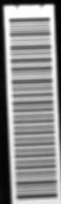




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**Birder Preferences for Attributes of Birding Sites:
A Binary-Choice Experiment**

presented by

Karin M.J. Steffens

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**BIRDER PREFERENCES FOR ATTRIBUTES OF BIRDING SITES:
A BINARY-CHOICE EXPERIMENT**

By

Karin M.J. Steffens

A DISSERTATION

**Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of**

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

1999

ABSTRACT

BIRDER PREFERENCES FOR ATTRIBUTES OF BIRDING SITES: A BINARY-CHOICE EXPERIMENT

By

Karin M.J. Steffens

This research uses a newly developed optimal experimental design for binary-choice experiments to explore birder preferences for selected attributes of birding sites. It also explores how these preferences are related to birder preferences for biodiversity, as measured by seven different biodiversity indicators. Qualitative interviews with birders generated information about birders and their birding activities. This information led to the development of a questionnaire, the selection of birding site attributes to be evaluated by survey respondents, and contributed to the creation of a birder profile.

Study participants, who were members of the American Birding Association (ABA) in Central Michigan were similar in socioeconomic characteristics to ABA birders in general. ABA birders tend to differ, however, from birders more broadly defined.

The birder preference data were analyzed using a binary-choice experiment. The new optimal experimental design differs from a traditional approach with pre-selected attribute levels in that a variable is updated in the process of data collection to try and achieve optimal choice probabilities. The

number of variables in the design solely determines the optimal choice probabilities. This study is the first to show that the model has practical applications. Using D-optimality as a criterion, the "updating" approach of the model is a more efficient design than a traditional approach. The limitations of the model include the trade-off between realism in the choice scenarios and the large differentials in the updating variable that are required for optimality, the potentially high cost of conducting the interviews, and the time and effort involved in implementing the design.

The binary-choice experiment was estimated as a binary-logit model. The model with six attributes of birding sites correctly predicted 64% of the responses and all coefficients were significant. Models with alternative biodiversity-indicators revealed that the biodiversity indicators explained site choice well and all seven indicators were significant.

Tests indicated that the preference model for six site attributes was not equivalent to the biodiversity-indicator models. The user-preference model is preferable. Thus, birders care about the composition of biodiversity but where birder preference information is not available biodiversity measures were a good indicator of birder preferences for birding sites.

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To John, my mother and in memory of my father

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Chapter 1

INTRODUCTION TO THE RESEARCH PROJECT AND OVERVIEW

Purpose of the Study and Justification

This research explores birdwatchers preferences and attitudes about birdwatching in an attempt to understand the value of biodiversity to recreationists.¹ The main goal of this research was to develop procedures for examining the relationship between birder preferences for attributes of birding sites and measures of biodiversity. A secondary goal was to generate a birder profile that highlights some of the main characteristics of birders.

The literature on biodiversity is extensive, reflecting the concern over loss of species as more and more natural areas are converted for development purposes (Polasky et al. 1999). Natural areas are increasingly managed for biodiversity and they are also a source of benefit to outdoor recreationists who enjoy the natural environment for hiking, fishing, camping, and other outdoor activities (Barbier et al. 1994, Pearce 1993, Burton et al. 1992, McNeely 1988, Wilson 1988, Margules and Usher, 1981). Yet very little is known about what it is that recreationists value about the natural areas. If part of the goal of preserving natural areas is to afford recreation opportunities to users, it is important to know just what it is that recreationists value since the management of natural areas can and does alter natural area characteristics. Uninformed management may

¹ The terms 'birder' and 'birding,' rather than 'birdwatcher' and 'birdwatching,' are used in the remainder of the text.

unnecessarily alter characteristics that are highly valued by birders. This research explores birdwatchers' preferences and attitudes about birdwatching in an attempt to understand the value of biodiversity to recreationists.

Objectives

The objectives of this research are summarized as follows.

1. To develop procedures for examining the relationship between birder preferences for selected attributes of birding sites and measures of biodiversity.
2. To compare model efficiency of a new approach to experimental design, an approach based on optimal "updating" (Kanninen, 1998), relative to a traditional experimental design that remains fixed throughout a preference experiment.
3. To develop a birder profile that describes birders in terms of their socio-demographic characteristics and their birding activities.

