health and environmental economics in the 1990s. Choice experiments ask individuals to choose one alternative from a set of choices, where each alternative is described by a number of attributes. This technique is designed to elicit individuals' preferences via their willingness to make trade-offs among attributes. Assuming one of these attributes is price, one can assess marginal willingness to pay (MWTP) for each of the other attributes (Roe *et al*., 1996). This approach has received considerable attention relative to other attribute-based methods because the choice-based approach mimics actual market behavior and is consistent with random utility theory (Adamowicz *et al*., 1998; Holmes and Adamowicz, 2003).

4.2. OBJECTIVES

Choice experiments are popular tools used to estimate the value of non-market goods. Despite the fact that the popularity of the method is growing, a number of issues remain unresolved. In this chapter, I will focus on two issues: the format and modeling of the opt-out options and the welfare calculation method. The opt-out alternative, which is also referred to as "status quo" alternative, allows the survey respondents to face a more closely imitated market situation, where they have the option to reject all alternatives. It is the current recommendation to include the opt-out option in the choice experiment questions. However, the form it should take and how it should be modeled are not yet fully explored in the literature. In the Yellowstone choice experiment survey, if the opt-out option was selected, the respondents were asked a follow up question about what they would most likely do instead. Using the richer information about individuals' opting-out behavior I will explore different ways to model opt-out choices and thus evaluate the advantages of survey designs that allow and collect more detailed information.

The ultimate goal of non-market valuation studies is to estimate welfare impacts so they can be used in policy analysis. In this chapter, I will assess the changes in consumer surplus to YNP winter visitors that may come about as a result of changing winter management plans in YNP. However, the method of welfare calculation in choice experiments is not yet fully agreed upon in the literature. I will discuss the current state of the literature and investigate a calculation method that is consistent with theory. A related issue in choice experiment welfare analysis is how the baseline utility level is set. In the survey, respondents were asked to characterize their actual experience at the park using the same attributes as in the choice experiments. I will use this information on subjective assessment of the current trip as a basis for calculating individual-specific baseline utility to obtain a better measure for welfare changes.

The overall purpose of this essay is to investigate whether there are advantages in choice experiment survey designs that collect more detailed information on opt-out choices and individuals' subjective assessment as the actual baseline conditions.

4.3. LITERATURE REVIEW

Boyle *et al*. (2001) state that if the choices do not include an opt-out alternative, a nonzero value is implied in the estimated likelihood function for people who would not choose one of the alternatives, which in general results in upwardly biased welfare estimates. Holmes and Adamowicz (2003) also believe that choice scenarios should include opt-out options, which is a common recommendation at present, because in most real world choice situations individuals are not forced to make a choice and have the option to choose not to choose.

On the other hand, there are several disadvantages to including an opt-out option. Respondents may select the opt-out option not because it provides the highest utility but to avoid making a difficult decision (Banzhaf *et al*., 2001). Opt-out options can also create econometric challenges when researchers do not know what attribute levels are associated with the opt-out option (Banzhaf *et al*., 2001). Banzhaf *et al*. argue that if a respondent chooses to opt out, then it is unclear what they are deciding to do instead and thus it is unclear how to model the opt-out alternative. It is common in choice experiment data that a large number of respondents always choose the opt-out option or they always choose the alternative with the highest (or lowest) level of a particular attribute. Such a behavior is called serial nonparticipation. von Haefen *et al*. (2005) developed single and double hurdle repeated discrete choice econometric models that address such a phenomenon. Their results show that hurdle models improve model estimation and affect policy inference by accounting for serial nonparticipation.

There are two main forms of opt-out options used in market research: the 'no-purchase' option and the 'my current brand' option. In a recreation choice experiment, the equivalent formats are 'no trip' and 'my current (preferred) site,' respectively. The best opt-out format is what reflects the actual choice situations faced by the respondents most accurately. Most previous recreational choice studies (Hanley *et al*., 2002, Adamowicz, 1994, Adamowicz, 1996, Boxall *et al*., 1996) have used the "no-trip" format. One study that compared the effect of the two formats of an opt-out choice is Banzhaf *et al*. (2001)'s study on anglers' choices of saltwater fishing sites. They split the sample into two, and one group was given the alternative of "I will not go saltwater fishing" and the other was given "I would go saltwater fishing at another site (my preferred site)" option if respondents did not like either of the two hypothetical fishing sites offered. Respondents who chose "prefer another site" were asked to provide the name of that fishing site, and Banzhaf *et al*. incorporated site characteristics of sites that respondents specified in the model estimation.

The authors compare the rescaled coefficients of two models and find that most coefficients in the prefer-another-site model are significantly larger than the ones in the not-go-fishing model. Banzhaf *et al*. explain that these results suggest that when respondents are given the choice of specifying an alternative site, they are more likely to specify sites with characteristics of their interest, thus increasing the salience of these attributes. They suggest that it is important to consider in which situations each form would be more applicable. In their case, the sample consists of active anglers who have many substitutes in the area. However, in the situation when the sample does not consist of active anglers, applying a not go fishing opt-out treatment may be more appropriate.

To evaluate the effects of different opt-out option modeling on the welfare measures, I need to calculate the welfare changes with each modeling specification and compare them. The method of welfare calculation is, however, not yet fully agreed upon in the literature. In general, utility for a specific alternative is characterized by systematic (V_{ij}) and error (ε_{ij}) components:

$$U_{ij} = V_{ij} + \varepsilon_{ij}, \tag{4.1}$$

where *i* denotes people and *j* choice alternatives. Assuming a linear-in-parameters functional form, the systematic component of the indirect utility function is

$$V_{ij} = \beta' X_{ij} + \gamma' Z_i, \tag{4.2}$$

where X_{ij} is the vector of attributes of the *j*th choice as viewed by the *i*th individual including price and Z_i is a vector of personal characteristics for individual *i*. A number of health economics studies have calculated the MWTP for a change in a single attribute (X_1) as the ratio of the estimated coefficients on X_1 and the price in equation (4.2):

$$MWTP_1 = \frac{\partial V / \partial X_1}{\partial V / \partial p} = \frac{\beta_1}{\beta_p}, \tag{4.3}$$

where β_1 and β_p are the coefficients on X_1 and price, respectively. They also calculate the WTP from a change in all attributes of a commodity as follows:

$$WTP = -\sum_{k} \frac{\beta_k}{\beta_p} (\Delta X_k), \tag{4.4}$$

where k indexes the attributes and β_p is the marginal disutility of price. This is the unweighted summation of the product of MWTP multiplied by the change in levels across all attributes. Lancsar and Savage (2004a) state that equations (4.3) and (4.4) are appropriate only if a particular alternative is chosen with certainty. In other words, they are the *ex post* welfare calculation methods. Estimation of the choice experiment, however, involves uncertainty: the researcher does not know which alternative will be chosen *ex ante*, but only knows the probability of each being chosen. Changes in attribute levels, in fact, can affect the level of utility derived from each alternative and alter the probability of which alternative in the choice set will be chosen. In this sense, Lancsar and Savage (2004) argue that neither equations (4.3) and (4.4) are consistent with RUM theory because they do not consider the choice uncertainty. They also state that welfare calculation that is consistent with the RUM model must be implicitly weighted by the probability of choosing each alternative in the choice set. They propose to use the compensating variation (CV), which was proposed by Small and Rosen, as a measure of welfare:

$$CV = -\beta_p^{-1} \left(\ln \sum_{j=1}^{J} \exp[V_j^1] - \ln \sum_{j=1}^{J} \exp[V_j^0] \right), \tag{4.5}$$

where β_p is the marginal utility of income, V_j^1 and V_j^0 are the expected values of conditional utility after the change and before the change respectively, and J is the number of alternatives in the choice set.

Ryan (2004) and Santos (2004) argue that equation (4.4), the traditional WTP calculation, is consistent with equation (4.5) under the following circumstances:

(1) when there are only two alternatives on offer and the approximation of $\ln\left(1+\exp^{V_1^i}\right)\approx V_1^i$ holds,

(2) when we know with certainty which alternative will be chosen,

(3) when there is an infinitesimal change in the probability of choosing a given alternative,

(4) when the attributes of the choice alternatives change in such a way that leave the choice probabilities unchanged.

Lancsar and Savage (2004b) show that these circumstances require a number of assumptions that are unrealistic or ad hoc. First, the approximation of $\ln\left(1+\exp^{V_1^i}\right)\approx V_1^i$ does not hold if there are more than two choice alternatives. Second, state-of-the-world models (Ryan, 2004), where there is only one alternative on offer at any one time and individuals thus take the alternative with certainty, does not acknowledge that individual may have an opt-out option even when there is only one alternative available in the market. Third, it is agreed by Silva (2004) and Lancsar and Savage (2004b) that the traditional method is an approximation to CV when there is an infinitesimal change in one of the attributes. Lancsar and Savage argue against using an approximation when the CV formula is available, and that infinitesimal changes may not be proper in practice. Lastly, the probability of choosing each of the alternatives will not be changed if a single attribute changes by the same amount across all alternatives. This, however, is unlikely to be the case.

Lancsar and Savage (2004b) argue that the CV method is more general than the traditional method used and can accommodate each of the four special circumstances raised by Ryan (2004) and Santos (2004). They, therefore, suggest that the CV method is the appropriate approach to calculating welfare measures for choice experiment study. Espino *et al*. (2006) also agree with Lancsar and Savage (2004) in that equation (4.4) is appropriate as a welfare measure only if individuals do not choose a different alternative after X_k changes. This is likely to happen when only a marginal changes in X_k are considered.

Environmental economists (Adamowicz *et al*., 1994, Blamey *et al*., 2000, Hanley *et al*., 2002) have acknowledged that the correct expression of welfare measure in choice experiments is Small and Rosen's CV method, equation (4.5). Among the three papers, however, only Adamowicz *et al*. (1994) actually used equation (4.5) to calculate SP, RP and joint models' welfare measures. When calculating SP welfare changes, they define a choice set, which reflects the set of sites from which the consumer can choose. Blamey *et al*. (2000) and Hanley *et al*. (2002) also recognize that equation (4.5) is the correct method to calculate welfare changes. However, Blamey *et al*. have a single option in the choice set, which reduces equation (4.5) to: $WTP = -\frac{1}{\beta_p}\left[V_{i1} - V_{i0}\right]$, and Hanley *et al*. only calculate the value of a marginal change in any of the attributes using $WTP = -\frac{\beta_c}{\beta_p}$, where β_c is the coefficient on any of the attributes.

4.4 DATA

The 2002-2003 Yellowstone and Grand Teton National Parks winter visitor survey included the choice experiment questions, which asked respondents to choose between two hypothetical trips and the opt-out option. Before respondents were presented with a series of six choice questions, they were given a warm up question about their recent trip. The warm up question (appendix A) asked respondents' to describe a typical day on their recent trip to YNP and introduced attributes and attribute levels that are to be used in choice questions. This information provides visitors' subjective assessment of the current trip and can be used as a basis for calculating individual-specific baseline utility to obtain a better measure for welfare changes. Because debate on snowmobile regulations in YNP is sensitive and controversial, the choices in the survey were described by nine attributes presented in table 2.2 rather than by management alternatives. The level of these attributes varied based on the different management plans. Because two choices (trip A and trip B) always presented different activities, I can evaluate whether current snowmobile riders will substitute their favorite activity with other activities in the park when snowmobile access is restricted. If respondents did not like either of the two hypothetical trips presented, they could choose an option of not visiting and were asked a follow up question about what they would most likely do instead. The choices included:

- Stay at home: I would not travel to the GYA
- Travel to the GYA to snowmobile outside the parks
- Travel to the GYA to cross-country ski outside the parks
- Travel to the GYA to downhill ski at Big Sky or one of the ski areas near Jackson Hole

It was tested and shown by Mansfield *et al*. (forthcoming) that there exist considerable differences among the types of visitors in YNP. Their findings suggest that non-riders have different preferences because non-riders visit the park to enjoy the natural wilderness ambience and riders are more focused on the recreational activity. Snowmobile riders can be further divided into two groups based on whether they own snowmobiles. Riders who own snowmobiles tend to be experienced and avid riders whereas riders who do not own a machine are likely less avid or serious about this activity. I, therefore, divided the sample into three groups: those who did not ride a snowmobile during their recent visit ('non-riders'), those who rode a snowmobile but did not own their own machine ('non-owners'), and those who rode a snowmobile during their recent visit and owned a machine ('owners'). This visitor type category will be maintained throughout this chapter.

Table 4.1 shows the percentages of each choice chosen by three different types of visitors. About a half of the respondents chose the not-visit option, and snowmobile riders, especially snowmobile owners, are the more likely to opt out (67.47%). Among the visitors who chose the opt-out option, the majority answered that they would stay at home rather than visit the GYA. Approximately 30 percent of non-snowmobile riders indicated they would go cross-country skiing in the GYA when they opt out (see table 4.2). Among the snowmobile riders who chose not to visit YNP, 22.54 percent and 34.50 percent of rider/non-owner and rider/owner respectively reported that they would continue snowmobiling at a different site in the GYA. None of snowmobile owners answered that they would cross-country ski instead of snowmobile riding. Non-riders are more willing than snowmobile riders to engage in other activities in the GYA instead of staying at home.

Table 4.3 and 4.4 summarize respondents' subjective assessment of the park conditions. At a glance, medians of the self-reported park ambient conditions (table 4.3) seem to indicate there are few problems with snowmobiles in YNP, because all ambient conditions have the *low* level as their medians. Table 4.4, however, gives more insights. First, non-snowmobile riders are most sensitive to the ambient conditions. A considerable number of them noticed high snowmobile traffic (8.40% at the entrance and 11.37% at the destination), bumpy roads (8.10%), loud noise (11.08%), and very high emission levels (8.04%). It is interesting to note how the three different visitor types reported the noise and emission levels. Almost none of riders who own snowmobiles describe the park as having any problems with noise and emissions from snowmobiles, whereas non-riders and non-owners perceive problems. Second, 10.34 percent and 17.30 percent of holiday visitors indicate that they noticed high snowmobile traffic at the entrance and at the destination, respectively, and only 1.66 percent and 2.96 percent of weekday visitors observed high snowmobile traffic at the entrance and destination. This is the case for all other ambient conditions in the park, which implies that holiday visitors are more likely to experience degraded park conditions, and weekday visitors notice much less nuisance from snowmobile traffic.

After removing incomplete choice answers, 1,532 respondents provide 8,952 individual choices for the choice experiment analysis. Among the respondents, 874 people were snowmobile riders and 658 were non-riders. Among the riders, 33.98 percent indicated they own a snowmobile.

4.5. MODEL ESTIMATION

4.5.1 Methods

I estimate the YNP winter visitors' preferences with random utility maximization (RUM) models with two specifications of the opt-out options to evaluate the usefulness of detailed opt-out options. I first estimate the model with a single opt-out option and then with the detailed opt-out behavior information. In general, the utility person *i* receives from selecting alternative *j* on choice occasion *t* is given by:

$$U_{jt}^{i} = V_{jt}^{i}\left(X_{jt}, p_{jt}, Z^{i}, \gamma\right) + \varepsilon_{jt}^{i},\ j = 0, 1, 2,\ t = 1, \ldots, 6,\ i = 1, \ldots, \text{N}, \qquad (4.6)$$

where V_{jt}^{i} is the deterministic component of utility, X_{jt} is a vector of attribute levels for the alternative, p_{jt} is its price, Z^{i} is a vector of personal characteristics, γ is a vector of utility function parameters to be estimated, and ε_{jt}^{i} is the unobserved component of preferences. I use a linear specification for utility such that preferences for the three alternatives (trip A, trip B, opt-out) on a given choice occasion are given by:

$$U_{jt}^{i} = X_{jt}\beta + p_{jt}\delta + \varepsilon_{jt}^{i},\ j = 1, 2, \qquad (4.7)$$

$$U_{jt}^{i} = \alpha_{j} + \varepsilon_{jt}^{i},\ j = 3,$$

where *j* = 1,2 denote the trip choices (trip A and trip B), *j* = 3 denotes the opt-out option, α_j is an alternative-specific constant, β is a vector of parameters associated with the non-price attributes, and δ is the parameter associated with price. With the expanded opt-out options, the utility specification is modified to include six alternatives as:

$$U_{jt}^{i} = X_{jt}\beta + p_{jt}\delta + \varepsilon_{jt}^{i},\ j = 1, 2, \qquad (4.8)$$

$$U_{jt}^{i} = \alpha_{j} + \varepsilon_{jt}^{i},\ j = 3, 4, 5, 6,$$

where *j* = 1,2 denote the trip choices (trip A and trip B) and *j* = 3,4,5,6 denote opt-out options: stay-at-home, snowmobiling in GYA, cross-country skiing in GYA, and downhill skiing in GYA.

Utility maximization implies that a person will choose the alternative on a given choice occasion that provides the highest utility. If the errors are independently and identically distributed with a type I extreme value distribution, the probability of an individual selecting alternative *j* on occasion *t* is given by:

$$\pi^i_{jt} = \frac{\exp\left(V^i_{jt}\right)}{\sum_{k=1}^{6} \exp\left(V^i_{kt}\right)}, \tag{4.9}$$

where V^i_{jt} is the deterministic component of utility. The likelihood function is constructed based on equation (4.9) and observation of each respondent's *ex post* choice outcomes as follows:

$$L(\beta) = \prod_{i=1}^{N} \prod_{j} \left(\pi^i_{jt}\right)^{y^i_{jt}}, \tag{4.10}$$

where $y^i_{jt} = 1$ if person *i* chose *j* and zero otherwise, and *β* is a vector of utility function parameters. The log-likelihood function is

$$LL(\beta) = \prod_{i=1}^{N} \prod_{j} y^i_{jt} \ln \pi^i_{jt}, \tag{4.11}$$

and maximum likelihood is used to estimate the utility function parameters, *β*, that maximize the above function.

All the elements of X_{jt} are qualitative variables, which means that cost is the only continuous variable in the model. Traditionally dummy variables can be used to incorporate qualitative explanatory variables. There is, however, a problem associated with applying dummy coding when the intercept term is included (Bech and Gyrd-Hansen, 2005). Assuming that there is only one explanatory variable (i.e. crowing at entrance) with three qualitative levels of attributes (i.e. low, moderate and high) and that they are coded with dummy variables, the main effects model of the qualitative attribute levels can be expressed as follows:

$$Y = \alpha + \beta_1 D_1 + \beta_2 D_2 , \quad (4.12)$$

where Y represents the answer to a choice question, D_1 and D_2 are dummy variables for low and moderate crowding, and β_1 and β_2 are the utility weights for each of the qualitative attribute levels. The constant term, α, describes the effect of the omitted attribute level (high crowding). The coefficients β_1 and β_2 are interpreted as the added or subtracted utility of the attribute levels D_1 and D_2 relative to the utility associated with the omitted level. This means that the estimated β coefficients are correlated with the intercept term, which introduces an identification problem in dummy coding because the utility associated with the omitted level cannot be separated from other elements of utility incorporated in the intercept term (Bech and Gyrd-Hansen, 2005). In this case, effects coding, which is functionally equivalent to dummy coding but eliminates the problem that dummy coding bears, should be used. In effects coding, the reference level (the omitted level) is assigned a value of -1 instead of 0 as in dummy coding. The value of the omitted level in effects coding is the negative sum of the included coefficients. With dummy coding, individual coefficients for attribute levels are interpreted relative to the omitted category while in effects coding they are interpreted relative to the zero mean effect. Opt-out alternative specific constants and the 'no-snowmobile' variable that is created for "no crowding at the entrance/ destination" are coded with dummy variables.