Research Steps

Data were collected through a survey to address the research objectives. Survey development was a major step in the research process as not much is known about the relationship between birder preferences for attributes of birding sites and biodiversity. To learn about birding activities, qualitative pre-survey interviews were conducted in 1996 and 1997 with birders in the Lansing and Flint areas. The information was used to identify the salient activities of birders

and to develop an understanding of the attributes of site choice that birders care most about. The survey data for this application came from personal interviews that were conducted in 1998 with members of the American Birding Association (ABA) in the Lansing area.

Once relevant attributes of birding sites were identified, a utility-theoretic approach was taken to study the relationship between birders' site choice and site attributes. Under this approach, birders choose a site from alternative sites based on the combination of attributes that provides them with the highest level of utility. Table 1-1 shows a stylized binary-choice scenario. Survey respondents are asked to choose one of the two alternatives given in the choice scenario. Alternatives, A and B, are described by m attributes and distinguished by the attribute levels, the x 's. In this study's choice experiment, respondents evaluated eight choice scenarios with two alternatives each.

Site attributes were previously identified through qualitative research. Attribute levels, the x 's, are typically assigned with experimental designs for all of the attributes, $1 \dots m$, across alternatives, A and B. A recently developed optimal experimental design for binary-choice experiments was applied in this study to assign attribute levels across all alternatives.² The relationship between site choice, a dichotomous variable, and site attributes was then estimated using a logit model. The new approach, the "updating" approach, was compared to a traditional approach to binary choice experiments in terms of their relative design efficiency (Objective 2).

Table 1-1: Binary-Choice Scenario*

Question: Which alternative do you prefer, A or B?		
	Alternative A	Alternative B
Attribute 1	x_1^A	x_1^B
Attribute 2	x_2^A	x_2^B
.	.	.
.	.	.
.	.	.
Attribute m	x_m^A	x_m^B

* Two alternatives described by their attributes (1...m); attribute levels (x^A , x^B) differ across alternatives A and B

The logit model also served to estimate the relationship between site choice and alternative measures of biodiversity. All but one of the biodiversity measures are non-linear combinations of some of the x's that appear in the site-choice experiment. The choice model was estimated using the full set of x's and compared to a choice model based on the biodiversity measures. One of the biodiversity models is nested in the birder preference model. It was tested against the disaggregated model using a nested test. The biodiversity models that are not nested versions of the model for birder preferences of birding sites were compared to the disaggregated birder preference model by conducting a non-nested test. The tests were used to determine whether the two models are equivalent (Objective 1).

Respondents to the survey were asked about their birding activities and their socio-demographic characteristics to generate the birder profile. Qualitative

² Implementation of the new approach requires the levels of one of the attributes to be updated and only the starting values were assigned using the experimental design.

interviews and evidence from the literature served to supplement the survey data for the birder profile (Objective 3).

Organization of Thesis

The remainder of this thesis is organized as follows. Chapter 2 describes the design of the questionnaire as input for a binary-choice experiment of birder preferences and a birder profile.

The utility-theoretic foundation for the binary-choice experiment of birder preferences for attributes of birding sites, the random-utility model, and the binary-choice experiment are explained in chapter 3. The chapter describes the optimal experimental design, recently developed by Kanninen (1998), that was used for this research and compares it to a traditional approach.

Chapter 4 estimates a logit model of birder preferences for six attributes of birding sites: number of warblers, abundance category for warblers, rare or unusual species, number of other species, habitat, and entrance fee. The model is then compared with a model that uses alternative biodiversity indicators as explanatory variable. The biodiversity indicators were: Shannon's H, Simpson, McIntosh, Menhinick, species richness, Margalef, and Berger-Parker.

Important Findings of the Research

This section describes some of the salient findings of the study. These findings are discussed more fully in the body of the thesis. The birder profile revealed that the study population of birders is made up of more male birders

than female birders, tends to be married, middle-aged, has relatively high household incomes, and high levels of education. The study population is similar in socio-demographic characteristics to the general ABA population of birders (ABA 1994).

Within the literature, birders are defined in different ways (McFarlane 1996, Kerlinger 1995b, ABA 1994, Boxall and McFarlane 1993, Butler and Fenton 1986). Birders that include but are not limited to ABA members tend to have less birding expertise, as measured by the number of birds on a lifelist and by their bird identification skills, than do the ABA birders. The study found that male birders did not differ significantly from female birders in selected characteristics. There was a significant difference in the number of species that can be identified by sight without a field guide and their reported birding expertise in their home area. The study found significant differences for groups of different birding expertise in North America in terms of the number of species on a lifelist, the number of species that can be identified by sight, the number of bird books owned, and the farthest distance traveled in the 12 months prior to the survey.

The qualitative research results indicated that birding trips were the most important component of respondents' birding activities. Birders weigh many factors in their decision of which birding site to visit, but bird-related attributes play a prominent role. Bird-related attributes emerged as important characteristics for birding activities and the selection of a birding site.

Comparison of model designs revealed that the “updating” approach resulted in improved statistical efficiency over a traditional approach. The choice model application to estimating birder preferences indicated that there is a trade-off between realism of the choice scenarios and design efficiency. In deciding which approach to use, the time, effort, and cost of tracking the choice probabilities and updating the continuous variable have to be weighed against the gains in efficiency.

The estimation of the binary-logit model revealed that all six attribute coefficients in the birder preference model and all of the biodiversity indicators in the alternative biodiversity models were significant and had the expected sign. No clear preference can be given to any of the seven biodiversity indicators as all of them were significant and explain birders' site choice about equally well.

A nested and non-nested test was conducted to test the hypothesis that the model examining birders' site choice as a function of six site attributes is as close to the true data as the model specifying site choice as a function of biodiversity. The tests revealed that the two models are not equivalent. The test results indicated that the model using six site attributes as explanatory variables are preferable to the model using biodiversity as an explanatory variable. This result confirms evidence from other measures of model fit. Overall the results suggest that the biodiversity indicators used in the study application explain birders' site choice well and are a good indicator of birder preference for birding sites. However, birders care about the composition of birding sites and where birder preference information for individual attributes of birding sites is

available, it is preferable to an aggregate indicator of biodiversity. The aggregate measures used in this research do not fully capture the complex relationship that determines site choice.

Chapter 2

BIRDER PREFERENCES FOR ATTRIBUTES OF BIRDING SERVICES: SURVEY DEVELOPMENT, AND DESCRIPTIVE RESULTS

Introduction

The main goal of this research was to develop a survey-based approach to assess the overlap between birder preferences for site attributes and measures of biodiversity. This chapter reports on the collection of the data on birder preferences for attributes of birding sites. Data was obtained from a questionnaire administered to a small sample of birders. The questionnaire included a sequence of questions that asked individual birders to make pairwise choices among birding sites with different site characteristics. These questions support the choice experiment that was conducted to estimate birder preferences for site attributes and biodiversity (described in chapter 3). The questionnaire also contained questions regarding the personal characteristics and experience of the respondent to provide data for the birder profile, a secondary goal of this research (characterized below).

This chapter describes the questionnaire, the methods used to develop and administer the questionnaire, and a descriptive profile of the birders included in the sample. The first subsection explains how the survey questionnaire was developed from pre-survey qualitative interviews to pretesting of the questionnaire. The second subsection details the structure of the

questionnaire, and the third subsection describes the sample population. The description of birders in the birder profile concludes the chapter.

Survey

Survey Development

In the fall of 1996 and 1997, qualitative interviews were conducted with 20 individual birders. The interviews drew on open-ended ethnographic questions and closed-ended survey-type questions (Fetterman 1998, Sudman et al. 1996, Johnston et al. 1995, Weiss 1994, Spradley 1979). Participant responses revealed the terms and concepts birders use when talking about their birding activities and helped to determine what is important to birders when they pursue their birding activities. The interviews generated information for the birder profile and provided a list of attributes to be used in the binary-choice experiment. Bird-related characteristics were mentioned by the majority of respondents as positive characteristics of birding activities and birding sites.