Utility function parameters estimated from the conditional logit model are constant over all respondents. This is appropriate only if every one has the same preference over a certain attribute, for example, the price. Decision makers, however, may value attributes of alternatives differently. Some of the taste variation can be explained by observed characteristics such as household income or the ownership of snowmobiles in this application. Other taste differences can come from unobserved variables or can be purely random because everyone is different. I define the variables whose effects are constant over respondents as "homogeneous" variables, ones that are systematically different across observed characteristics as "heterogeneous" variables, and ones that are random as "random" variables. Because there seems to be considerable differences between the three types of visitors (non-rider, rider/non-owner, rider/owner) as shown in Mansfield *et al*. (forthcoming), I will use the observed characteristics of visitors to construct "heterogeneous" variables.

The conditional logit model can represent systematic taste variation by allowing some attributes' coefficients in the utility function to vary across the visitor types. To incorporate random taste variation, the mixed logit model can be used instead of the logit model. The coefficient on the price attribute is always restricted to be constant across all visitors to set the scale of utility constant across visitor types, but coefficients on non-price attributes were allowed to be homogeneous, heterogeneous or random in searching for the best model specification.

4.5.2 Results

Tables 4.5 and 4.6 present the results from conditional logit estimations, in which all variables are assigned to be heterogeneous across three visitor types. The first estimation includes a single opt-out option, and the second includes the detailed opt-out options (stay-at-home, snowmobiling in GYA, cross-country skiing in GYA, and downhill skiing in GYA).

Because there are no observations in the cross-country ski option for snowmobile owners, I combined the cross-country ski and downhill ski options in one ("ski in GYA"). The results with a single opt-out and the detailed opt-out options are comparable in terms of the estimates on the designed attributes. Price coefficients are in both cases significant and negative. Because the price coefficient is constant across all visitor types, I can directly compare the other estimated coefficients across visitor types. Riders who own a snowmobile show a strong positive preference for snowmobile riding activity and negative preferences for the other activities, which indicate that owners are disinclined to substitute towards other park activities. Riders who do not own a snowmobile also display a preference for snowmobile riding relative to the other park activities, but the magnitude of coefficients is smaller than the riders/owners. Non-riders, on the other hand, are indisposed to ride a snowmobile but have positive preferences for skiing and taking a car tour, implying they are the most flexible in their park activity preferences. All user groups have negative preferences for taking a snowcoach tour though estimated effects are all insignificant. Both types of snowmobile riders, non-owners and owners, have significantly negative preferences for guided tours while non-riders show a positive preference for guided tour though this is insignificant. Coefficients for all entrances are insignificant and do not provide much resolution on visitors' preference on entrances when they are set as heterogeneous parameters. This may imply that entrances should be represented as random parameters instead.

The three user groups responded similarly to crowding at destination and to road conditions. They all prefer less crowing at destination to more. The magnitude of crowding at destination and its significance, however, show that non-riders are more sensitive to crowding than snowmobile riders. All types of visitors show a preference for smooth roads over bumpy roads, which support the notion that visitors' preferences are homogeneous for this attribute. Both non-riders and riders/non-owners reveal a preference for low noise levels over moderate noise whereas riders who own a snowmobile prefer more noise to less. As Mansfield *et al*. (forthcoming) speculate snowmobile riders may enjoy the noise associated with riding snowmobiles. In addition, they might associate lower noise level with a four-stroke engine snowmobile and higher noise with a two-stroke engine snowmobile. Because many riders already own a two-stroke engine machine, they are unwilling to change their snowmobiles and, therefore, show a preference for the high noise level. The findings for emission levels are less clear. For non-riders and non-owners the medium level coefficient is positive and the high level coefficient is negative, implying a preference for lower emission. The negative coefficients on the low emission level, however, contradict this interpretation. This mixed finding suggests that the preference variation for emission levels is not explained by heterogeneous parameters and should be handled as random.

With a single opt-out option (table 4.5) the coefficients for the opt-out alternative specific constants are all positive and significant, which implies that opting-out is an appealing choice relative to selecting a trip. Among the three visitor types snowmobile owners are most likely not to visit the park relative to the designed alternatives. With the detailed opt-out options (table 4.6) YNP winter visitors' opting-out behavior can be explained more completely. Conditional on not entering the park, all visitor types are most likely to stay at home with snowmobile owners having the largest magnitude of the coefficient. A significantly positive coefficient on 'snowmobile in GYA' shows that some owners are willing to go to different sites in GYA to ride snowmobiles, which indicates that this is a viable substitute for them. The 'stay-at-home' variable for owners, however, has a larger coefficient than the ‘snowmobile in GYA’ variable, meaning that owners are more likely to stay at home than visit GYA for snowmobiling. Snowmobile non-riders and riders/non-owners have negative coefficients for all opt-out options except for ‘stay-at-home’ option, suggesting that they would rather stay at home than go to GYA. Non-riders and riders/non-owners are least likely to ride snowmobiles and to ski in the GYA, respectively, when they choose not to visit YNP. The parameter estimates are almost identical between the models with a single opt-out and with detailed opt-out options. By including the detailed opt-out options, however, I can observe visitors’ opting-out behavior more closely.

Preference differences for some attributes such as emission levels were not captured by the observed heterogeneity, which was the visitors’ type. To account for these taste variation, I allowed some variables to be random and estimated a mixed logit model, containing a mixture of homogeneous, heterogeneous, and random parameters. Because all visitor types responded similarly to crowding at destination and road condition as shown in tables 4.5 and 4.6, they were assigned as homogeneous variables along with the price. There was considerable heterogeneity among visitor types for activity, guide status, noise level, and opt-out options, and, therefore, they were designated as the heterogeneous variables.

Table 4.7 presents the results where parameters for crowding at entrance and emission levels were treated as random. By examining the significance of the standard deviation of random parameters, the degree of heterogeneity in preferences across respondents can be seen. The standard errors for these variables are highly significant, indicating statistically different preferences for these attributes across respondents. I also assigned entrance variables as random and re-estimated the model, and table 4.8 shows the result. Standard errors for *West* and *South* entrances are highly significant, which imply that respondents have random preferences for entrance attributes as well.

The log-likelihood value is improved when homogeneous, heterogeneous, and random parameters were used instead of forcing all variables to vary across visitor types. It improved from -7,750 to -7,542 and from -12,472 to -12,309 with the single and detailed opt-out options, respectively. The price coefficient is larger in absolute value and is slightly more significant in mixed model specification. Most of the standard deviations for entrances, crowding at entrance, and emission levels are significant, which indicates that there exists randomness among visitors in these variables.

4.6. WELFARE ANALYSIS

4.6.1 Methods

After estimating several mixed logit models with different sets of homogenous, heterogeneous, and random variables, the models whose results are presented in table 4.8 and 4.9 seem to be most appealing.[8] With the most preferred model in hand, I estimate welfare impacts of the snowmobile policy change in YNP on different types of visitors. Mansfield *et al*. (forthcoming) assumed that the current snowmobile policy results in high crowding, bumpy road, and high noise and emission levels and these conditions were used as the baseline. However, respondents may characterize their current experience at YNP differently. Only 8.40 percent of non-riders, 6.53 percent of rider/non-owner and 2.52 percent of

[8] These models have price, crowding at destination, road condition as homogeneous, activities, guide status, noise level, no-snowmobile scenario, and opt-out options as heterogeneous, and entrances, crowding at entrance and emission level as random. Table 4.8 is with detailed opt-out options, and table 4.9 includes a single opt-out option.

rider/owners reported that the park was highly crowded at the entrance during their recent visit. If we assume that all visitors perceive the park condition as high crowding, bumpy road, and high noise and emission levels, then the improvement in the park condition by alternative management plans will bias the welfare analysis upward. In the survey, respondents were asked to characterize their current experience at the park using the same attributes as in the choice experiments. I use this information on subjective assessment of the current trip as a basis for calculating individual-specific baseline utility to obtain a better measure for welfare changes. I also calculate welfare changes using assumed park conditions (high and moderate crowding conditions) as baselines and compare results in order to examine the value of the self-reported information.

Individual visitors' estimates of the *ex ante* choice occasion expected utility under the current and new conditions after a new management plan is adopted are calculated. The *ex ante* expected utility of an individual i on a choice occasion is calculated as follows:

$$E\left(U_p^i\right) = \ln\left\{\sum_{j=1}^{J_p} \exp\left[V_j^i\left(q_p^i\right)\right]\right\}, \tag{4.13}$$

where U_p^i is the utility a visitor i receives from a choice occasion under snowmobile policy p, J_p denotes the set of choice alternatives available under policy p, V_j^i is the deterministic component of utility for alternative j, and q_p^i denotes the conditions in the park that are expected to occur when policy p is in place and perceived by visitor i. The welfare change of an individual i for the policy change from p to p' is given by

$$CV_i = \delta^{-1}\left[E\left(U_{p'}\right) - E\left(U_p\right)\right], \tag{4.14}$$

where δ is the marginal utility of income.

Calculation of *ex ante* expected utility requires all choice alternatives that are available to visitors. The set of choice alternatives consists of the different combinations of activity, entrance, and guide status. Table 4.10 lists twenty-one natural delineations of choice alternatives and an option of not visiting the park. When the detailed opt-out option is used the choice set expands to include twenty-five choices (table 4.11). Prices for each of these alternatives were calculated based on current entrance fees, guided tour service price, and rental costs of snowmobile machines. Park visitors can freely choose the activity/entrance/guide status combination of their trips. They cannot, however, influence the park ambient conditions such as crowding, noise, emissions, and road conditions, which are mainly determined by the winter management policies in place. Based on the NPS proposed policies I consider four management scenarios:

1. Snowmobiles are banned from the park (*ban*)
2. All snowmobile riders must be guided by commercial guides (*guided tour*).
3. Only a limited number of snowmobiles are allowed in the park (*cap*)
4. All snowmobiles must be 4-stroke machines (*technology restriction*).

The park conditions that correspond to the four management policies are listed in Tables 4.12 and 4.13. The tables also include the baseline conditions when snowmobile access to the park was unrestricted, but the conditions in table 4.12 are self-reported and in table 4.13 they are assumed. Baseline conditions will be different depending on the day of the week, holidays and the weather. For this analysis, I used two baseline conditions: baseline I with high crowding conditions and baseline II with moderate crowding conditions. For three policies (*guided tour*, *cap*, and *technology restriction*) two scenarios are considered each: one resulting in low crowding and the other in moderate levels. These welfare calculations are done with a single opt-out specification and also with full opt-out options specification.

Each of the management policies restricts the choice set in a particular way. For the snowmobile ban all choices including the snowmobile activities are eliminated from the choice set. For the guided tour requirement choices with unguided options are removed. Under the cap policy, some visitors gain access to the park while others do not. For those who enter the park, the choice set does not change but will face improved park conditions from the decreased number of snowmobiles inside the park. On the other hand, for those who do not obtain the access to the park, all snowmobile activity options are eliminated. The technology restriction policy does not change the choice set, but it increases the costs of snowmobile activity for snowmobile owners because most of them own 4-stroke machines and now must rent a snowmobile.

4.6.2 Results

Table 4.14 provides point estimates and Krinsky and Robb[9] (1986) standard errors for each welfare scenario for each of the three visitor types using self-reported park condition as the baseline. Because the majority of respondents reported low snowmobile crowding level in the park (low traffic, emission level and noise, and smooth road), the moderate crowding of the park as the outcome of a policy scenario always results in welfare losses for every group. Therefore, when individual assessment of the park condition is used as the baseline, the end results of any policy scenario are set to be the low crowding level. Welfare changes

[9] The Krinsky-Robb method is used to obtain the distribution of the welfare effects. This method is based on a number of random draws from the asymptotic normal distribution of the parameter estimates and the welfare measure is then calculated for each of these draws (Alpizar *et al*., 2003).

calculated with the full opt-out options are overall larger than the ones with a single opt-out option. The difference ranges from $15 to $95 per choice occasion, which results in an enormous overall welfare change considering the number of visitors each winter to YNP. The basic story is, however, identical between the two specifications meaning that the ranking of proposed policies effect is unaffected by the treatment of opt-out options (table 4.15). Hereafter I will refer to the single opt-out specification when I discuss the results.

Non-snowmobile riders experience a positive welfare change from any changes in the snowmobile regulation. When snowmobiles are banned from the park they experience the most utility gains while riders, especially snowmobile owners, experience the most utility losses. When the park allows only a limited number of snowmobile in the park each day and snowmobile riders, both non-owners and owners, do not obtain access to the park, they experience big losses. On the other hand, if riders gain the entrance rights under the same policy they gain positive welfare. The guided tour requirement makes riders, both non-owners and owners, worse off. Non-snowmobile riders face considerably less welfare gains when a cap policy is in place ($39.11) compare to the snowmobile ban scenario ($222.49), which indicates that they prefer the snowmobile-free park even though the resulting ambient conditions are identical between the two policies. It can be also noted that snowmobile owners' loss from the technology restriction is the smaller than the disutility they experience from the guided tour requirement, which could suggest that they put more values on the independent trips than the increased price of machines or reduced noise level. Non-owners are, however, not affected by the technology restriction because they rent machines to use in the park in any case.

Table 4.16 provides estimates for each welfare scenario for each of the three visitor types under assumed baseline conditions I and II. Results in table 4.16 were calculated using the parameter estimates (table 4.9) obtained from a single opt-out specification. For random parameters such as entrance, crowding at entrance and emission level, the means were used to calculate the welfare changes. Table 4.17 provides welfare estimates for each management scenario, which are calculated using estimates from the model with the detailed opt-out specification (table 4.8). Figures in tables 4.16 and 4.17 are almost identical to each other. This is because the estimated coefficients are also similar in two different opt-out specifications. The difference in welfare estimates between the two specifications ranges from $0.01 to $1.53 per choice occasion. Even though this is a much smaller difference compared to welfare calculated using self-reported park condition, it cannot be neglected. About 140,000 visitors come to YNP during a winter season, and, therefore, one cent makes a welfare difference of approximately $1,400 per year. The ranking of different policies' effect is also unaffected by the treatment of opt-out options (table 4.18) as it was the case with subjective assessment. It is, however, less clear which opt-out options result in the larger or smaller welfare estimates. When baseline I is used, about a half of welfare calculated with full opt-out options is larger than the ones calculated with a single opt-out option, which was the case with self-reported park condition as the baseline. It is, however, reversed when baseline II is used. There is another difference between the results from baseline I and II, which is that the magnitude of welfare changes is larger when the baseline condition is set as high crowding level (I). This is not surprising because the park condition improves greatly when baseline I is used (from high crowding condition to either low or moderate crowding), which increase well-being of overall visitors, while the park condition improves just a little bit or stays the same when baseline II is used. I will refer to table 4.16 when I discuss the result in this section.

Non-snowmobile riders experience a positive welfare change from any changes in the snowmobile regulation. The largest welfare gains come from the snowmobile ban policy and the smallest gain comes from the technology restriction. The technology restriction improves the park condition only partially by reducing the noise and emission levels but does not affect the number of snowmobiles in the park. This suggests that non-snowmobile riders are more concerned about the presence of snowmobiles in the park than the noise and emission problems. Snowmobile owners, on the other hand, experience a welfare loss from any policy change that affects the free snowmobile access condition. When they obtain entrance rights under the cap policy, they gain utility because their snowmobile activity is unrestricted and also have improved park conditions from the decreased number of snowmobiles in the park. The largest welfare loss for snowmobile owners come from the snowmobile ban and the least loss come from guided tour requirement with low crowding level as the result of the policy. Snowmobile riders who are non-owners also benefit the most when they have access rights under the cap policy just like snowmobile owners. An interesting finding is that riders/non-owners respond somewhat to the ambient conditions, which means that policies that improve conditions in the park while restricting snowmobile access can improve well-being of this group. For example, if the guided tour policy substantially improves ambient park conditions there is a welfare gain for non-owners. If the guided tour policy, however, leads to only a moderate change, they experience welfare losses. Another interesting finding about this group of visitors is they are also better-off under the snowmobile ban policy when there is large improvement in the park condition though it is insignificant. Indeed when baseline I is used they gain utility from banning snowmobiles while they lose utility when baseline II is used. These results suggest that non-owners are willing to substitute between different in-park activities if there is a significant improvement in park conditions. All visitor types including snowmobile owners experience welfare gains from the improved ambient condition, which can be seen by comparing the welfare effect of the a policy scenario with different levels of ambient condition. As it is expected non-snowmobile riders are the most responsive to the change in the ambient condition, and snowmobile owners are the least responsive.

Now, I compare welfare changes calculated using self-reported and assumed park conditions to examine the value of the subjective information. Because the results between the single and full opt-out specifications are similar, I will only compare results obtained using the single opt-out models here. Baseline I results show much larger welfare changes compared to the changes reported in the first part of table 4.14 because it assumes that the initial park condition was highly crowded, noisy and polluted. As mentioned before only a small percentage of visitors (8.40 percent non-riders 6.53 percent of rider/non-owners and 2.52 percent of rider/owners), however, reported the park was highly crowded during their recent trip. Results in the first part of table 4.14 are comparable to the baseline II results in table 4.15. The directions of welfare changes are the same, but the magnitudes differ significantly, which range from \$89.79 to \$257.75. It appears that welfare measures using assumed baseline condition are overall larger than the ones using self-reported baseline condition. When rankings of different policies' impact are compared (table 4.19), the orders are quite similar except for technology restrictions. When the self-reported condition is used, the technology restriction ranks the third for non-snowmobile riders and the second and for snowmobile riders, both owners and non-owners. Snowmobile riders seem to prefer to pay a higher price to rent a snowmobile and sacrifice high speed and noise than to lose an independent trip. When the assumed condition is used, however, the technology restriction ranks the last for non-riders and non-owners, and the third for the owners. This result is puzzling especially for the snowmobile riders who are non-owners, who appear to show that they are worse off by the technology restriction than snowmobile banning policy.

4.7. CONCLUSION

I evaluated the advantages of choice experiment survey designs that allow and collect more detailed information from respondents. The 2002-2003 Yellowstone and Grand Teton National Parks winter visitor survey included questions to solicit information on individuals' opting out behavior and subjective assessment of the park condition. To examine the value of this information I estimated the YNP winter visitors' preference with two different specifications of opt-out options and calculated welfare impact of snowmobile policy changes in YNP using both subjective assessment and assumed park condition as the baselines. A mixed logit model is used to estimate utility function parameters allowing taste variation that cannot be explained by observed characteristics to be random. I also used *ex ante* welfare calculation instead of *ex post* calculation to account for uncertainty researchers face in the estimation of the choice experiment.

Even though utility function parameter estimates between single and detailed opt-out option treatments are very similar to each other, the detailed options allows us to observe visitors' opting-out behavior more closely, which could not be captured with just a single opt-out option. Also, when results from the two different opt-out specifications are used in welfare calculation with subjective assessment as baseline, there are clear distinctions between them. Welfare changes calculated with the full opt-out options are overall larger ($15 ~ $95 per choice occasion) than the ones with a single opt-out option. This distinction is, however, less apparent when the assumed park condition is used as the baseline. The difference in welfare estimates between the two specifications ranges from $0.01 to $1.53 per choice occasion, and it is not clear which opt-out options result in the larger or smaller welfare estimates. In both cases (self-reported and assumed baseline conditions) the rankings of different policies' effect are unaffected by the specification of opt-out options. When policy rankings are compared between different baseline specifications, the self-reported one seems to make more sense than the assumed one.

Table 4.1: Percentages of Alternatives Chosen by Respondents

Choice	Overall	Non-Snowmobile Riders	Snowmobile Riders/Non-Owners	Snowmobile Riders/Owners
TRIP A	25.18%	29.38%	25.07%	16.55%
TRIP B	70.71%	22.11%	21.74%	15.98%
Not Visit	54.11%	48.51%	53.19%	67.47%

Table 4.2: Details about Respondents' Opt-Out Behavior

Opt-Out Choice	Non-Snowmobile Riders	Snowmobile Riders/Non-Owners	Snowmobile Riders/Owners
Stay Home	49.89%	56.30%	64.05%
Snowmobile in GYA	2.80%	22.54%	34.50%
Cross-Country Ski in GYA	33.19%	1.89%	0.00%
Downhill Ski in GYA	14.12%	19.27%	1.45%

Table 4.3: Medians of the Park Ambient Condition

	Non-Snowmobile Riders	Snowmobile Riders/Non-Owners	Snowmobile Riders/ Owners	Weekend/ Holiday Visitors	Weekday Visitors
Traffic at Entrance	Low	Low	Low	Low	Low
Traffic at Destination	Low	Low	Low	Low	Low
Road Condition	Smooth	Smooth	Smooth	Smooth	Smooth
Noise Level	Low noise	Low noise	Low noise	Low noise	Low noise
Emission Level	Unnoticeable	Unnoticeable	Unnoticeable	Unnoticeable	Unnoticeable

Table 4.4: Self-Reported Park Ambient Condition

By User Types				
Attributes		**Non-Snowmobile Riders**	**Snowmobile Riders/Non-Owners**	**Snowmobile Riders/ Owners**
Traffic at the entrance	High	8.40%	6.53%	2.52%
	Moderate	12.52%	17.97%	22.01%
	Low	29.00%	43.90%	56.60%
	I did not see any snowmobile	50.08%	31.61%	18.87%
Traffic at the destination	High	11.37%	10.86%	5.36%
	Moderate	18.80%	26.26%	33.75%
	Low	27.80%	40.32%	56.15%
	I did not see any snowmobile	42.02%	22.56%	4.73%
Road condition	Bumpy and rough for all or most of the trip	8.10%	6.92%	3.18%
	Bumpy and rough for some of the day	38.41%	42.99%	29.30%
	Smooth	53.48%	50.09%	67.52%
Noise level	Loud	11.08%	7.20%	0.32%
	Moderate	17.72%	21.86%	12.70%
	Low noise	71.20%	70.93%	86.98%
Emission level	Very noticeable	8.04%	6.67%	0.32%
	Noticeable	28.55%	33.53%	19.43%
	I did not notice	63.41%	59.80%	80.25%
By Visiting Date				
Attributes		**Holiday Visitors**	**Weekend Visitors**	**Weekdays Visitors**
Traffic at the entrance	High	10.34%	5.39%	1.66%
	Moderate	17.24%	18.53%	20.52%
	Low	43.41%	42.89%	52.68%
	I did not see any snowmobile	29.01%	33.19%	25.14%
Traffic at the destination	High	17.30%	9.31%	2.96%
	Moderate	28.23%	24.89%	30.00%
	Low	32.01%	42.21%	55.74%
	I did not see any snowmobile	22.47%	23.59%	11.30%
Road condition	Bumpy and rough for all or most of the trip	7.47%	7.06%	4.10%
	Bumpy and rough for some of the day	44.04%	40.84%	35.82%
	Smooth	48.48%	52.10%	60.07%
Noise level	Loud	8.85%	6.09%	2.60%
	Moderate	22.54%	17.17%	19.89%
	Low noise	68.61%	76.74%	77.51%
Emission level	Very noticeable	9.27%	3.89%	2.97%
	Noticeable	28.63%	31.32%	31.73%
	I did not notice	62.10%	64.79%	65.31%

Table 4.5: Conditional Logit Results with a Single Opt-out Option

	Non-Snowmobile Riders			Snowmobile Riders/ Non-Owners			Snowmobile Riders/Owners		
	Estimate	Std Err	*p*-value	Estimate	Std Err	*p*-value	Estimate	Std Err	*p*-value
Price	-0.300	0.101	0.000	-0.300	0.101	0.000	-0.300	0.101	0.000
Entrance									
West	0.081	0.084	0.336	0.116	0.088	0.191	0.294	0.169	0.082
North	0.005	0.069	0.937	-0.027	0.066	0.676	-0.009	0.111	0.934
South	-0.142	0.092	0.121	-0.047	0.085	0.583	-0.235	0.143	0.100
Tetons[a]	0.056			-0.041			-0.050		
Activity									
Snwmble	-0.510	0.086	0.000	1.024	0.079	0.000	1.359	0.127	0.000
Coach	-0.161	0.099	0.104	-0.053	0.105	0.611	-0.071	0.221	0.746
Ski/hike	0.178	0.077	0.021	-0.389	0.083	0.000	-0.624	0.171	0.000
Car[a]	0.493			-0.581			-0.664		
Guide Status									
Guided	0.073	0.067	0.280	-0.353	0.054	0.000	-0.548	0.078	0.000
Unguided[a]	-0.073			0.353			0.548		
Crowding at Entrance									
Low	0.347	0.084	0.000	0.201	0.079	0.011	0.171	0.144	0.237
Medium	-0.076	0.076	0.314	0.024	0.078	0.760	-0.087	0.135	0.523
High[a]	-0.270			-0.225			-0.084		
Crowding at Destination									
Low	0.481	0.090	0.000	0.167	0.099	0.093	0.341	0.188	0.070
Medium	0.009	0.077	0.903	0.083	0.075	0.269	0.053	0.134	0.693
High[a]	-0.491			-0.250			-0.394		
Road Condition									
Smooth	0.062	0.043	0.155	0.140	0.047	0.003	0.233	0.087	0.007
Bumpy[a]	-0.062			-0.140			-0.233		
Noise Level									
Low	0.138	0.085	0.107	0.035	0.085	0.679	-0.154	0.158	0.330
Medium	-0.139	0.062	0.025	-0.076	0.075	0.313	-0.362	0.155	0.019
High[a]	0.001			0.041			0.516		
Emission Level									
Low	-0.010	0.099	0.920	0.086	0.102	0.398	-0.285	0.182	0.118
Medium	0.133	0.080	0.098	0.157	0.076	0.039	0.240	0.145	0.097
High[a]	-0.123			-0.243			0.045		
No snwbls	1.316	0.175	0.000	0.220	0.175	0.207	-0.404	0.359	0.260
Opt-Out	0.765	0.121	0.000	0.752	0.116	0.000	1.642	0.145	0.000

[a] Omitted effect-coded variables
Log-likelihood value: -7,705

Table 4.6: Condition Logit Results with Detailed Opt-out Options

	Non-Snowmobile Riders			Snowmobile Riders/ Non-Owners			Snowmobile Riders/Owners		
	Estimate	Std Err	*p*-value	Estimate	Std Err	*p*-value	Estimate	Std Err	*p*-value
Price	-0.3297	0.0823	0.0001	-0.3297	0.0823	0.0001	-0.3297	0.0823	0.0001
Entrance									
West	0.0831	0.0842	0.3235	0.1124	0.0885	0.2042	0.2907	0.1693	0.0860
North	0.0106	0.0688	0.8773	-0.0260	0.0656	0.6916	-0.0073	0.1112	0.9475
South	-0.1382	0.0920	0.1330	-0.0414	0.0850	0.6261	-0.2316	0.1433	0.1060
Tetons[a]	0.0445			-0.0450			-0.0518		
Activity									
Snwmble	-0.5029	0.0857	0.0000	1.0310	0.0795	0.0000	1.3667	0.1271	0.0000
Coach	-0.1557	0.0989	0.1152	-0.0484	0.1054	0.6462	-0.0645	0.2208	0.7701
Ski/hike	0.1829	0.0770	0.0176	-0.3904	0.0834	0.0000	-0.6262	0.1707	0.0002
Car[a]	0.4757			-0.5922			-0.6760		
Guide Status									
Guided	0.0699	0.0670	0.2969	-0.3515	0.0538	0.0000	-0.5474	0.0777	0.0000
Unguided	-0.0699			0.3515			0.5474		
Crowding at Entrance									
Low	0.3479	0.0834	0.0000	0.1986	0.0788	0.0117	0.1677	0.1444	0.2457
Medium	-0.0729	0.0760	0.3372	0.0279	0.0786	0.7223	-0.0821	0.1354	0.5443
High[a]	-0.2750			-0.2265			-0.0856		
Crowding at Destination									
Low	0.4677	0.0901	0.0000	0.1596	0.0996	0.1092	0.3329	0.1888	0.0778
Medium	0.0042	0.0773	0.9567	0.0811	0.0753	0.2815	0.0515	0.1337	0.7001
High[a]	-0.4719			-0.2407			-0.3844		
Road Condition									
Smooth	0.0605	0.0432	0.1612	0.1403	0.0466	0.0026	0.2331	0.0869	0.0073
Bumpy[a]	-0.0605			-0.1403			-0.2331		
Noise Level									
Low	0.1397	0.0852	0.1009	0.0360	0.0846	0.6709	-0.1536	0.1581	0.3314
Medium	-0.1326	0.0619	0.0322	-0.0728	0.0755	0.3347	-0.3586	0.1548	0.0205
High[a]	-0.0071			0.0368			0.5122		
Emissions Level									
Low	0.0039	0.0993	0.9683	0.0945	0.1019	0.3536	-0.2767	0.1827	0.1299
Medium	0.1259	0.0800	0.1155	0.1535	0.0760	0.0434	0.2369	0.1447	0.1017
High[a]	-0.1298			-0.2480			0.0398		
No snwbls	1.3028	0.1746	0.0000	0.2173	0.1749	0.2141	-0.4062	0.3587	0.2575
Stay_home	0.0465	0.1246	0.7092	0.1590	0.1194	0.1830	1.1779	0.1474	0.0000
sm_gya	-2.8332	0.1835	0.0000	-0.7563	0.1254	0.0000	0.5591	0.1512	0.0002
Xski_gya	-0.3612	0.1267	0.0044	-3.2363	0.2066	0.0000			
Ski_gya	-1.2161	0.1351	0.0000	-0.9134	0.1271	0.0000	-3.3047	0.2814	0.0000

[a] Omitted effect-coded variables
Log-likelihood value: -12,472

Table 4.7: Mixed Logit Results with Detailed Opt-Out Options (1)

	Non-Snowmobile Riders			Snowmobile Riders/ Non-Owners			Snowmobile Riders/Owners		
	Estimate	Std Err	*p*-value	Estimate	Std Err	*p*-value	Estimate	Std Err	*p*-value
HOMOGENEOUS VARIABLES									
Price	-0.3740	0.0874	0.0000	-0.3740	0.0874	0.0000	-0.3740	0.0874	0.0000
Entrance									
West	0.1466	0.0627	0.0193	0.1466	0.0627	0.0193	0.1466	0.0627	0.0193
North	-0.0686	0.0468	0.1427	-0.0686	0.0468	0.1427	-0.0686	0.0468	0.1427
South	-0.0513	0.0654	0.4326	-0.0513	0.0654	0.4326	-0.0513	0.0654	0.4326
Tetons[a]	-0.0267			-0.0267			-0.0267		
Crowding at Destination									
Low	0.3135	0.0719	0.0000	0.3135	0.0719	0.0000	0.3135	0.0719	0.0000
Medium	0.0318	0.0542	0.5517	0.0318	0.0542	0.5517	0.0318	0.0542	0.5517
High[a]	-0.3453			-0.3453			-0.3453		
Road Condition									
Smooth	0.1246	0.0319	0.0001	0.1246	0.0319	0.0001	0.1246	0.0319	0.0001
Bumpy[a]	-0.1246			-0.1246			-0.1246		
HETEROGENEOUS VARIABLES									
Activity									
Snwmble	-0.4739	0.0848	0.0000	1.1236	0.0805	0.0000	1.4679	0.1120	0.0000
Coach	-0.0913	0.0906	0.3136	-0.0508	0.0955	0.5950	0.2055	0.1649	0.2127
Ski/hike	0.1183	0.0732	0.1059	-0.3971	0.0809	0.0000	-0.7357	0.1496	0.0000
Car[a]	0.4469			0.4469			0.4469		
Guide Status									
Guided	0.0026	0.0634	0.9672	-0.4010	0.0553	0.0000	-0.6389	0.0786	0.0000
Unguided[a]	-0.0026			-0.0026			-0.0026		
Noise Level									
Low	0.2508	0.0771	0.0011	0.0145	0.0854	0.8649	-0.3059	0.1479	0.0387
Medium	-0.0399	0.0606	0.5106	-0.1579	0.0682	0.0206	-0.4575	0.1112	0.0000
High[a]	-0.2109			-0.2109			-0.2109		
No snwbls	1.2459	0.1503	0.0000	0.3069	0.1630	0.0597	-0.5727	0.3035	0.0592
Stay_home	0.1638	0.1279	0.2005	0.3481	0.1247	0.0053	1.3337	0.1425	0.0000
sm_gya	-2.7158	0.1858	0.0000	-0.5672	0.1305	0.0000	0.7149	0.1464	0.0000
Xski_gya	-0.2438	0.1301	0.0608	-3.0472	0.2097	0.0000	-3.1489	0.2789	0.0000
Ski_gya	-1.0987	0.1382	0.0000	-0.7243	0.1321	0.0000			

[a] Omitted effect-coded variables
Log-likelihood value: -12,418

Table 4.7(continued)

RANDOM VARIABLES									
Crowding at Entrance									
	Estimate	Std Err	*p*-value						
Low – Mean	0.2929	0.0585	0.0000						
Low – Std. dev	0.4721	0.0734	0.0000						
Medium – Mean	0.1041	0.0603	0.0846						
Medium – Std. dev	0.2695	0.1235	0.0292						
High[a]	-0.3970								
Emissions Level									
Low – Mean	0.1020	0.0851	0.2307						
Low – Std. dev	0.8924	0.0523	0.0000						
Medium – Mean	0.1999	0.0600	0.0009						
Medium – Std. dev	0.4730	0.0658	0.0000						
High[a]	-0.3019								

[a] Omitted effect-coded variables
Log-likelihood value: -12,418

Table 4.8: Mixed Logit Results with Detailed Opt-Out Options (2)

	Non-Snowmobile Riders			Snowmobile Riders/ Non-Owners			Snowmobile Riders/Owners		
	Estimate	Std Err	*p*-value	Estimate	Std Err	*p*-value	Estimate	Std Err	*p*-value
HOMOGENEOUS VARIABLES									
Price	-0.4192	0.0917	0.0000	-0.4192	0.0917	0.0000	-0.4192	0.0917	0.0000
Crowding at Destination									
Low	0.3180	0.0762	0.0000	0.3180	0.0762	0.0000	0.3180	0.0762	0.0000
Medium	0.0494	0.0577	0.3920	0.0494	0.0577	0.3920	0.0494	0.0577	0.3920
High[a]	-0.3674			-0.3674			-0.3674		
Road Condition									
Smooth	0.1412	0.0336	0.0000	0.1412	0.0336	0.0000	0.1412	0.0336	0.0000
Bumpy[a]	-0.1412			-0.1412			-0.1412		
HETEROGENEOUS VARIABLES									
Activity									
Snwmble	-0.5085	0.0902	0.0000	1.1925	0.0869	0.0000	1.5452	0.1185	0.0000
Coach	-0.0936	0.0971	0.3350	-0.0674	0.1013	0.5056	0.1981	0.1722	0.2499
Ski/hike	0.0997	0.0786	0.2043	-0.4441	0.0862	0.0000	-0.7597	0.1561	0.0000
Car[a]	0.5024			-0.6810			-0.9836		
Guide Status									
Guided	-0.0152	0.0662	0.8181	-0.4087	0.0579	0.0000	-0.6614	0.0821	0.0000
Unguided[a]	0.0152			0.4087			0.6614		
Noise Level									
Low	0.2684	0.0826	0.0012	0.0024	0.0917	0.9787	-0.3008	0.1551	0.0524
Medium	-0.0478	0.0642	0.4571	-0.1841	0.0718	0.0103	-0.5164	0.1157	0.0000
High[a]	-0.2206			0.1817			0.8172		
No snwbls	1.4421	0.1631	0.0000	0.4276	0.1767	0.0156	-0.5566	0.3191	0.0811
Stay_home	0.2490	0.1342	0.0636	0.4463	0.1314	0.0007	1.4449	0.1494	0.0000
sm_gya	-2.6306	0.1902	0.0000	-0.4690	0.1369	0.0006	0.8260	0.1531	0.0000
Xski_gya	-0.1586	0.1362	0.2442	-2.9490	0.2137	0.0000			
Ski_gya	-1.0135	0.1440	0.0000	-0.6260	0.1384	0.0000	-3.0378	0.2825	0.0000

[a] Omitted effect-coded variables
Log-likelihood value: -12,309

Table 4.8 (continued)