The questionnaire was pretested to ensure that survey questions consistently produce answers that provide comparable information across the sample and answers generate reliable and valid measures of the question objectives (Fowler Jr. 1995, Mitchell and Carson 1989). The pretesting took place in several stages. The survey questions were tested for wording and understanding as well as clarity in its lay-out, its visual appeal and ease with which respondents could follow the flow of questions (Sudman et al. 1996,

Fowler Jr. 1995). Twenty-one birders were asked to test the choice scenarios. Responses to willingness-to-pay questions were used to set starting values for the entrance fee attribute (see Table 1-1 for a stylized choice scenario, setting of the other attribute levels is described in Chapter 4).

Structure of Questionnaire

The full text of the questionnaire is listed in Appendix A. The questionnaire contained four data collection sections. The first section obtained data on respondents' birding activities. Respondents were asked about their birding trips, birding skills, birdlists, and participation in birding activities. The information was used for the birder profile.

The second section elicited data for the choice experiment. Respondents were provided with detailed information, including definitions, (in writing and orally) about the choice experiment. Qualitative interviews had revealed the importance of bird-related attributes of birding sites. The bird-related variables selected for the choice experiment were: number of warblers, abundance of warblers, rare or unusual species, and other species. Diversity of habitat was included as a variable to test for an effect on site choice independent of bird diversity. An entrance fee served as a payment vehicle. Several feedback questions were asked to learn how familiar respondents were with the choice setting and to give them an opportunity to ask clarification questions. Most of the information served to draw up a consistent choice setting for all respondents

(Sudman et al. 1996, Fowler Jr. 1995). The table with equivalent terms was included in the information sheet to be able to model site choice as a function of biodiversity measures (see Chapter 4). The choice experiment itself consisted of eight different choice scenarios that were administered in random order (see Chapter 3 for a detailed description of the choice experiment).

In the third section, respondents were asked to indicate how important the six selected site attributes were in their choice of a birding site. This information and importance ratings of listed statements about a variety of considerations for birding served as a check of survey respondents' priorities in birding against pre-survey data. The importance ratings of listed statements and questions about respondents' socioeconomic characteristics were self-administered by the respondents. The socioeconomic information became part of the birder profile.

The questionnaire concluded with a set of debriefing questions and interviewer observations. These responses were not analyzed statistically but served to give the researcher some feedback as to respondents' degree of familiarity with the terminology used, degree of perceived difficulty of the site choices, and their level of experience with entrance fees for birding.

Sample

Respondents were selected from a list of 85 ABA members in regions 488 and 489 in Michigan. The regions were selected because of their proximity to the Michigan State University campus in East Lansing. The area extends from South

of Clare to North of Jackson and East of Grand Rapids to West of Saginaw and is referred to below as the central Michigan sample (CMS). The ABA list was used since ABA members were thought to be experienced birders with a good understanding of site characteristics (Butcher 1995). The sample size was kept small in order to keep interview costs to a minimum while assuring adequate quality control.

The ABA list provided addresses for 85 members. These 85 potential respondents were sent a contact letter on official University letterhead (von Kammen and Stouthamer-Loeber 1998, Salant and Dillman 1994, Dillman 1977). This letter contained information on the objectives of the study, why the potential participant was selected, and how his or her name was obtained. The letter mentioned that the researcher would follow up with a telephone call to set up a time for an interview. The approximate length of the interview was also indicated. The contact letter included a written endorsement from the ABA in order to increase the likelihood that potential respondents would participate and to reduce any fears associated with admitting a stranger to their home or workplace.

Of the 85 birders that were contacted by letter, 12 respondents could not be interviewed because either the contact letter was not deliverable, the person had moved outside the study area, or an interview could not be successfully scheduled during the interviewing phase. Three respondents refused to be interviewed when they were contacted by telephone. Sixty personal interviews

were conducted to yield a response rate of 82%. Two interviews were not usable for the choice experiment because of item non-response.

Birder Profile

Socioeconomic Characteristics

Table 2-2 reports the results of the socioeconomic characteristics of the study population (CMS) and provides results from other birding studies for comparison. Seventy percent of the birders in the CMS were male. The median birder age was between 50 and 59 years old. This was the median age category for male as well as female birders. Thirty-five percent of the CMS birders were retired. Most birders were married and 46 percent indicated that a family member was a birding partner with whom they birded most of the time in the past 12 months. The birders tended to be highly educated, with 80 to 85 percent holding a Bachelor's degree or higher. Generally speaking, the male birders had somewhat higher levels of education than female birders, for example, 31 percent of male respondents in the CMS held a doctoral degree as compared to six percent of female respondents. Approximately 50 percent of surveyed birder households had annual incomes of \$60,000 or more in 1997.