RANDOM VARIABLES									
Entrance									
	Estimate	Std Err	*p*-value						
West – Mean	0.1378	0.0703	0.0502						
West – Std. dev	0.6989	0.0539	0.0000						
North – Mean	0.0003	0.0516	0.9958						
North – Std. dev	0.2117	0.2123	0.3187						
South – Mean	-0.0014	0.0701	0.9844						
South – Std. dev	0.4150	0.1320	0.0017						
Tetons[a]	-0.1367								
Crowding at Entrance									
Low – Mean	0.3143	0.0629	0.0000						
Low – Std. dev	0.5865	0.0701	0.0000						
Medium – Mean	0.0825	0.0644	0.2004						
Medium – Std. dev	-0.2081	0.1779	0.2421						
High[a]	-0.3968								
Emissions Level									
Low – Mean	0.0742	0.0890	0.4041						
Low – Std. dev	0.9370	0.0562	0.0000						
Medium – Mean	0.2420	0.0638	0.0002						
Medium – Std. dev	0.4789	0.0704	0.0000						
High[a]	-0.3162								

[a] Omitted effect-coded variables
Log-likelihood value: -12,309

Table 4.9: Mixed Logit Results with a Single Opt-Out Option

	Non-Snowmobile Riders			Snowmobile Riders/ Non-Owners			Snowmobile Riders/Owners		
	Estimate	Std Err	*p*-value	Estimate	Std Err	*p*-value	Estimate	Std Err	*p*-value
HOMOGENEOUS VARIABLES									
Price	-0.421	0.0919	0.0000	-0.421	0.0919	0.0000	-0.421	0.0919	0.0000
Crowding at Destination									
Low	0.3202	0.0765	0.0000	0.3202	0.0765	0.0000	0.3202	0.0765	0.0000
Medium	0.0480	0.0580	0.4075	0.0480	0.0580	0.4075	0.0480	0.0580	0.4075
High[a]	-0.3682			-0.3682			-0.3682		
Road Condition									
Smooth	0.1418	0.0336	0.0000	0.1418	0.0336	0.0000	0.1418	0.0336	0.0000
Bumpy[a]	-0.1418			-0.1418			-0.1418		
HETEROGENEOUS VARIABLES									
Activity									
Snwmble	-0.5100	0.0906	0.0000	1.2015	0.0872	0.0000	1.5535	0.1189	0.0000
Coach	-0.0946	0.0972	0.3307	-0.0656	0.1016	0.5183	0.2023	0.1725	0.2409
Ski/hike	0.0971	0.0786	0.2165	-0.4459	0.0865	0.0000	-0.7621	0.1566	0.0000
Car[a]	0.5075			-0.69			-0.9937		
Guide Status									
Guided	-0.0172	0.0664	0.7953	-0.4125	0.0581	0.0000	-0.6665	0.0825	0.0000
Unguided[a]	0.0172			0.4125			0.6665		
Noise Level									
Low	0.2714	0.0829	0.0011	0.0041	0.0919	0.9647	-0.2986	0.1555	0.0548
Medium	-0.0446	0.0645	0.4891	-0.1823	0.0721	0.0114	-0.5157	0.1161	0.0000
High[a]	-0.2268			0.1782			0.8143		
No snwbls	1.4453	0.1640	0.0000	0.4283	0.1774	0.0158	-0.5554	0.3191	0.0818
Opt-Out	0.9497	0.1210	0.0000	1.0274	0.1300	0.0000	1.9003	0.1481	0.0000

[a] Omitted effect-coded variables
Log-likelihood value: -7,542

Table 4.9 (continued)

RANDOM VARIABLES									
Entrance									
	Estimate	Std Err	*p*-value						
West – Mean	0.1435	0.0703	0.0412						
West – Std. dev	0.7014	0.0541	0.0000						
North – Mean	-0.0067	0.0516	0.8972						
North – Std. dev	-0.3134	0.1168	0.0073						
South – Mean	0.0061	0.0702	0.9306						
South – Std. dev	0.4042	0.1379	0.0034						
Tetons[a]	-0.1429								
Crowding at Entrance									
Low – Mean	0.3147	0.0629	0.0000						
Low – Std. dev	0.5921	0.0693	0.0000						
Medium – Mean	0.0867	0.0646	0.1793						
Medium – Std. dev	-0.2371	0.1551	0.1265						
High[a]	-0.4014								
Emissions Level									
Low – Mean	0.0736	0.0893	0.4099						
Low – Std. dev	0.9392	0.0559	0.0000						
Medium – Mean	0.2405	0.0641	0.0002						
Medium – Std. dev	0.4716	0.0705	0.0000						
High[a]	-0.3141								

[a] Omitted effect-coded variables
Log-likelihood value: -7,542

Table 4.10: Choice Alternatives under Baseline Conditions - A Single Opt-Out Option

Activity	Entrance	Guide Status	Price
Snowmobile	West	Guided	$200
Snowmobile	West	Unguided	$15
Snowmobile	South	Guided	$230
Snowmobile	South	Unguided	$15
Snowmobile	North	Guided	$200
Snowmobile	North	Unguided	$15
Snowmobile	Grand Teton	Guided	$200
Snowmobile	Grand Teton	Unguided	$15
Snow Coach Tour	West	Guided	$100
Snow Coach Tour	South	Guided	$120
Snow Coach Tour	North	Guided	$100
Ski or Hike	West	Guided	$110
Ski or Hike	West	Unguided	$20
Ski or Hike	South	Guided	$110
Ski or Hike	South	Unguided	$20
Ski or Hike	North	Guided	$110
Ski or Hike	North	Unguided	$20
Ski or Hike	Grand Teton	Guided	$110
Ski or Hike	Grand Teton	Unguided	$20
Car Tour	North	Unguided	$20
Car Tour	Grand Teton	Unguided	$20
Opt-Out	NA	NA	NA

Table 4.11: Choice Alternatives under Baseline Conditions - Detailed Opt-Out Options

Activity	Entrance	Guide Status	Price
Snowmobile	West	Guided	$200
Snowmobile	West	Unguided	$15
Snowmobile	South	Guided	$230
Snowmobile	South	Unguided	$15
Snowmobile	North	Guided	$200
Snowmobile	North	Unguided	$15
Snowmobile	Grand Teton	Guided	$200
Snowmobile	Grand Teton	Unguided	$15
Snow Coach Tour	West	Guided	$100
Snow Coach Tour	South	Guided	$120
Snow Coach Tour	North	Guided	$100
Ski or Hike	West	Guided	$110
Ski or Hike	West	Unguided	$20
Ski or Hike	South	Guided	$110
Ski or Hike	South	Unguided	$20
Ski or Hike	North	Guided	$110
Ski or Hike	North	Unguided	$20
Ski or Hike	Grand Teton	Guided	$110
Ski or Hike	Grand Teton	Unguided	$20
Car Tour	North	Unguided	$20
Car Tour	Grand Teton	Unguided	$20
Opt-Out (stay home)	NA	NA	NA
Opt-Out (smgya)	NA	NA	NA
Opt-Out (xskigya)	NA	NA	NA
Opt-Out (skigya)	NA	NA	NA

Table 4.12: Self- Reported Park Conditions and Welfare Scenarios

	Baseline	**Ban**	**Guided Tours**: Low	**Guided Tours**: Mod	**Cap** (For Entrants) : Low	**Cap** (For Entrants) : Mod
	Unrestricted snowmobile access	Snowmobiles banned from the park	Snowmobiles in park must be on guided tour	Snowmobiles in park must be on guided tour	Daily cap on the number of snowmobiles in the park	Daily cap on the number of snowmobiles in the park
Crowding – entrance	self-reported	none	low	moderate	low	moderate
Crowding – destination	self-reported	none	low	moderate	low	moderate
Road Conditions	self-reported	smooth	smooth	smooth	smooth	smooth
Noise	self-reported	low	low	moderate	low	moderate
Emissions	self-reported	low	low	moderate	low	moderate
Cost[10]	I	I	I	I	I	I

Table 4.12 (continued)

	Cap (For Non-Entrants) : Low	**Cap** (For Non-Entrants) : Mod	**Technology Restriction**: Low	**Technology Restriction**: Mod
	Daily cap on the number of snowmobiles in the park	Daily cap on the number of snowmobiles in the park	Only 4-stroke engine snowmobiles in the park	Only 4-stroke engine snowmobiles in the park
Crowding – entrance	low	moderate	low	moderate
Crowding – destination	low	moderate	low	moderate
Road Conditions	smooth	smooth	smooth	smooth
Noise	low	moderate	low	moderate
Emissions	low	moderate	low	moderate
Cost[10]	I	I	II	II

Table 4.13: Assumed Park Conditions and Welfare Scenarios

	Baseline I	Baseline II	Ban	Guided Tours: Low	Guided Tours: Mod
	Unrestricted snowmobile access	Unrestricted snowmobile access	Snowmobiles banned from the park	Snowmobiles in park must be on guided tour	Snowmobiles in park must be on guided tour
Crowding – entrance	High	Moderate	None	Low	Moderate
Crowding – destination	High	Moderate	None	Low	Moderate
Road Conditions	Bumpy	Bumpy	Smooth	Smooth	Smooth
Noise	High	Moderate	Low	Low	Moderate
Emissions	High	Moderate	Low	Low	Moderate
Cost[10]	I	I	I	I	I

Table 4.13 (continued)

	Cap (For Entrants) : Low	Cap (For Entrants) : Mod	Cap (For Non-Entrants) : Low	Cap (For Non-Entrants) : Mod	Technology Restriction
	Daily cap on the number of snowmobiles in the park	Daily cap on the number of snowmobiles in the park	Daily cap on the number of snowmobiles in the park	Daily cap on the number of snowmobiles in the park	Only 4-stroke engine snowmobiles in the park
Crowding – entrance	Low	Moderate	Low	Moderate	High[11]
Crowding – destination	Low	Moderate	Low	Moderate	High[11]
Road Conditions	Smooth	Bumpy	Smooth	Bumpy	Bumpy
Noise	Low	Moderate	Low	Moderate	Low
Emissions	Low	Moderate	Low	Moderate	Low
Cost[12]	I	I	I	I	II

[10] The cost for all options remaining in the choice set is the same as under baseline conditions for all scenarios labeled I. For the technology restriction the price of an unguided snowmobile tour rises to $200, while the prices for the other options remain unchanged.

[11] When Baseline II is used 'Crowding – entrance' and 'Crowding – destination' are set to be moderate instead of high.

[12] The cost for all options remaining in the choice set is the same as under baseline conditions for all scenarios labeled I. For the technology restriction the price of an unguided snowmobile tour rises to $200, while the prices for the other options remain unchanged.

Table 4.14: Per Choice Occasion Welfare Effect using Self-Reported Baseline Conditions

Single Opt-Out					
	Ban	**Guided Tours**	**Cap (for entrants)**	**Cap (for non entrants)**	**Technology Restriction**
		(low)	**(low)**	**(low)**	**(low)**
Non-Snowmobile Riders	222.49* (39.82)	57.37* (17.55)	95.06* (21.83)	39.11* (14.68)	75.41* (21.70)
Snowmobile Riders/Non-Owners	-262.39* (64.60)	-134.08* (25.00)	90.05* (24.68)	-220.93* (46.47)	-5.24 (24.81)
Snowmobile Riders/ Owners	-445.90* (91.55)	-230.67* (36.45)	60.96* (19.99)	-309.83* (60.24)	-53.57* (20.44)

Full Opt-Out					
	Ban	**Guided Tours**	**Cap (for entrants)**	**Cap (for non entrants)**	**Technology Restriction**
		(low)	**(low)**	**(low)**	**(low)**
Non-Snowmobile Riders	246.90* (47.43)	71.38* (22.24)	105.62* (27.57)	54.85* (18.08)	87.76* (27.34)
Snowmobile Riders/Non-Owners	-238.69* (75.78)	-114.03* (26.67)	94.75* (30.26)	-191.13* (53.84)	4.61 (29.61)
Snowmobile Riders/ Owners	-540.84* (104.20)	-193.59* (41.47)	68.31* (21.32)	-258.39* (67.70)	-37.98 (21.14)

Krinsky-Robb standard errors in parentheses
* Significant at 5% level

Table 4.15: Ranking of Proposed Policies' Effects with Self-Reported Baseline Conditions

	Positive Welfare Change	→	→	→	**Negative Welfare Change**
Non-Snowmobile Riders	Ban	Cap (For Entrants)	Technology Restriction	Guided Tour	Cap (For Non-Entrants)
Snowmobile Riders/Non-Owners	Cap (For Entrants)	Technology Restriction	Guided Tour	Cap (For Non-Entrants)	Ban
Snowmobile Riders/ Owners	Cap (For Entrants)	Technology Restriction	Guided Tour	Cap (For Non-Entrants)	Ban

Table 4.16: Per Choice Occasion Welfare Effect using Assumed Baseline Conditions – A Single Opt-Out Option

Baseline I Results								
	Ban	**Guided Tours**: Low	**Guided Tours**: Mod	**Cap** (For Entrants): Low	**Cap** (For Entrants): Mod	**Cap** (For Non-Entrants): Low	**Cap** (For Non-Entrants): Mod	**Technology Restriction**
Non-Snowmobile Riders	620.01* (121.34)	454.89* (99.63)	313.91* (64.57)	492.57* (104.46)	349.70* (68.26)	436.63* (94.87)	296.69* (60.98)	126.20* (35.91)
Snowmobile Riders/Non-Owners	52.38 (38.00)	180.69* (59.52)	72.66 (37.71)	404.83* (90.71)	287.50* (58.63)	93.84* (43.85)	-7.68 (36.44)	-38.01 (39.73)
Snowmobile Riders/ Owners	-306.52* (67.39)	-91.30 (50.31)	-179.45* (50.49)	200.34* (74.57)	82.89 (47.24)	-170.45* (53.13)	-243.67* (60.34)	-209.59* (61.55)

Baseline II Results								
	Ban	**Guided Tours**: Low	**Guided Tours**: Mod	**Cap** (For Entrants): Low	**Cap** (For Entrants): Mod	**Cap** (For Non-Entrants): Low	**Cap** (For Non-Entrants): Mod	**Technology Restriction**
Non-Snowmobile Riders	330.18* (75.31)	165.05* (64.27)	24.08 (15.14)	202.74* (68.10)	59.87* (17.64)	146.80* (61.02)	6.85 (14.43)	-163.63* (40.72)
Snowmobile Riders/Non-Owners	-172.60* (56.66)	-44.29 (54.65)	-152.31* (26.57)	179.85* (71.98)	62.52* (18.51)	-131.14* (54.12)	-232.66* (48.12)	-262.99* (46.51)
Snowmobile Riders/ Owners	-331.85* (76.78)	-116.62* (55.65)	-204.78* (37.91)	175.01* (73.56)	57.56* (17.06)	-195.78* (62.04)	-268.99* (55.39)	-234.92* (56.68)

Krinsky-Robb standard errors in parentheses
* Significant at 5% level

Table 4.17: Per Choice Occasion Welfare Effect using Assumed Baseline Conditions – Detailed Opt-Out Options

Baseline I Results								
	Ban	**Guided Tours**: Low	**Guided Tours**: Mod	**Cap** (For Entrants): Low	**Cap** (For Entrants): Mod	**Cap** (For Non-Entrants): Low	**Cap** (For Non-Entrants): Mod	**Technology Restriction**
Non-Snowmobile Riders	620.56* (124.05)	454.94* (100.85)	313.44* (64.04)	492.68* (105.68)	349.29* (67.72)	436.52* (95.94)	296.05* (60.43)	126.39* (39.34)
Snowmobile Riders/Non-Owners	52.78* (43.27)	181.03* (65.34)	72.62 (38.55)	404.14* (95.02)	286.48* (58.67)	94.07 (49.85)	-7.87 (36.83)	-37.93 (43.84)
Snowmobile Riders/ Owners	-308.46* (68.75)	-91.87 (54.80)	-180.26* (49.42)	198.81* (78.07)	81.37 (42.02)	-171.44* (57.93)	-244.94* (59.73)	-210.63* (61.33)

Baseline II Results								
	Ban	**Guided Tours**: Low	**Guided Tours**: Mod	**Cap** (For Entrants): Low	**Cap** (For Entrants): Mod	**Cap** (For Non-Entrants): Low	**Cap** (For Non-Entrants): Mod	**Technology Restriction**
Non-Snowmobile Riders	331.16* (71.39)	165.54* (56.03)	24.04 (15.10)	203.29* (60.06)	59.89* (18.12)	147.12* (52.29)	6.65 (14.30)	-163.00* (35.97)
Snowmobile Riders/Non-Owners	-171.19* (53.67)	-42.93 (46.85)	-151.35* (24.39)	180.17* (62.65)	62.51* (18.94)	-129.89* (48.69)	-231.83* (44.09)	-261.90* (36.14)
Snowmobile Riders/ Owners	-332.29* (66.59)	-115.70* (50.63)	-204.09* (30.79)	174.99* (74.25)	57.55* (17.01)	-195.27* (54.19)	-268.76* (47.30)	-234.46* (49.66)

Krinsky-Robb standard errors in parentheses
* Significant at 5% level

Table 4.18: Ranking of Proposed Policies' Effects with Assumed Baseline Conditions

Baseline I Results					
	Positive Welfare Change	→			**Negative Welfare Change**
Non-Snowmobile Riders	Ban	Cap (For Entrants)	Guided Tours	Cap (For Non-Entrants)	Technology Restriction
Snowmobile Riders/Non-Owners	Cap (For Entrants)	Guided Tours	Cap (For Non-Entrants)	Ban	Technology Restriction
Snowmobile Riders/ Owners	Cap (For Entrants)	Guided Tours	Cap (For Non-Entrants)	Technology Restriction	Ban

Baseline II Results					
Non-Snowmobile Riders	Ban	Cap (For Entrants)	Guided Tours	Cap (For Non-Entrants)	Technology Restriction
Snowmobile Riders/Non-Owners	Cap (For Entrants)	Guided Tours	Ban	Cap (For Non-Entrants)	Technology Restriction
Snowmobile Riders/ Owners	Cap (For Entrants)	Guided Tours	Technology Restriction	Cap (For Non-Entrants)	Ban

Table 4.19: Ranking Comparisons between Self-Reported and Assumed Baseline Conditions

Self-Reported Baseline Conditions					
	Positive Welfare Change →				**Negative Welfare Change**
Non-Snowmobile Riders	Ban	Cap (For Entrants)	Technology Restriction	Guided Tour	Cap (For Non-Entrants)
Snowmobile Riders/Non-Owners	Cap (For Entrants)	Technology Restriction	Guided Tour	Cap (For Non-Entrants)	Ban
Snowmobile Riders/ Owners	Cap (For Entrants)	Technology Restriction	Guided Tour	Cap (For Non-Entrants)	Ban

Assumed Baseline Conditions					
Non-Snowmobile Riders	Ban	Cap (For Entrants)	Guided Tours	Cap (For Non-Entrants)	Technology Restriction
Snowmobile Riders/Non-Owners	Cap (For Entrants)	Guided Tours	Ban	Cap (For Non-Entrants)	Technology Restriction
Snowmobile Riders/ Owners	Cap (For Entrants)	Guided Tours	Technology Restriction	Cap (For Non-Entrants)	Ban

CHAPTER 5

A DISCRETE-COUNT MODEL OF YELLOWSTONE VISITORS' PREFERENCES

5.1. INTRODUCTION

Choice experiments, which are one of the stated preference (SP) methods to value non-market goods, ask individuals to choose one alternative from a set of choices, where each alternative is described by a number of attributes. This technique is designed to elicit individuals' preferences via their willingness to make trade-offs between attributes. Assuming one of these attributes is price, one can assess marginal willingness to pay (MWTP) for each of the other attributes (Roe *et al*., 1996).

When respondents choose an alternative, they may think not only about which alternative maximizes their utility, but also about how intensely they would use the alternative. If this is the case there may be efficiency and modeling advantages to soliciting intensity of use information. With this as motivation the Yellowstone choice experiment survey asked respondents to choose between two hypothetical trips, which are described by attributes related to activity and park conditions, and also obtained the number of days they would spend in the park on the chosen trip. In other words, survey respondents make a discrete choice of which kind of trip to choose (if they choose to visit the park) and a frequency choice of the number of days to spend in the park. This process resembles the discrete-continuous choice models that are applied in many fields such as labor economics, energy, transportation, and marketing. Such models are characterized by a structural approach that jointly estimates both decision stages. Previous applications rely primarily on revealed preference data, and only a limited number of papers apply discrete-continuous choice modeling to stated preference data. To my knowledge there are no environmental choice model applications that have adopted this approach.

The objective of this chapter is to evaluate the extent to which obtaining frequency information in a choice experiment leads to improved modeling and policy inference. I will specify and estimate models that do and do not exploit frequency information, and compare estimates and welfare calculations to evaluate the value of incorporating the additional information.

5.2. LITERATURE REVIEW

We often observe consumers making qualitative or discrete choices in addition to a related continuous decision. For example, a consumer decides whether to have an electric or a gas appliance, as well as how much electricity or gas to consume (Dubin and McFadden (1984), Nesbakken (2001)). A consumer decides which flavor of yogurt to buy as well as how many cartons (Kim *et al*. (2002)), and households decide which vehicle types to purchase as well as how many miles to travel with each (Kim (2002), West (2004), Bhat and Sen (2006)). By way of environmental examples an angler decides which sites to visit and how often and how long to visit (Feather *et al*. (1995), Paulrud and Laitila (2004)). The optimal discrete choice depends partly on the continuous choices, and vice versa. Because the two choices are related, they should be modeled in a mutually consistent manner. One way to achieve this goal is to derive both choices from a single underlying preference structure.

In general, assume that the consumer has a conditional indirect utility function as:

$$U_j = V_j\left(y - r_j, p_j, q_j, \varepsilon_j, \eta\right), j = 1, \ldots, J, \tag{5.1}$$

where y is income, r_j is the purchase price, p_j is the use price , q_j is observed non-price attributes, ε_j is unobserved attributes of the good, and η is unobserved characteristics of the consumer. In the example of purchasing vehicles for a household, r_j is the price of vehicle j and p_j is the per-mile operating cost such as gas and maintenance. The discrete choice involves choosing a product that maximizes the consumer's utility. Given the consumer's choice of j, the continuous choice can be derived via Roy's identity:

$$X_j \mid j\left(y - r_j, p_j, q_j, \varepsilon_j, \eta\right) = \frac{-\partial V_j / \partial p_j}{\partial V_j / \partial y}. \tag{5.2}$$

Consumers' discrete and continuous choices modeled this way ensure that the two decisions flow from a single underlying utility maximization decision. It can be noted that the random elements (ε_j , η), which affect the consumer's discrete choice, also affect his continuous choices.

Early studies (Dubin and McFadden (1985), Lohr and Park (1995), West (2004)) estimated equations (5.1) and (5.2) in two steps. For example, Dubin and McFadden use a multinomial logit model for the discrete choice and a continuous linear regression model for the frequency choice. This procedure generates two different sets of estimates for the same set of parameters, which could be inconsistent with maintained hypotheses about the utility function and utility maximization (Feng, 2005). Other more recent studies (Kim (2002), Bento *et al.* (2005), Feng (2005), Bhat and Sen (2006)), on the other hand, estimated them simultaneously, which is more complex than two-step methods but provides for structural parameter restrictions and improves efficiency.

In either method, the simplest way to estimate equations (5.1) and (5.2) is to use standard discrete choice models with a linear utility function and independently and identically distributed error terms. This is restrictive in several ways. First, the standard choice model allows only one of the discrete alternatives to be selected. This is only reasonable if the choice alternatives are structurally mutually exclusive in consumption or if the consumer's tastes lead her to prefer only one of the alternatives (Hanemann, 1984). However, this may not be the case in some applications (e.g. vehicle holdings for a household) and therefore some other method is needed to allow multiple selections. Second, there may exist some correlation between unobserved aspects that affect both choices. For example, a person who lives far from work may prefer to commute in a large, comfortable vehicle. Also, residence location makes it likely that this person will drive more miles. This property of discrete-continuous choices cannot be captured in the simple error structure forms and thus requires a model that allows some correlation of unobserved factors.

There is a group of previous studies that employ the restrictive assumptions of the simple model or examine cases that meet these assumptions. Hanemann (1984), Dubin and McFadden (1984), Lohr and Park (1995) and Nesbakken (2001) assume goods are mutually exclusive or perfect substitutes so that only one of the discrete alternatives is selected. Lohr and Park (1995) also assume there is no correlation between unobserved characteristics affecting discrete and continuous choices.

Other studies seek to relax the restrictions. Bento *et al*. (2005) use the repeated discrete-continuous framework so that households can have multiple vehicles holdings. Because this model assumes that a household's automobile choice and utilization arise from decisions made on a series of separable choice occasions, it does not completely account for the fact that households own a mix of vehicle types to satisfy different functional or variety-seeking needs. For example, a household that owns a minivan is less likely to purchase another minivan because of diminishing marginal returns in using a single vehicle type, which is the main driving force for households holding multiple vehicle types (Bhat and Sen, 2006). To allow multiple selection due to diminishing marginal returns from the usage of each product, Kim *et al*. (2002) and Bhat and Sen (2006) adopt a nonstandard utility specification (translated, nonlinear but additive utility function).

Studies that use two-stage estimation such as Dubin and McFadden (1984) and West (2004) encounter an endogeneity problem in the second stage (continuous choice model) when correlation between unobserved variables that affect discrete and continuous choices is allowed. This can be seen clearly with an example. West (2004) specifies the indirect utility function as follows:

$$U_b = \left(\alpha_0^b + \frac{\alpha_1}{\beta} + \alpha_1 p_b + h'\gamma + \beta\left(y - r_b\right) + \eta \right) e^{-\beta p_b} + \varepsilon_b \text{, } b = 1, \ldots, B \tag{5.3}$$

where α_0^b is a bundle-specific constant, p_b is the operating cost per mile for the vehicles in bundle b, h is observed household characteristics, y is household quarterly total expenditures, r_b is the quarterly life-cycle cost of vehicle in bundle b, η is unobserved household characteristics, ε_b is unobserved attributes of bundle b and α_1, β and the vector γ are parameters to be estimated. Using Roy's identity, the quarterly demand for miles conditional on vehicle b is:

$$VMT_b = q_b + \alpha_0^b + \alpha_1 p_b + h'\gamma + \beta\left(y - r_b\right) + \eta \text{ .} \tag{5.4}$$

West rewrites equation (5.4) in a more convenient form for estimation as:

$$VMT_b - q_b = \sum_i \alpha_0^b \delta_{bi} + \alpha_1 \sum_i p_b \delta_{bi} + h'\gamma + \beta \left(y - \sum_i r_b \delta_{bi} \right) + \eta \ , \qquad (5.5)$$

where δ_{bi} is an indicator variable equal to one when $i = b$. If vehicle bundle choice and unobserved term, η, in equation (5.5) are statistically independent, then ordinary least squares can be used to obtain unbiased parameter estimates of (5.5). However, when η are correlated with the choice indicators δ_{bi}, and thus the expectation of given bundle-choice b does not equal zero, there exist the endogeneity problem. Dubin and McFadden (1984) suggests to three alternative methods that yield consistent estimates of parameters for continuous demand: the instrumental variable method, the reduced form method, and the conditional expectation correction method.

When the model is estimated simultaneously as in Kim (2002), Bento *et al.* (2005), Feng (2005), and Bhat and Sen (2006), it captures household-specific heterogeneity in both discrete and continuous choices and therefore allows for the unobserved factors to be correlated among the two types of choices.

5.3. DATA

The 2002-03 winter survey included a choice experiment section that asked respondents to choose between two hypothetical trips and the opt-out option. Hypothetical trips were described by park attributes (noise, road condition, congestion, and air quality), and the level of these attributes varied based on the different management plans. If respondents did not like either of the two hypothetical trips presented, they could choose an option of not visiting and were asked a follow up question about what they would most likely do instead. It was shown in the fourth chapter that there exists considerable preference differences among the types of visitors in YNP: snowmobile non-riders, riders/non-owners, and riders/owners. This visitor type category will also be maintained in this chapter.

If one of the hypothetical trips was chosen, respondents were asked to indicate the number of days they would spend on the chosen trip (appendix D). Some respondents who chose one of the hypothetical trips did not indicate the number of days they would stay at the park, though most did. The number of responses without frequency information is 1,673, or 19 percent of the total responses to the choice questions. Because they chose a trip, I assume for these respondents that one day is spent at the park. Table 5.1 more generally reports the number of days respondents would stay at the park conditional on choosing a trip. Thirty-nine percent of people who chose one of the trips indicated that they would stay more than a day at the park, and the rest would visit for a single day (table 5.2). Thus, a large proportion of respondents did provide extra information about their intensity of park use, which may be useful in modeling visitors' preferences. Mean and median numbers of days respondents would stay in the park are 1.96 and one days, respectively. For those who indicated they would stay more than a day in the park, mean and median numbers of days are 3.45 and three days, respectively. Non-snowmobile riders are the most likely to stay for more than a day among visitor types, and snowmobile riders who own snowmobiles are the least likely. Other summary statistics about choice experiment questions can be found in the fourth chapter.

The discrete-continuous models that will be used in this chapter require calculation of the price of arriving in the GYA for all respondents. That is, a respondent must bear the fixed cost of taking a trip as opposed to remaining at home if he chooses to visit YNP. The respondent then pays cost of visiting the park depending on the number of days she decides to stay. There are 45 people from abroad whose travel costs are difficult to measure, at least in the travel cost modeling framework. After removing these people and incomplete choice answers, 1,507 respondents provide 8,807 individual choices for the choice experiment analysis. Among the respondents, 855 people were snowmobile riders and 652 were non-riders. Among the riders, 33.92 percent indicated they own a snowmobile.

5.4. MODEL ESTIMATION

5.4.1 Motivation

One way to think of the decision process used by respondents to the choice questions is as follows. When answering questions, a person considers whether to visit YNP or not. If he chooses to visit, he must bear the fixed cost of getting to the park from home. Given that he visits, he chooses from the two scenarios to maximize his utility. He then decides how many days to spend in the park given his choice of alternative. This decision depends not only on the park conditions but also on the marginal price of a park day as given in the choice experiment question.

This process is similar to the discrete-continuous choice problems discussed in West (2004), Bento *et al*. (2005), Feng *et al*. (2005), and Bhat and Sen (2006) in which a household faces the discrete choice of which vehicle type to own and the continuous choice of vehicle-miles traveled (VMT). For instance, Bento *et al*. assume that each household makes a choice of whether or not to own a car. If a household decides to own an automobile, it selects from hundreds of available vehicle types and pays the purchase rate for the vehicle obtained. Given the purchase, the intensity of vehicle use depends on the per-mile operating cost. West (2004), Bento *et al*. (2005), Feng *et al*. (2005), and Bhat and Sen (2006) estimate the choice of vehicle and demand for VMT jointly since characteristics that influence a household's vehicle choice also influence that household's choice of miles. Researchers specify a functional form for the conditional indirect utility for a vehicle type and derive household's conditional VMT demand via Roy's identity.

Bento *et al*. (2005) represent household *i*'s conditional indirect utility on choice occasion *t* for car *j* (*j*=1,…,*J*) as:

$$U_{itj} = V_{ij} + \mu_i \varepsilon_{ijt} ,$$
$$V_{ij} = -\frac{1}{\lambda_i} \exp\left(-\lambda_i \left(y_i - r_{ij}\right)\right) - \frac{\alpha_{ij}}{\beta_{ij}} \exp\left(\beta_{ij} p_{ij}\right) + \tau_{ij} , \tag{5.6}$$
$$\alpha_{ij} = \exp\left(\tilde{\alpha}_i^T z_{ij}^{\alpha}\right),\ \beta_{ij} = -\exp\left(\tilde{\beta}_i^T z_{ij}^{\beta}\right),\ \lambda_i = \exp\left(\tilde{\lambda}_i^T z_i^{\lambda}\right),\ \tau_{ij} = \tilde{\tau}_i^T z_{ij}^T,\ \mu_i = \exp\left(\mu_i^*\right),$$

where $\left(y_i, r_{ij}, p_{ij}\right)$ are household *i*'s income, rental price for the *j*th auto, VMT price for the *j*th car, respectively, $\left(z_{ij}^{\alpha}, z_{ij}^{\beta}, z_{ij}^{\tau}\right)$ are alternative automobile characteristics interacted with household demographics, z_i^{λ} contains just household characteristics, $\left(\tilde{\alpha}_i, \tilde{\beta}_i, \tilde{\lambda}_i, \tilde{\tau}_i, \mu_i^*\right)$ are parameters that vary randomly across households, and ε_{ijt} contains additional unobserved heterogeneity that vary randomly across households, automobiles, and choice occasions. If ε_{ijt} follows a type I extreme value distribution, the probability that individual *i* chooses alternative *j* on choice occasion *t* conditional on the model's structural parameters is:

$$Pr_{it}(j) = \frac{\exp\left(V_{ij} / \mu_i\right)}{\sum_{k=0}^{J} \exp\left(V_{ik} / \mu_i\right)} . \tag{5.7}$$

Assuming the household chooses automobile *j*, the household's conditional VMT demand (the continuous choice) can be derived via Roy's identity:

$$VMT_{itj} = \exp\left(\alpha_{ij} + \beta_{ij} p_{ij} + \lambda_i \left(y_i - r_{ij}\right)\right). \quad (5.8)$$

5.4.1 Model Setup

I will estimate a discrete-continuous model using the Yellowstone choice experiment data with frequency information following a functional specification similar to Bento *et al*. (2005). Respondents can choose from j=1, 2 and opt-out. If they do not opt out they can provide frequency information on the number of days they would spend in the park. Respondents' discrete choice can be modeled as follows:

$$\begin{gathered} U_{itj} = V_{itj} + \varepsilon_{itj}, j = 0,1,2, \\ V_{itj} = -\frac{1}{\lambda}\exp\left[-\lambda\left(y_i - r_i\right)\right] - \frac{1}{\beta}\exp\left[\beta p_{jt} + \gamma' q_{jt}\right], j = 1, 2, \\ V_{itj} = -\frac{1}{\lambda}\exp\left(-\lambda y_i\right) - \frac{\exp\left(\gamma' q_{jt}\right)}{\beta}, j = 0, \end{gathered} \quad (5.9)$$

where r_i is the travel cost of getting to the GYA from the respondent's home, p_j is the per-day cost of a day in YNP for choice scenario j (part of the SP design), and q_j is the vector of non-price attributes for choice scenario j (also from the design). Given respondent i's choice of j on a choice occasion t, the demand for days in YNP can be derived via Roy's identity:

$$\begin{gathered} X \mid j = \exp\left[\beta p_j + \gamma' q_j + \lambda\left(y - r_j\right)\right], j = 1,2, \\ X \mid j = 0, j = 0. \end{gathered} \quad (5.10)$$

If I assume that every visitor comes to the GYA, incurring the cost of arriving at the area, and then makes a decision whether he will enter the park (trip A or trip B) or opt out, the discrete choice is modeled as follows:

$$U_{itj} = V_{itj} + \varepsilon_{itj}, j = 0,1,2,$$

$$V_{itj} = -\frac{1}{\lambda}\exp\left[-\lambda\left(y_i - r_i\right)\right] - \frac{1}{\beta}\exp\left[\beta p_{jt} + \gamma' q_{jt}\right], j = 1, 2, \tag{5.11}$$

$$V_{itj} = -\frac{1}{\lambda}\exp\left(-\lambda\left(y_i - r_i\right)\right) - \frac{\exp\left(\gamma' q_{jt}\right)}{\beta}, j = 0.$$

A difference between utility specifications (5.9) and (5.11) is that in equation (5.11) the respondent pays the cost of getting to the GYA, r_j, even though he chooses to opt out. If utility function (5.11) is used, there is no variability in net income, $\left(y_i - r_i\right)$, across the three choices and therefore the income coefficient, λ, may not be identified. In the Yellowstone application, furthermore, the mean fraction of income that is spent on traveling to the GYA is only about one percent, which means that there is little net income variability across j = 0, 1, 2 even if utility specification (5.9) is used. In this chapter, I use equation (5.9) to represent a respondent's discrete choice, and return to the topic of estimating λ below.