Table 2-2: Socioeconomic Characteristics (N= number of observations)

	CMS N=60	ABA (1994) N=1026	Boxall/ McFarlane (1993) N=508	McFarlane (1994) N=787	Butler/ Fenton (1986) N=1005	Kellert* (1985) N=79	Kim et al. (1997) N=517	Wiedner/ Kerlinger (1990) N=1033
Gender:								
Female	30%	35%	47-61%	about 50%	47%	27%	77%	37%
Male	70%	65%	39-53%	about 50%	53%	73%	23%	63%
Marital Status:								
Married	75%	71%...					73%	
Single	25%	22%					27%	
Age:								
mean	50-59	53		51		42		47
< 20	0%	0%						
20-29	3%	3%						
30-39	7%	13%						
40-49	23%	26%	≥ 45: 42-56%				> 45	70%
50-59	33%	26%						
60-69	15%	19%						
> 69	18%	12%						
Education level:								
Bachelor's	30%	37%			30%			
Master's	32%	25%			14%			
Doctorate	23%	18%			16%			
≥ Bachelor's	85%	80%	34-36%	> 70%	60%	nearly 66%	> 50%	74%
Income:			(CDN)\$ ('000) ≥ \$60:29-45%	(CDN)\$ ('000) ≥ \$60>30%		higher than non-birders	('000) >\$50	(excl. students) ('000) mean: \$25-35 <\$25 41% \$25-\$50 43% >\$50 16%
< \$20,000	4%	< \$10:						
\$20,000-39,999	20%	\$10-29:						
\$40,000-59,999	20%	\$30-49:						
\$60,000-79,999	24%	\$50-69:						
\$80,000-99,999	20%	\$70-89:						
\$100,000-120,000	8%	\$90-110:						
> \$120,000	6%	> \$110:						

* Data apply only to committed birdwatchers (those able to identify more than 40 bird species).

** Christmas Bird Count participants range for Calgary, previous Edmonton, and new Edmonton recruits.

... 7% identified themselves as "unmarried, in a serious relationship".

Birding

Comparisons of research results from the CMS and the ABA membership survey with results from studies in which a sample of birders was drawn from a larger population reveal that ABA birders differ from birders more broadly defined (Table 2-4). Kim et al. (1997) found that ABA birders have more personal and behavioral investments associated with birding than do visitors to a bird festival.

The average ABA birder has birded for over 20 years, mostly by himself or herself but also with friends or family. Surveys that sampled birders from a wider birder population found that the average number of years of experience ranged from 5-28 years, depending on the level of birding expertise (Boxall and McFarlane 1993). Seventy eight percent of visitors to Pt. Pelee National Park, Ontario, had been birding for five years or more and the average visitor had been birding for 14 years (Butler and Fenton 1986). Most CMS respondents (95%) kept a lifelist (Wauer [1991] reports 98%). Eighty seven percent of respondents kept a list of birds they had ever seen anywhere (Wauer [1991] world list: 40%). Regarding specific locational lists, 53% of respondents recorded birds seen in the United States, and the same percentage kept lists for their backyard, 48% of respondents (Wauer [1991]: 57%) had an ABA area list (which essentially covers North America). A large percentage (60%) of respondents kept a daylist where they recorded the bird species they had seen in the course of a day of birding.

CMS participants took an average of 33 daytrips in the 12 months preceding the survey. Sixty percent of respondents typically take birding vacations 2-3 times per year. The average number of bird books owned was 61. But 50% of respondents owned more than 34 bird books. This high average figure was biased by the large number of books owned by one of the respondents. The mean number of subscriptions held by respondents was 2.8. This is slightly higher than the mean of 2.3 subscriptions held by advanced birders in McFarlane's (1996) sample. 95% of the CMS respondents kept a lifelist with a total of 590 species entered on average on a respondent's lifelist. This number is higher than the median number of species on a lifelist (435) because of the very high number given by some respondents. Only 21% of respondents in McFarlane's sample (1999) kept a lifelist. The mean number of species on the lifelist across her sample was 48 but it was 363 for advanced birders (McFarlane 1996).