If I assume that errors are independently and identically distributed with a type I extreme value distribution, the probability of observing alternative j conditional on the structural parameters is:

$$\Pr_j = \frac{\exp\left(V_j\right)}{\sum_{k=0}^{2}\exp\left(V_k\right)}, j = 0,1,2. \tag{5.12}$$

Unlike Bento *et al.*, where the VMT demand is assumed to be continuous, days in YNP are strictly positive and generally small integers, which suggests a count distribution is more appropriate. Thus, I assume X|j is distributed Poisson with conditional mean defined by:

$$\mu_j = \exp\left[\beta p_j + \gamma' q_j + \lambda\left(y - r_j\right)\right], j = 1,2. \tag{5.13}$$

The demand for days in YNP is truncated in that the number of trips given the choice of *j* is greater than or equal to one. Therefore, the probability of observing the outcome conditional on choice *j* is:

$$\Pr\left(X = x \mid X > 0\right) = \frac{e^{-\mu_j}\mu_j^x}{x!\left[1-\exp\left(-\lambda\right)\right]}. \tag{5.14}$$

The likelihood of respondent *i*'s answers to the six choice experiment questions conditional on the utility parameters is:

$$L_i = \prod_{t=1}^{6}\left(\Pr_{it}\left(j\right)\times \Pr\left(X_{itj} \mid j\right)^{1_{j\neq 0}}\right), \tag{5.15}$$

where $1_{j\neq 0}$ is an indicator function equal to one if a trip is chosen and zero if the opt-out option is chosen. Substituting equation (5.12) and (5.14) into equation (5.15), the likelihood function becomes

$$L_i = \prod_{t=1}^{6}\left(\frac{\exp\left(V_{itj}\right)}{\sum_{k=0}^{2}\exp\left(V_{itk}\right)}\times\frac{e^{-\mu_{itj}}\left(\mu_{itj}\right)^{x_{itj}}}{x_{itj}!\left[1-\exp\left(-\lambda\right)\right]}\right). \tag{5.16}$$

To assess the value of frequency information I will estimate models that utilize frequency information (discrete-count models) and models that do not (discrete-only models). Because previous work has shown considerable differences between the three visitor types (non-snowmobile riders, snowmobile riders/non-owners, and snowmobile riders/owners), I will consider this information when estimating preferences. That is, each approach will be estimated with two specifications: one without user-type interactions (simple models) and the other with user-type interactions (user-type specific models). Four models that will be examined in this chapter are:

(1) discrete-count, simple model,

(2) discrete-count, user-type specific model

(3) discrete-only, simple model, and

(4) discrete-only, user-type specific model.

These models are estimated via Bayesian methods interpreted from a classical perspective.

In the discrete-count model, the income coefficient λ is estimated by variability both in the discrete choice among options that cost $\left(y_i - r_i\right)$, $\left(y_i - r_i\right)$, and $\left(y_i - 0\right)$ in specification (5.9), and in the continuous choice of day frequencies among people with different income levels. When the discrete-only model is used, however, λ is estimated only from the discrete choice, and if specification (5.11) is used it will be difficult to estimate λ because there is be no variability in net income among the three choices. Identification of λ in the discrete-only model can still be difficult even with specification (5.9) due to the limited effective variability in net income across choice alternatives in this application.

5.4.2 Methods

Standard maximum likelihood was initially attempted to estimate utility function parameters via the likelihood function (5.16), assuming all parameters were fixed across individuals. It was, however, not possible to find estimates because the algorithm failed to converge. I suspect that the non-linearity of the utility function made it difficult to find the maximum numerically. I then decided to approach the problem with Bayesian methods. Bayesian procedures do not require maximization of a function and therefore are not prone to optimization difficulties. The estimates provided by Bayesian procedures can be interpreted in classical ways via the Bernstein-von Mises theorem, which states that the mean of the

Bayesian posterior distribution (i.e. posterior mean) is asymptotically equivalent to the maximum likelihood estimator. I adapt procedures previously used for Bayesian mixed logit estimation for my four models.

I estimate my models using Gibbs sampling following procedures presented in Train (2003). I assume the unknown parameters of the utility function, $B = (\beta, \gamma, \lambda)$, are distributed multivariate normal with mean *b* and variance-covariance matrix *W*. The Bayesian procedure assumes that the researcher has initial beliefs about the unknown parameters $\theta = (b, W)$ that can be summarized by a prior distribution, $k(\theta)$. When the researcher observes a set of choices *Y*, she forms the probability of observing *Y*, $L(Y \mid \theta)$, which is the likelihood function of the observed choices. The researcher then updates her prior beliefs about the distribution of θ to form a posterior distribution for θ conditional on the data, $K(\theta \mid Y)$. By Bayes' rule, the posterior distribution is proportional to the product of the prior distribution and the likelihood function: $K(\theta \mid Y) \propto L(Y \mid \theta) k(\theta)$. The mean of the posterior distribution is then $\bar{\theta} = \int \theta K(\theta \mid Y) d\theta$.

I specify the following diffuse priors for *b* and *W*:

$$\begin{aligned} b &\sim N(b_0, \tau I_k) \\ W &\sim IW(k, I_k), \end{aligned} \tag{5.18}$$

where $N(\cdot)$ and $IW(\cdot)$ denote the multivariate normal and inverse Wishart distribution, respectively, b_0 are the fixed parameter maximum likelihood estimates, τ is a scalar chosen such that $1/\tau$ approaches zero[13], *k* is the dimension of *b* and I_k is a *k*-dimensional identity

[13] I used *k* as the value for *τ*.

matrix. A sample of 1,532 people is observed in the survey. The probability of person *n*'s observed choices, conditional on B_n is $L\left(y_n \mid B_n, b, W\right)$, which is equation (5.16). The probability *not* conditional on B_n is:

$$L\left(y_n \mid b, W\right) = \int L\left(y_n \mid B_n\right)\phi\left(B_n \mid b, W\right) dB, \tag{5.19}$$

where $\phi\left(B_n \mid b, W\right)$ is the normal density with mean *b* and variance *W*. The posterior distribution of *b* and *W* is

$$K\left(b, W \mid Y\right) \propto \prod_n L\left(y_n \mid b, W\right) k\left(b\right) k\left(W\right). \tag{5.20}$$

The posterior distribution of *b*, *W*, and $B_n \ \forall n$ is

$$K\left(b, W, B_n \forall n \mid Y\right) \propto \prod_n L\left(y_n \mid B_n\right)\phi\left(B_n \mid b, W\right) k\left(b\right) k\left(W\right). \tag{5.21}$$

Draws from this posterior are obtained through Gibbs sampling. A draw of each parameter is taken, conditional on the other parameters. This procedure consists of three steps. The first step takes a draw of *b* conditional on values of *W* and $B_n \ \forall n$, and the second step takes a draw of *W* conditional on values of *b* and $B_n \ \forall n$. The third step takes a draw of $B_n \ \forall n$ conditional on values of *b* and *W*. The first two steps are easy as it will be explain below. The third step is, however, is more complex. The posterior for each person's B_n, conditional on their choices and values of *b* and *W* is $K\left(B_n \mid b, W, y_n\right) \propto L\left(y_n \mid B_n\right)\phi\left(B_n \mid b, W\right)$. As Train (2003) notes, there is no easy way to draw from this posterior and thus requires the Metropolis-Hastings (MH) algorithm.

I start with initial values of b_0, W_0, and $B_n^0 \ \forall n$. At *t*th iteration of Gibbs sampler combined with the MH algorithm involves the following steps:

(1) Draw of b^t from $N\left(\overline{B}^{t-1}, W^{t-1}/N\right)$, where $\overline{B}^{t-1}$ is the mean of the B_n^{t-1}'s.

(2) Draw of W_t from $IW\left(K+N, \frac{KI+NS^{t-1}}{K+N}\right)$, where $S^{t-1} = \sum_n \left(B_n^{t-1}-b\right)\left(B_n^{t-1}-b\right)' \Big/ N$.

(3) For each *n*, draw B_n^t using one iteration of the following the MH algorithm.

a. start with a value B_n^{t-1}.

b. Draw η^t, a *k*-dimensional standard normal vector.

c. Create a trial value for B_n^t: $\tilde{B}_n^t = B_n^{t-1} + \rho L \eta^t$, where ρ is a scalar specified by the researcher and *L* is the Choleski factor of *W*.

d. Draw a standard uniform variable, μ_n^t.

e. Calculate: $F_n^t = \frac{L\left(y_n \mid \tilde{B}_n^t\right)\phi\left(\tilde{B}_n^t \mid b^t, W^t\right)}{L\left(y_n \mid B_n^{t-1}\right)\phi\left(B_n^{t-1} \mid b^t, W^t\right)}$.

f. If $\mu_n^t \le F_n^t$, accept B_n^t and let $B_n^t = \tilde{B}_n^t$.

If $\mu_n^t > F_n^t$, reject B_n^t and let $B_n^t = B_n^{t-1}$.

(4) Iterate.

After a sufficiently long burn-in, this algorithm generates random draws from the posterior distributions of *b*, *W*, and $B_n \ \forall n$. The means and standard deviation of the draws can be calculated to obtain estimates and standard errors of the parameters. It can be noted that this process, specifically the MH algorithm, provides information about B_n for each *n*, which are individual-specific parameters. Each person has his own distribution with its posterior mean and standard deviation of B_n, which describes the taste of that person.

5.4.3 Results

Tables 5.3, 5.4, 5.5, and 5.6 present posterior summaries for population means and variances of parameter estimates. These estimates were generated with a total of 320,000 iterations of the Gibbs sampler estimation algorithm where I treated the first 300,000 iterations as burn-in and used every tenth iteration thereafter to construct the reported estimates.

In general, there are many similarities in signs and significances between estimates obtained from discrete-count and discrete-only models and the ones from the fourth chapter. For instance, all visitors have a significantly negative preference for price. They prefer unguided trips to guided ones, less crowding to more at both entrance and destination, and smooth road to bumpy one. It should be noted that dummy variables are used for non-price attribute variables in this chapter whereas the effects codes are used in the last chapter. With effects coding, individual coefficients for attribute levels are interpreted relative to the zero mean effect while in effects coding they are interpreted relative to the omitted category.

In this section I will focus on differences between model specifications. The most notable differences between the discrete-count and discrete-only estimates are the opposite signs on the income and opt-out coefficients. I will first consider the implication of different signs of income coefficients. The income coefficient plays two roles in this structural model: as an income shifter in the demand equation (5.13) and in understanding the marginal utility of money. First, the negative (positive) income coefficient implies that days in the park are an inferior (normal) good, and secondly increasing (decreasing) marginal utility income[14]. I will discuss them in turn.

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[14] To see this note that $\frac{\partial^2 V_{itj}}{\partial y_i^2} = -\lambda \cdot \exp\left[-\lambda\left(y_i - r_i\right)\right] \gtrless 0 \; if \; \lambda \lessgtr 0$.

In the discrete-count models (both simple and user-type specific), the income coefficient is significantly negative whereas it is significantly positive in the discrete-only models. The difference in signs could have been driven by different sources of variability included in each model: net income and days of staying in the park. While both are included in the discrete-count model, the latter is not included in the discrete-only model. It can be, therefore, doubted whether the positive income coefficient is carefully determined due to the identification problem mentioned before. When the frequency information is included, it suggests that days in the park are an inferior good. One potential reason for this is that if luxury activities, such as downhill skiing, are more readily available outside the park, visitors with higher income might spend comparatively fewer days in the park.

The discrete-only model (both simple and user-type specific) suggests diminishing marginal utility of income as expected intuitively, whereas the discrete-count model finds the opposite. For increasing marginal utility of income, the willingness to pay (WTP) for an improvement in the park conditions will be greater than for an otherwise identical problem with constant marginal utility of income. This is because each additional dollar taken away provides less utility-equivalence, and therefore respondents are willing to pay higher amounts for the improvement in amenity. Likewise the willingness to accept (WTA) for forgoing an improvement is smaller under increasing marginal utility of income because each dollar given is associated with more and more utility gain. This may explain why some welfare gains, which are WTP measures for improvements, are larger in magnitude than in the previous chapter. This will be discussed further in the welfare results section.

The opt-out coefficients are negative in the discrete-count models and positive in discrete-only models. The utility function specification (5.9) indicates that it is not the signs of opt-out coefficients that matter but the magnitudes of them. In either case, the larger the opt-out coefficient, the more utility is received from opting out and the more frequently we expect the person to opt out. With the discrete-count, user-type specific model, non-snowmobile riders are the most likely to opt out ($\gamma_{opt-out}$ = -0.1390) and snowmobile riders/non-owners are the least likely ($\gamma_{opt-out}$ = -0.6814). This partially contradicts the results of the previous chapter (table 4.9), in which non-snowmobile riders are the least likely to choose not to visit and snowmobile riders/owners are the most likely due to the large number of substitutable sites nearby for snowmobilers. The relative magnitudes of opt-out coefficients from the discrete-only model are, however, identical to the previous chapter's results. One way to think about the discrete-count model is that it changes the relative frequency of observed opt-out behavior by effectively scaling up trip-choosing by the reported frequency information. Thus the different intensity of use among the different user groups will impact (along with other factors) the relative size of the opt-out coefficients. Results suggest that non-users have the highest utility from opting out followed by owners and finally non-owners. The intuition of this ranking is still unclear and is the subject of ongoing investigation.

I will now compare the results between simple and user-type specific models. Results from the simple models (tables 5.3A and 5.4A) indicate that visitors prefer high noise levels to lower ones and also that snowmobile riding is less attractive relative to the car tours even though it is insignificant. These are rather counter-intuitive, but when user-type interaction terms are included in estimation (tables 5.5A and 5.6A), noise and activities' coefficients improve. Non-snowmobile riders on average prefer low noise level to the higher ones, and snowmobile riders, both owners and non-owners, have negative preferences for low and medium noise levels relative to the high level. The magnitude of coefficients is, however larger for owners than for non-owners. This is consistent with the findings in the fourth chapter. Snowmobile riders may enjoy the noise associated with riding snowmobiles. In addition, they might associate lower noise level with a four-stroke engine snowmobile and higher noise with a two-stroke engine snowmobile. Because many snowmobile owners already own a two-stroke engine machine, they are especially unwilling to change their snowmobiles and, therefore, show a preference for the high noise level.

With the user-type specific models, all activity coefficients are significant and intuitive. Snowmobile riders, especially those who own a snowmobile, show a strong positive preference for snowmobile riding relative to car tour. Riders who do not own a snowmobile also display a preference for snowmobile riding relative to the other park activities, but the magnitude of coefficients is smaller than the riders/owners. Non-riders are indisposed to ride a snowmobile but have a positive preference for skiing/hiking relative to taking a car tour.

5.5. WELFARE ANALYSIS

Using the draws from the posterior for individual-specific parameters, $B_n \ \forall n$, I estimate welfare impacts of the snowmobile policy change in YNP on different types of visitors. As in the fourth chapter, I will calculate compensating variation (CV) defined as the income equivalent of a change in exogenous conditions that comes about from changes in management policies. The baseline condition[15], policy-altered choice sets and ambient conditions are also defined similarly to the previous chapter.

5.5.1 Methods

In general the utility a person receives from selecting alternative j is defined as:

$$U_j = U\left(y - p_j, q_j, \varepsilon_j\right), j = 1, \ldots, J, \tag{5.22}$$

where y is income, p_j is its price, q_j is a vector of attribute levels for the alternative, and ε_j is the unobserved component of preferences. The compensating variation (CV) for changes in attribute conditions or prices associated with the choice alternatives can be defined as:

$$\max_{j \notin J^0}\left[U_j^0\left(y - p_j^0, q_j^0, \varepsilon_j\right)\right] = \max_{j \notin J^1}\left[U_j^1\left(y - p_j^1 - CV, q_j^1, \varepsilon_j\right)\right], \tag{5.23}$$

where J denotes the choice set and the superscripts "0" and "1" are used to distinguish the baseline and changed conditions. When the utility function is linear in income, there exists a closed-form solution (conditional on random parameters) for CV as it was used in the fourth chapter. Because the utility function used in this chapter (5.9) is nonlinear in income, I can no longer use the closed-form expression for CV. Instead, a non-linear utility function requires simulation and numerical techniques to compute CV as discussed by McFadden (1995) and Herriges and Kling (1999). An algorithm for computing CV for a given person is as follows:

(1) Draw from the posterior of K individual-specific parameter vectors for person i, B_i^k, $k = 1, \ldots, K$ and $i = 1, \ldots, N$.

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[15] I use baseline I, which assumes the unregulated park condition is in the high crowding, as the baseline condition.

(2) For a given individual-specific parameter vector, B_i^k, simulate values for the extreme value additive errors, ε_j^r, j = 1, …, J and r = 1, …, R.

(3) Substitute B_i^k and ε_j^r into equation (5.9) to calculate the baseline and changed utility values.

(4) Use a numerical bisection routine to find the income differential that makes the two utility values approximately equal. The resulting income differential is the estimated *CV* for this person and this draw of the error.

(5) Iterate *R* times. The average over *CV*(r)'s is an estimate of the *CV* for this person. Repeat for all people. The average over people is an estimate for the population.

5.5.2 Results

Tables 5.7 and 5.8 provide point estimates and standard errors for each welfare scenario for each of the three visitor types using the results from the simple and user-type specific, discrete-count models, respectively. Welfare estimates obtained with discrete-only models' results (not reported) are exceptionally large. For example, when snowmobiles are banned from the park, non-snowmobile riders are better off by about $4,200 per occasion. This estimate seems implausible. One explanation for this is that the income coefficient, which plays an important role in welfare calculation, is poorly identified in the discrete-only models. As mentioned in section 5.4.1 there is little net income variability among the three choices (trip A, trip B, opt-out) in the data. Because the income term enters the likelihood function in both its discrete and count components when the discrete-count model specification is used, the income coefficient is more readily identified. With the discrete-only mode, however, the income term enters the likelihood function only through the discrete component, and the income coefficient may not be identified properly. I believe that the income coefficients of discrete-only models (tables 5.4A and 5.6A) are identified only through the non-linearity of the utility function and the prior and therefore do not represent appropriate values.

The general welfare results in the discrete-count model (table 5.8) are similar to those in the previous chapter (table 4.16) in terms of policies' effects on different types of visitors (signs and rankings). The magnitudes of welfare changes, however, are different between them. Overall, the welfare impacts in this chapter are larger in absolute value than in the previous one. This is partially explained by increasing marginal utility of income, which the discrete-count model suggests. It was shown in section 5.4.3 that for increasing marginal utility of income, the WTP for an improvement in the park conditions is greater than for constant marginal utility of income, and the WTA for forgoing an improvement is smaller. Snowmobile non-riders' welfare gains (WTP) are indeed larger with discrete-count models than with the previous analysis, where constant marginal utility of income was assumed. However, the magnitudes of welfare losses (WTA) for riders are also larger in the discrete-count model, which indicates that this is not the only explanation for the differences in the estimates.

5.6. CONCLUSION

In this chapter, I evaluated the extent to which obtaining frequency information in a choice experiment leads to improved modeling and policy inference. The 2002-2003 Yellowstone and Grand Teton National Parks winter visitor survey included choice experiment questions that asked respondents to choose between two hypothetical trips and an opt-out option and also to indicate the number of days they would spend in the park if they choose one of the trips. In this setting, survey respondents make a discrete choice of which kind of trip to choose (if they choose to visit the park) and also a frequency choice of the number of days to spend in the park. The two choices are related because characteristics that influence a respondent to choose a trip may also influence that respondent's choice of days, and therefore they should be estimated simultaneously. I specify and estimate models that do and do not exploit frequency information, and compare estimates and welfare calculations to assess the value of incorporating the frequency information. Methodologically this chapter contributes the development of a model that accommodates the idea of discrete and continuous outcomes in stated preference choice experiments. Previous studies apply discrete-continuous choice modeling primarily to revealed preference data, and this approach is relatively novel in the choice experiment framework.

Both discrete-count and discrete-only models are estimated via Bayesian methods and interpreted from a classical perspective. A clear distinction between the discrete-count and discrete-only models is the different signs on the income coefficients. In the discrete-count model, income has a negative coefficient, which indicates that days in the park are inferior goods, while the discrete-only model suggests that they are normal goods. It is interesting that I find that a day in the park to be inferior when the income effect is introduced in the model and is properly identified. Different signs of the income coefficient also imply different marginal utilities of income. The discrete-count model suggests increasing marginal utility of income, whereas the discrete-only model finds the opposite. This has potential ramifications for welfare analysis, as was seen with non-riders' WTP being larger than the ones in the previous chapter. Another difference between the two model specifications is the opt-out coefficients. When the frequency information is added in the discrete-count model, the relative magnitudes of the opt-out coefficients among the visitor types are different from the previous chapter.

The extra information collected in the choice experiment does not seem to matter in terms of ranking of the policies, but does affect the magnitude of welfare effects for different visitor types. In general, when the frequency information is incorporated, I find larger welfare changes in absolute terms. In the Yellowstone application, asking respondents about the frequency information does not seem to result in qualitatively different findings, however. This is not necessarily a general result, and future choice experiment research could seek to confirm or refute the information-neutrality of frequency solicitation.

Table 5.1: Number of Days Respondents Would Spend on Their Chosen Trip

Number of Days in the Park	Number of Responses
0	4,765
1	2,466
2	636
3	469
4	203
5	141
6	32
7	66
8	5
9	4
10	9
11	2
14	3
30	3
50	1
100	1
125	1

Table 5.2: Percentages of Number of Days Reported by Respondents

Number of Days	Overall	Non-Snowmobile Riders	Snowmobile Riders/Non-Owners	Snowmobile Riders/Owners
= 1	60.70%	51.70%	66.82%	77.76%
> 1	39.30%	48.30%	33.18%	22.24%

Table 5.3: Results for Discrete-Count, Simple Model

A. Posteriors Summary for Population Means of Utility Function Parameters (Means and Std. Err of Unknown Parameters)

	Mean	**Std. Err**	**Ratio**
Income	-0.0120	0.0008	-14.1463
Price	-0.0684	0.0025	-27.5696
Entrance			
West	0.1232	0.0279	4.4168
North	-0.0037	0.0223	-0.1651
South	-0.0518	0.0191	-2.7189
Tetons			
Activity			
Snowmobile	-0.0243	0.0453	-0.5363
Coach	-0.2076	0.0347	-5.9844
Ski/Hike	-0.1129	0.0197	-5.7389
Car			
Guide Status			
Guided	-0.3803	0.0309	-12.3229
Unguided			
Crowding at Entrance			
Low	0.2218	0.0135	16.4715
Medium	0.0122	0.0263	0.4636
High			
Crowding at Destination			
Low	0.5086	0.0221	23.0117
Medium	0.2240	0.0194	11.5307
High			
Road Condition			
Smooth	0.0387	0.0177	2.1854
Bumpy			
Noise Level			
Low	-0.2449	0.0274	-8.9448
Medium	-0.3504	0.0232	-15.1356
High			
Emission Level			
Low	-0.0825	0.0228	-3.6191
Medium	0.1946	0.0215	9.0523
High			
No Snowmobiles	0.9124	0.0261	34.9290
Opt out	-0.5538	0.0420	-13.1958

B. Posterior Summary for Variance of Utility Function Parameters (Means and Std. Err of Unknown Parameters)

	Mean	**Std. Err**	**Ratio**
Income	0.0306	0.0006	50.2200
Price	0.0567	0.0016	35.5594
Entrance			
West	0.3805	0.0199	19.0837
North	0.3302	0.0205	16.1345
South	0.3101	0.0270	11.4964
Tetons			
Activity			
Snowmobile	1.1911	0.0510	23.3471
Coach	0.6486	0.0381	17.0072
Ski/Hike	0.3549	0.0271	13.1156
Car			
Guide Status			
Guided	0.7130	0.0290	24.5622
Unguided			
Crowding at Entrance			
Low	0.2769	0.0130	21.3769
Medium	0.3164	0.0237	13.3404
High			
Crowding at Destination			
Low	0.2829	0.0223	12.7093
Medium	0.3531	0.0202	17.4402
High			
Road Condition			
Smooth	0.3126	0.0192	16.2561
Bumpy			
Noise Level			
Low	0.5345	0.0396	13.4986
Medium	0.3623	0.0233	15.5466
High			
Emission Level			
Low	0.4368	0.0253	17.2638
Medium	0.3071	0.0263	11.6911
High			
No Snowmobiles	0.6279	0.0362	17.3630
Opt out	0.8246	0.0323	25.5544

[a] Omitted dummy variables. All estimates generated with 320,000 iterations of the Gibbs sampling algorithm. The first 300,000 iterations were discarded as burn-in, and every 10^{th} iteration thereafter was used to construct the reported estimates.

Table 5.4: Results for Discrete-Only, Simple Model

A. Posteriors Summary for Population Means of Utility Function Parameters (Means and Std. Err of Unknown Parameters)

	Mean	**Std. Err**	**Ratio**
Income	1.5102	0.1866	8.0945
Price	-0.9519	0.0759	-12.5393
Entrance			
West	0.6407	0.0819	7.8238
North	0.0995	0.1293	0.7694
South	0.2869	0.0715	4.0144
Tetons[a]			
Activity			
Snowmobile	0.1829	0.1384	1.3213
Coach	-0.2935	0.1522	-1.9276
Ski/Hike	0.0201	0.0746	0.2692
Car[a]			
Guide Status			
Guided	-1.6347	0.1799	-9.0856
Unguided[a]			
Crowding at Entrance			
Low	1.0084	0.1200	8.4036
Medium	0.4292	0.0723	5.9345
High[a]			
Crowding at Destination			
Low	0.5449	0.1176	4.6336
Medium	0.2012	0.0953	2.1114
High[a]			
Road Condition			
Smooth	0.0423	0.0613	0.6900
Bumpy[a]			
Noise Level			
Low	-0.3878	0.1247	-3.1107
Medium	-0.4447	0.1261	-3.5254
High[a]			
Emission Level			
Low	0.2830	0.1109	2.5515
Medium	0.4471	0.0596	7.4987
High[a]			
No Snowmobiles	1.9022	0.1794	10.6023
Opt out	1.6039	0.0883	18.1612

B. Posterior Summary for Variance of Utility Function Parameters (Means and Std. Err of Unknown Parameters)

	Mean	**Std. Err**	**Ratio**
Income	0.5106	0.1041	4.9043
Price	0.3341	0.0301	11.1097
Entrance			
West	0.5528	0.1292	4.2800
North	0.7891	0.2119	3.7233
South	0.7712	0.1245	6.1961
Tetons[a]			
Activity			
Snowmobile	3.2502	0.2568	12.6551
Coach	1.7495	0.2037	8.5882
Ski/Hike	0.3996	0.0571	6.9936
Car[a]			
Guide Status			
Guided	2.7728	0.2663	10.4126
Unguided[a]			
Crowding at Entrance			
Low	0.7461	0.1101	6.7740
Medium	0.5183	0.0769	6.7423
High[a]			
Crowding at Destination			
Low	1.1068	0.1620	6.8320
Medium	0.5269	0.0664	7.9338
High[a]			
Road Condition			
Smooth	0.6854	0.1193	5.7432
Bumpy[a]			
Noise Level			
Low	1.6063	0.1303	12.3272
Medium	0.8618	0.1306	6.5971
High[a]			
Emission Level			
Low	0.8387	0.1279	6.5558
Medium	0.4801	0.1048	4.5800
High[a]			
No Snowmobiles	2.3827	0.4004	5.9513
Opt out	1.4319	0.1133	12.6408

[a] Omitted dummy variables. All estimates generated with 320,000 iterations of the Gibbs sampling algorithm. The first 300,000 iterations were discarded as burn-in, and every 10th iteration thereafter was used to construct the reported estimates.

Table 5.5: Results for Discrete-Count, User-Type Specific Model

A. Posteriors Summary for Population Means of Utility Function Parameters (Means and Std. Err of Unknown Parameters)

	Estimate	Std. Err	Ratio						
Income	-0.0115	0.0008	-14.0341						
Price	-0.0560	0.0020	-27.6404						
Entrance									
West	0.0446	0.0200	2.2240						
North	0.0067	0.0161	0.4162						
South	-0.1359	0.0111	-12.2595						
Tetons[a]									
Crowding at Entrance									
Low	0.1492	0.0151	9.8779						
Medium	-0.0631	0.0214	-2.9483						
High[a]									
Crowding at Destination									
Low	0.4449	0.0151	29.4569						
Medium	0.1782	0.0193	9.2157						
High[a]									
Road Condition									
Smooth	-0.0040	0.0173	-0.2302						
Bumpy[a]									
Emissions Level									
Low	-0.0871	0.0119	-7.3272						
Medium	0.1552	0.0133	11.6339						
High[a]									
USER-TYPE SPECIFIC VARIABLES									
	Non-Snowmobile Riders			**Snowmobile Riders/Non-Owners**			**Snowmobile Riders/Owners**		
Activity									
Snowmobile	-0.9916	0.0328	-30.2482	0.5445	0.0377	14.4392	1.0370	0.0344	30.1862
Coach	-0.3409	0.0185	-18.4205	-0.1587	0.0278	-5.7141	-0.1552	0.0504	-3.0829
Ski/hike	-0.2190	0.0209	-10.4568	-0.1824	0.0221	-8.2598	-0.0749	0.0236	-3.1765
Car[a]									
Guide Status									
Guided	-0.0153	0.0315	-0.4865	-0.4319	0.0308	-14.0389	-1.1724	0.0504	-23.2558
Unguided[a]									
Noise Level									
Low	0.0760	0.0305	2.4892	-0.3752	0.0240	-15.6343	-0.7233	0.0333	-21.7023
Medium	-0.1358	0.0166	-8.1718	-0.3285	0.0183	-17.9977	-0.7861	0.0162	-48.3910
High[a]									
No Snowmobiles	1.0651	0.0166	64.0158	0.4785	0.0239	20.0555	-0.1068	0.0241	-4.4275
Opt out	-0.1390	0.0380	-3.6535	-0.6814	0.0263	-25.9535	-0.4822	0.0172	-28.0535

Table 5.5 (continued)

B. Posterior Summary for Variance of Utility Function Parameters (Means and Std. Err of Unknown Parameters)

	Estimate	Std. Err	Ratio						
Income	0.0307	0.0007	46.7631						
Price	0.0577	0.0018	32.4941						
Entrance									
West	0.4125	0.0184	22.4705						
North	0.3828	0.0194	19.7795						
South	0.2656	0.0112	23.7863						
Tetons[a]									
Crowding at Entrance									
Low	0.2876	0.0137	20.9268						
Medium	0.3236	0.0176	18.4333						
High[a]									
Crowding at Destination									
Low	0.3872	0.0147	26.3058						
Medium	0.3439	0.0140	24.5216						
High[a]									
Road Condition									
Smooth	0.3743	0.0157	23.7937						
Bumpy[a]									
Emissions Level									
Low	0.3424	0.0215	15.9556						
Medium	0.2756	0.0107	25.6552						
High[a]									
USER-TYPE SPECIFIC VARIABLES									
	Non-Snowmobile Riders			**Snowmobile Riders/Non-Owners**			**Snowmobile Riders/Owners**		
Activity									
Snowmobile	0.7658	0.0211	36.2869	0.8312	0.0261	31.8193	0.8927	0.0313	28.5659
Coach	0.4555	0.0197	23.0876	0.8775	0.0308	28.4905	1.1940	0.0552	21.6292
Ski/hike	0.4091	0.0152	26.9552	0.4533	0.0166	27.3068	0.4828	0.0313	15.4320
Car[a]									
Guide Status									
Guided	0.5547	0.0244	22.7158	0.7978	0.0274	29.0639	1.3064	0.0366	35.7134
Unguided[a]									
Noise Level									
Low	0.5352	0.0215	24.8837	0.6060	0.0258	23.5121	0.6888	0.0310	22.2520
Medium	0.3381	0.0206	16.3997	0.3648	0.0218	16.7588	0.4504	0.0160	28.2025
High[a]									
No Snowmobiles	0.4662	0.0317	14.6879	0.5846	0.0389	15.0332	0.3249	0.0109	29.7273
Opt out	0.5967	0.0244	24.4505	0.7696	0.0309	24.9307	0.4964	0.0171	29.0234

Table 5.6: Results for Discrete-Only, User-Type Specific Model

A. Posteriors Summary for Population Means of Utility Function Parameters (Means and Std. Err of Unknown Parameters)

	Estimate	Std. Err	Ratio						
Income	1.0146	0.0238	42.5423						
Price	-0.9174	0.0223	-41.0673						
Entrance									
West	-0.0043	0.0601	-0.0714						
North	0.0052	0.0587	0.0883						
South	-0.1215	0.0576	-2.1083						
Tetons[a]									
Crowding at Entrance									
Low	0.5754	0.0316	18.2089						
Medium	0.4526	0.0384	11.7751						
High[a]									
Crowding at Destination									
Low	0.6737	0.0488	13.8073						
Medium	-0.0053	0.0627	-0.0840						
High[a]									
Road Condition									
Smooth	-0.0256	0.0519	-0.4929						
Bumpy[a]									
Emissions Level									
Low	0.6141	0.0397	15.4658						
Medium	0.5955	0.0335	17.7839						
High[a]									
USER-TYPE SPECIFIC VARIABLES									
	Non-Snowmobile Riders			**Snowmobile Riders/Non-Owners**			**Snowmobile Riders/Owners**		
Activity									
Snowmobile	-1.8661	0.1355	-13.7692	2.4378	0.1166	20.9162	2.8393	0.0714	39.7704
Coach	-0.1768	0.0875	-2.0202	0.3885	0.1515	2.5641	1.0630	0.0613	17.3361
Ski/hike	0.4508	0.0399	11.2859	0.3346	0.0747	4.4812	-0.1675	0.0437	-3.8354
Car[a]									
Guide Status									
Guided	-0.3553	0.1088	-3.2661	-1.6465	0.1658	-9.9295	-2.4045	0.2043	-11.7716
Unguided[a]									
Noise Level									
Low	0.4904	0.0519	9.4581	-0.6276	0.1425	-4.4025	-1.7629	0.1435	-12.2833
Medium	0.1751	0.0363	4.8243	-0.5513	0.1417	-3.8921	-1.7048	0.1040	-16.3863
High[a]									
No Snowmobiles	2.2236	0.1052	21.1370	0.9233	0.1127	8.1933	-0.8785	0.0898	-9.7848
Opt out	1.3694	0.0620	22.0791	1.7506	0.1049	16.6918	1.8123	0.1568	11.5608

Table 5.6 (continued)

B. Posterior Summary for Variance of Utility Function Parameters (Means and Std. Err of Unknown Parameters)

	Estimate	**Std. Err**	**Ratio**						
Income	0.2348	0.0294	7.9804						
Price	0.3281	0.0160	20.4659						
Entrance									
West	1.0117	0.0950	10.6477						
North	0.7555	0.0512	14.7466						
South	0.6701	0.0531	12.6118						
Tetons[a]									
Crowding at Entrance									
Low	0.4156	0.0366	11.3680						
Medium	0.5867	0.0323	18.1369						
High[a]									
Crowding at Destination									
Low	0.4063	0.0310	13.1062						
Medium	0.4822	0.0541	8.9114						
High[a]									
Road Condition									
Smooth	0.5442	0.1135	4.7937						
Bumpy[a]									
Emissions Level									
Low	0.4109	0.0206	19.9530						
Medium	0.4185	0.0397	10.5409						
High[a]									
USER-TYPE SPECIFIC VARIABLES									
	Non-Snowmobile Riders			**Snowmobile Riders/Non-Owners**			**Snowmobile Riders/Owners**		
Activity									
Snowmobile	2.3285	0.1212	19.2141	2.2192	0.1580	14.0416	0.8920	0.1047	8.5165
Coach	1.2588	0.1063	11.8436	2.4096	0.1494	16.1266	0.9572	0.0543	17.6315
Ski/hike	0.4633	0.0437	10.5949	0.9267	0.1385	6.6929	0.7886	0.0639	12.3359
Car[a]									
Guide Status									
Guided	1.7212	0.1314	13.1007	2.6987	0.2161	12.4873	2.3723	0.1594	14.8787
Unguided[a]									
Noise Level									
Low	0.6861	0.0618	11.1048	1.4502	0.0910	15.9438	1.4426	0.0917	15.7241
Medium	0.6776	0.0903	7.5057	1.5069	0.0757	19.8987	0.6632	0.0756	8.7740
High[a]									
No Snowmobiles	2.0187	0.0975	20.7133	1.4836	0.1134	13.0826	1.2506	0.1497	8.3543
Opt out	1.2706	0.0703	18.0734	1.5597	0.0745	20.9475	1.0646	0.0877	12.1407

Table 5.7: Per Choice Occasion Welfare Effect (Discrete-Count, Simple Model)

	Ban	**Guided Tours**: Low	**Guided Tours**: Mod	**Cap** (For Entrants): Low	**Cap** (For Entrants): Mod	**Cap** (For Non-Entrants): Low	**Cap** (For Non-Entrants): Mod	**Technology Restriction**
Non-Snowmobile Riders	771.84 (63.93)	569.27 (60.4)	139.17 (46.18)	643.56 (67.33)	143.95 (36.32)	462.46 (57.94)	46.31 (26.64)	69.37 (27.83)
Snowmobile Riders/Non-Owners	267.49 (62.91)	475.77 (65.76)	160.02 (79.98)	845.74 (94.47)	351.26 (77.93)	95.2 (43.81)	-161.54 (48.2)	-65.45 (41.42)
Snowmobile Riders/ Owners	-44.7 (67.4)	204.08 (88.92)	42.5 (64.87)	502.84 (107.05)	213.21 (66.95)	-93.8 (54.01)	-185.73 (45.14)	-66.29 (52.25)

Standard errors in parentheses

Table 5.8: Per Choice Occasion Welfare Effect (Discrete-Count, User-Type Specific Model)