The average CMS respondent was able to identify 305 species by sight without the use of a field guide. The median number of species was 254. Eighty percent of respondents (75% of ABA birders) identified some or most birds by song or call. In the qualitative interviews, several birders said that they had hearing problems and therefore did not rely on sound for bird identification. Other birders may not rely on sound because 'they are still developing that identification skill.'

Birders differ by their bird identification skills. Boxall and McFarlane (1993) found that identification skills increased with the level of birding expertise.

They concluded that self-reported skills are a reasonable measure of birding expertise. Their finding contrasts with research findings from a study of appreciative wildlife users at Brigantine National Wildlife Refuge. Applegate et al. (1982) found that visitor groups had a poor ability to judge their own birding competence. A comparison of birding expertise determined by cluster analysis (McFarlane 1996) self-rated expertise for the entire sample (McFarlane 1999) and self-rated expertise for a split subsample (Boxall and McFarlane 1993) reveals that there are large differences between the percentages for casual, intermediate and advanced categories (Table 2-3). The samples were not identical. Boxall and McFarlane (1993) birders were limited to Christmas Bird Count participants and McFarlane (1996 and 1999) included members of natural history societies.

Table 2-3: Comparison of Birding Expertise

	McFarlane 1996 (787) Grouping by cluster analysis	McFarlane 1999 (787) Self-rated	Boxall/McFarlane* 1993 (508) Self-rated split sample
casual	43%	9%	0-8%
novice	38%	40%	28-49%
intermediate	12%	45%	34-51%
advanced	7%	6%	9-22%

* Sample was split by region. Definitions: casual = rarely watches birds and is not really interested; novice = interested beginner who wants to learn more; intermediate and advanced were not defined

The CMS data on birding skills reveal that more birders consider themselves advanced or expert birders in their home area (67%) than in North America (37%) (Table 2-4). This observation is also true for ABA birders in general. The self-reported skill levels are similar across the different categories

for CMS respondents and ABA birders, indicating that ABA birders participating in the CMS are not very different from ABA birders in the rest of the country in terms of their self-reported birding skill levels. Noticeable differences appear in the comparison of the CMS and the ABA survey (ABA 1994) with McFarlane's survey (McFarlane 1996) (Table 2-4). McFarlane used cluster analysis on past experience, centrality-to-lifestyle, and economic commitment variables to derive four distinct categories labeled casual, novice, intermediate, and advanced birders. In Table 2-3, the self-reported birding expertise elicited in her survey is reported next to the data derived from the cluster analysis (McFarlane 1999). Her sample of Alberta (Canada) birdwatchers is drawn from a heterogeneous birder population, members of natural history societies, a bird observatory, a birdwatching club, and participants in the Edmonton Christmas bird count (45% of CMS respondents had participated in a bird count or survey such as the Christmas bird count, 20% of ABA respondents were involved in bird research [Wauer 1991]). The smaller percentage of advanced birdwatchers suggests that the ABA attracts more highly skilled birders rather than the broad range of individuals who are interested in observing birds in the wild (Table 2-4).

Qualitative results failed to show a clear relationship between the number of years a respondent had been birding and the number of species he or she had on the lifelist. A comparison of means test confirmed the finding for the CMS participants. The hypothesis that the mean number of species on the lifelist is the same for birders with 21 years or more of birding experience and those with less than 21 years of birding experience could not be rejected.

Table 2-4: Birding Characteristics (N=number of observations)