	Ban	**Guided Tours**: Low	**Guided Tours**: Mod	**Cap** (For Entrants): Low	**Cap** (For Entrants): Mod	**Cap** (For Non-Entrants): Low	**Cap** (For Non-Entrants): Mod	**Technology Restriction**
Non-Snowmobile Riders	1071.15 (85.46)	620.27 (60.25)	200.62 (25.33)	631.79 (60.31)	174.07 (24.42)	587.96 (61.74)	150.56 (25.67)	101.34 (24.33)
Snowmobile Riders/Non-Owners	60.35 (73.49)	417.62 (88.78)	92.78 (79.62)	775.87 (119.01)	300.15 (74.69)	39.83 (76.63)	-254.66 (63.53)	-126.19 (48.88)
Snowmobile Riders/ Owners	-539.4 (57.86)	-126.1 (96.82)	-358.27 (82.23)	262.78 (114.00)	-205.45 (82.93)	-342.6 (77.78)	-536.88 (53.03)	-347.66 (68.7)

Standard errors in parentheses

Table 5.9: Ranking of Proposed Policies' Effects (Discrete-Count, Simple Model)

	Positive Welfare Change →				**Negative Welfare Change**
Non-Snowmobile Riders	Ban	Cap (For Entrants)	Guided Tours	Cap (For Non-Entrants)	Technology Restriction
Snowmobile Riders/Non-Owners	Cap (For Entrants)	Guided Tours	Cap (For Non-Entrants)	Ban	Technology Restriction
Snowmobile Riders/ Owners	Cap (For Entrants)	Guided Tours	Cap (For Non-Entrants)	Technology Restriction	Ban

Table 5.10: Ranking of Proposed Policies' Effects (Discrete-Count, User-Type Specific Model)

	Positive Welfare Change →				**Negative Welfare Change**
Non-Snowmobile Riders	Ban	Cap (For Entrants)	Guided Tours	Cap (For Non-Entrants)	Technology Restriction
Snowmobile Riders/Non-Owners	Cap (For Entrants)	Guided Tours	Cap (For Non-Entrants)	Ban	Technology Restriction
Snowmobile Riders/ Owners	Cap (For Entrants)	Guided Tours	Cap (For Non-Entrants)	Technology Restriction	Ban

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APPENDICES

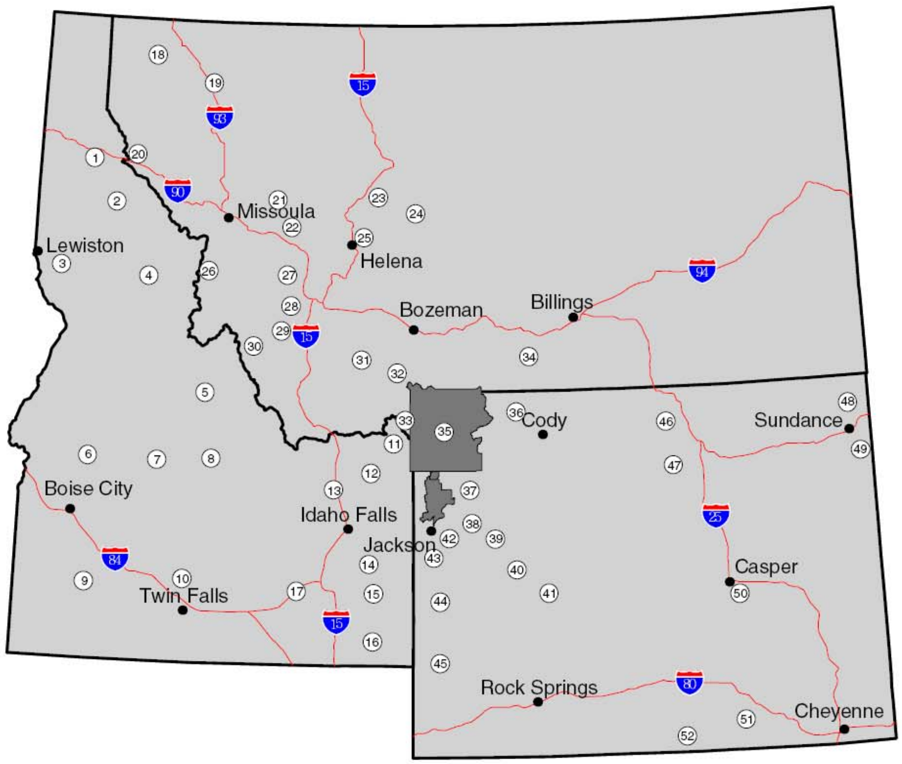
Appendix A: A Typical Day on a Visitor's Recent Trip

20.

Features of Trip	Your Trip (please check ONE BOX in each row that best describes Your Trip)	Trip B	Not Visit
a. Activity?	☐ Snowmobile ☐ Snowcoach tour ☐ Snowcoach Shuttle to ski or snowshoe ☐ Drive car to sightsee, ski or snowshoe ☐ Other	Snowmobile	**I would not enter Yellowstone or Grand Teton National Park if these were my only choices**
b. Entrance where you started the day?	☐ Yellowstone West near West Yellowstone, MT ☐ Yellowstone East near Cody, WY ☐ Yellowstone North near Gardiner, MT ☐ Yellowstone South near Flagg Ranch ☐ Grand Teton Moose entrance near Jackson Hole, WY ☐ Grand Teton Moran entrance near Flagg Ranch ☐ Other (please describe)	Yellowstone West Entrance	
c. Did you take a guided tour?	☐ Yes ☐ No	Unguided	
d. Daily snowmobile traffic at the entrance where you started?	☐ High, 800 to 1,500 snowmobiles (typical West Entrance on a holiday or crowded weekend) ☐ Moderate, 300 to 600 snowmobiles (typical West Entrance on weekdays and South entrance on busy holiday weeks) ☐ Low, 200 or fewer snowmobiles (typical North and East entrances on all days and South entrance on most weekdays and weekends) ☐ I did not see any snowmobiles near the entrance where my trip started	Low, 200 or fewer snowmobiles	
e. Level of snowmobile traffic at the most crowded area of the park you visited?	☐ High, 800 to 1,500 snowmobiles (typical Old Faithful on a holiday and busy weekends or weekdays in late January and February) ☐ Moderate, 300 to 600 snowmobiles (typical Old Faithful on less crowded weekdays and weekends) ☐ Low, 200 or fewer snowmobiles (very uncrowded days at Old Faithful) ☐ I did not see any snowmobiles on my most recent trip	Moderate 300 to 600 snowmobiles	
f. Condition of snow on road or trail surface?	☐ Bumpy and rough for all or most of the trip ☐ Bumpy and rough for some of the trip ☐ Smooth	Smooth	
g. Noise level at the noisiest part of the park you visited?	☐ Loud, standing next to the road you could not converse with someone standing next to you, noise level similar to standing next to a gas-powered lawn mower or a busy highway ☐ Moderate, you would need to raise your voice to talk to someone standing next to you, noise like a busy city street ☐ Low noise, occasional	Moderate	
h. Level of exhaust emissions during your day?	☐ Very noticeable for most or all of the trip ☐ Noticeable for some of the trip ☐ I did not notice any exhaust emissions	Noticeable for some of the trip	
i. Cost per person for day?	$______________________________	$100	
j. I would choose... (check only one)	Your Trip ☐	Trip B ☐	Not Visit ☐

Appendix B: Visitors' Snowmobile Trips in the Previous Year – "Experienced Snowmobile Riders" Version

We would now like to ask about your snowmobiling activity* last *winter (December 2001-March 2002). We will ask you about trips you made to areas in Idaho, Wyoming, and Montana using the map and general area list on this page for reference.



Idaho

1. Wallace Area Trails
2. Northern Idaho Trails
3. Grangeville Area Trails
4. North-Central Idaho Trails
5. Salmon/Challis Area Trails
6. Smith's Ferry Area Trails
7. Stanley Area Trails
8. Central Idaho Trails
9. South-Western Idaho Trails
10. South-Central Idaho Trails
11. Big Springs Area Trails
12. Ashton Area Trails
13. Eastern Idaho Trails
14. Bone Snowmobile Trails
15. Pocatello Area Trails
16. Bear Lake Area Trails
17. South-Eastern Idaho Trails

Montana

18. Kootenai Country
19. Flathead Valley
20. Haugan
21. Seeley Lake
22. Garnet
23. Lincoln
24. Kings Hill/Little Belts
25. Helena
26. Lolo Pass
27. Georgetown Lake
28. Wise River
29. Dillion/Polaris
30. Wisdom/Jackson/Sula
31. Virginia City/Ennis
32. Bozeman/Big Sky
33. West Yellowstone
34. Cooke City/Silver Gate

Wyoming

35. Yellowstone/Grand Teton National Parks
36. Bear Tooth
37. Continental Divide Togwotee
38. Continental Divide Gros Ventre
39. Continental Divide Dubois
40. Wyoming Range Kemmerer
41. Continental Divide Lander
42. Granite Hot Springs
43. Wyoming Range Alpine
44. Casper Mountain
45. Wyoming Ranger Kemmerer
46. North Big Horn Mountains
47. South Big Horn Mountains
48. Bear Lodge Mountains
49. Black Hills of WY
50. Wyoming Range Afton
51. Snowy Range
52. Sierra Madre Mountains

Appendix B (continued)

19. Please list the numbers corresponding to the areas you visited last winter (December 2001–March 2002) and indicate the number of trips you made to that area and the total days you spent in the area on all the trips. If during a single trip you visited multiple areas list the area where you spent most of your time. If you visited an area not included on this list, please add this under the "other areas" category.

Snowmobile Areas	Number of Trips	Total Days
Montana		
Areas from list (numbers):		
________	______	______
________	______	______
________	______	______
________	______	______
________	______	______
Other areas (please name area and nearest city):		
____________________	______	______
Idaho		
Areas from list (numbers):		
________	______	______
________	______	______
________	______	______
________	______	______
________	______	______
Other areas (please name area and nearest city):		
____________________	______	______
Wyoming		
Areas from list (numbers):		
________	______	______
________	______	______
________	______	______
________	______	______
________	______	______
Other areas (please name area and nearest city):		
____________________	______	______

Appendix C: Visitors' Winter Recreation Trips in the Previous Year – "All Others" Version

B.2 Alternative to Question 19: Winter Recreation Trips

We would like to ask about your cross-country skiing, snowshoeing, winter hiking, and winter camping trips during the previous winter season (December 2001–March 2002).

11. Did you cross-country ski, snowshoe, winter hike, or winter camp during the previous winter season (December 2001–March 2002)? **Please check all that apply.**

    ☐ Cross-country ski
    ☐ Snowshoe
    ☐ Winter hiking
    ☐ Winter camping
    ☐ No, I did not participate in these activities last winter—please skip to page 10.

12. Looking at the map on the next page, did you make any trips in the counties in or around Yellowstone and Grand Teton National Parks during the previous winter season (December 2001–March 2002)?

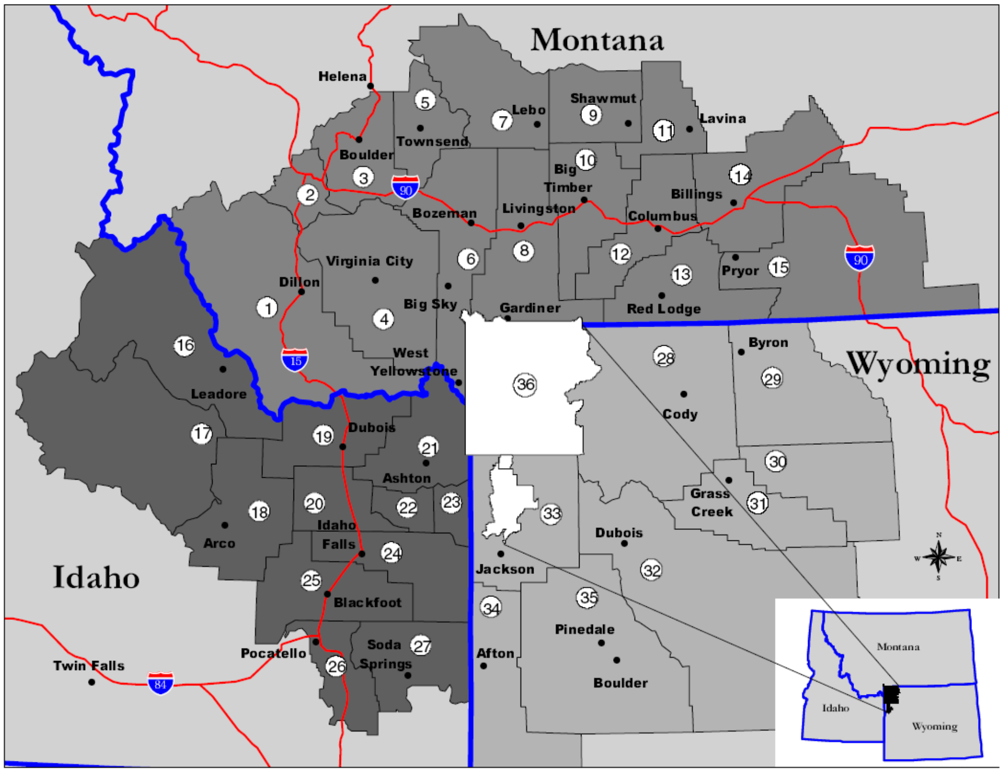
    ☐ Yes—please fill out the following table using the map on the next page for reference.
    ☐ No—please skip to page 10.

Using the map and county list on the following page for reference please indicate the counties you visited and the number of trips you made in this county during the previous winter season for cross-country skiing, snowshoeing, winter hiking, and winter camping. If you visited more than one county on a trip please list the county where you spent the most time. Trips can be a day outing or a longer visit.

Counties Visited for Winter Recreation	# Trips	Total Days
(List numbers from map)		
____________	_______	_______
____________	_______	_______
____________	_______	_______
____________	_______	_______
____________	_______	_______
____________	_______	_______
____________	_______	_______

Appendix C (continued)

Counties Surrounding Yellowstone and Grand Teton National Parks



Montana		Idaho		Wyoming	
1.	Beaverhead	16.	Lemhi	28.	Park
2.	Silver Bow	17.	Custer	29.	Big Horn
3.	Jefferson	18.	Butte	30.	Washakie
4.	Madison	19.	Clark	31.	Hot Springs
5.	Broadwater	20.	Jefferson	32.	Fremont
6.	Gallatin	21.	Fremont	33.	Teton
7.	Meagher	22.	Madison	34.	Wyoming
8.	Park	23.	Teton	35.	Sublette
9.	Wheatland	24.	Bonneville	36.	Yellowstone and Grand Teton National Parks
10.	Sweet Grass	25.	Bingham		
11.	Golden Valley	26.	Bannock		
12.	Stillwater	27.	Caribou		
13.	Carbon				
14.	Yellowstone				
15.	Big Horn				

Appendix D: A Sample Choice Experiment Question

22. CHOICE 1: Which do you prefer—Trip A, Trip B or "Not Visit"?

Please check ONE box at the bottom of the table to indicate whether you prefer Trip A, Trip B or Not Visit. If you choose Trip A or Trip B, write the number of days you spend on a trip doing only that activity.

Note that we shaded the boxes that are the same for both trips. The conditions and prices described in this question may be different than what the parks are like today.

		Trip A	Trip B	Not Visit
	Activity	Take a guided snowcoach tour to see park sights in Yellowstone starting at the South entrance (near Flagg Ranch)	Take an unguided snowmobile trip in Yellowstone starting from the West entrance (near West Yellowstone)	**I would not enter Yellowstone or Grand Teton National Park if these were my only choices**
Conditions during day trip	**Daily snowmobile traffic at the entrance where you started**	High (800 to 1,500 snowmobiles)	Moderate (300 to 600 snowmobiles)	
	Snowmobile traffic at most crowded part of the trip	High (800 to 1,500 snowmobiles)	Moderate (300 to 600 snowmobiles)	
	Condition of snow on the road or trail surface for all or most of the trip	Smooth	Bumpy and rough	
	Highest noise level experienced on trip	Loud (Like a gas-powered lawn mower or a busy highway)	Loud (Like a gas-powered lawn mower or a busy highway)	
	Exhaust emission levels	Very noticeable	Very noticeable	
	Total Cost for DAY per person	$230	$50	
	I would choose… (check only one)	☐ If you planned a trip doing just this activity, how many days would you spend on the trip? ________ days	☐ If you planned a trip doing just this activity, how many days would you spend on the trip? ________ days	☐ **go to Question 22b below**

22b. Answer this question if you chose "Not Visit": What would you likely do instead?

- ☐ Stay at home; I would not travel to the Greater Yellowstone Area
- ☐ Travel to the Greater Yellowstone Area to snowmobile outside the Parks.
- ☐ Travel to the Greater Yellowstone Area to cross-country ski outside the Parks.
- ☐ Travel to the Greater Yellowstone Area to downhill ski at Big Sky or one of the ski areas near Jackson Hole.
- ☐ Other, please describe activity ______________________________
  location ______________________________

Appendix E: A Sample Stated Behavior Question

As you may know Yellowstone and Grand Teton National Parks are evaluating the way winter access to the parks is managed. The parks are making plans for next winter season, but plans in future seasons may change. The following question will help us understand how you feel about one possible management option.

One proposed winter management plan for Yellowstone or Grand Teton National Parks would be phased in over several years.

- **Set daily limits on the number of snowmobiles allowed in the park that would primarily affect the West and South entrances to Yellowstone**
  - 550 per day from the West entrance and 250 per day from the South entrance. The current daily average at the West entrance is 538 snowmobiles each day and at the South 176 each day. Visitation is higher on holidays and weekends
- **Require all snowmobiles to be equipped with 4-stroke engine technology**
- **The average cost of entering the park for you could change (your actual costs might be somewhat higher or lower):**
  - Renting a 4-stroke snowmobile would cost on average $100 per day per person
  - A park entrance fee of $35 per person
- **Snowmobile trails and access in the surrounding National Forest areas would be unchanged.**
- **Expected changes in traffic, road conditions, noise, and level of exhaust fumes as a result of this plan are**:
  - Snowmobile traffic at the most crowded parts of Yellowstone National Park would be reduced from High (800 to 1,500) to Moderate (300 to 600) on a typical Saturday
  - Road conditions on a typical Saturday would generally be bumpy from the West entrance, but smooth from all other entrances
  - Noise levels on a typical Saturday would be reduced from high to moderate
  - Level of exhaust emissions on a typical Saturday would be reduced from very noticeable to noticeable some of your trip

28. If this plan had been in effect this winter season how would your decision to make your *recent trip* to Yellowstone or Grand Teton National Park have been affected? Please check only one.

☐ My visit would not have been different.
☐ I would have stayed *fewer* days. → How many fewer days? _______
☐ I would have stayed *more* days. → How many more days? _______
☐ I would not have visited the park.

29. If this plan were in effect this winter season how would your *total visits* to Yellowstone and Grand Teton National Parks be affected? Please check only one.

☐ No change in total visits.
☐ I would visit *less* often. → I would take ___________fewer annual trips
☐ I would visit *more* often. → I would take ___________more annual trips
☐ I would not visit Yellowstone and Grand Teton National Parks.