	CMS N=60	ABA 1994 N=1026	McFarlane 1996 N=787
No. years birding	mean: 25 > 21: 50%	mean: 22	
No. daytrips in 12 months	mean: 33 > 19: 50%		days birding: mean: 16 advanced: mean: 95
No. bird vacations	> 2-3 times per year: 60%	> 2-3 times per year: 55%	
No. bird books	mean: 61 > 34: 50%		
No. subscriptions	mean: 2.8 > 2: 50%		advanced: mean: 2.3
No. birds on lifelist	mean: 590 > 435: 50%		mean: 48 advanced: mean: 363
ID by sight	mean: 305 > 254: 50%		
ID by sound:			
Don't use sound at all	5%		
Follow sound for visual ID	15%	2%	
ID some birds by song/call	60%	24%	
ID most birds by song/call	20%	54%	
Birding skill:		21%	
Home area: beginning	0%	4%	
intermediate	33%	31%	
advanced	50%	50%	
expert	17%	15%	
North America:			
beginning/novice	5%	13%	cluster anal. self-report *
intermediate	58%	48%	38% 40%
advanced	32%	35%	12% 45
expert	5%	4%	7% 6% casual: 43% casual: 9%

* data based on McFarlane oral communication 06-28-1999.

Differences in birding experience between men and women have been noted in the literature (McFarlane 1994, ABA 1994). Women rated their bird identification skills lower than men (CMS, ABA 1994). Of the women in the CMS, 44% rated themselves as advanced and 6% as expert birders in their home area compared with 52% and 21%, respectively, of the men.

For North America the percentages for women were 17% advanced, 0% expert; the percentages for men were 38% advanced and 7% expert birder. On average, female birders could identify 193 bird species without using a field guide, whereas male birders reported 354 species. More women (44.4%) than men (16.7%) selected the categories "Don't use sound at all" or "Follow sound for visual identification" when asked how much they rely on sound when birding. McFarlane (1994) found that women, who made up approximately 50% of her sample, accounted for 60% of casual birders, but only 37% of advanced birders. But the average female birder had birded for fewer years than had the average male birder, 22 years as opposed to 26 years (CMS). This is confirmed by McFarlane (1994), 46% of women had 10 years or less of birding experience as compared with 36% of men, and 60% of respondents with 5 years or less of experience were women. Female Michigan birders had also birded on fewer occasions in a 12 months period (21 daytrips) than had the men (38 daytrips) (CMS).

A comparison of means test (Table 2-5) shows that there is a significant difference in means between female and male birders only for the number of

birds that can be identified by the respondent without the use of a field guide and self-reported level of expertise in the home area.

Table 2-5: Comparison of Means between Female and Male Birders

	t-test for Equality of Means		
	t	Sig. (2-tailed)	Mean Difference
No. on lifelist	-1.867	.068	-273.79
Years birding	-1.142	.259	-4.37
No. daytrips	-1.613	.113	-16.41
No. books	-1.304	.198	-21.12
No. subscriptions	-1.036	.308	-.46
ID by sight	-4.933	.000	-160.82
Expertise home	-2.197	.034	-.40
Expertise North America	-1.963	.055	-.29
ID by sound	-1.808	.082	-.40

Kellert (1985) found that there was a difference between committed birdwatchers and casual birdwatchers in their primary reason for birdwatching. The groups of birdwatchers were defined according to their level of birding experience as measured by the number of bird species a birder could identify without a field guide. Committed birdwatchers were defined as birdwatchers who could identify 40 bird species or more, and casual birdwatchers as birdwatchers who could identify 10 bird species or fewer. Committed birdwatchers were primarily motivated by their personal fascination with birds, while casual birdwatchers cited aesthetics as their main motivation for birdwatching.

These findings suggest that experience affects birder motivations for birding. Assuming that there is a link between motivation and preferences,

Kellert's results indicate that experience may explain preferences for certain attributes of birding services.

Comparison of means analysis using independent sample t-tests for the CMS data showed that there was a significant difference between birders with different self-reported birding skill levels (beginning birders were grouped with intermediate birders and advanced birders were grouped with expert birders) in the number of species on a birder's lifelist, the number of birds that can be identified by sight, the number of bird books owned, and the farthest distance traveled in the 12 months prior to the survey. Not significant were the number of daytrips in the previous 12 months, the farthest distance ever traveled for birding, the categories for sound identification (Table 2-4), and the number of bird magazine subscriptions.

Advanced birders were found to have a primary achievement motivation, causal birders were primarily motivated by appreciative experiences, novice and intermediate birders had a primary conservation orientation (McFarlane 1994). McFarlane (1994) suggests that wildlife management programs could be designed to meet the needs of the different specialization levels. If primary motivations are indicative of preferences, McFarlane's findings suggest that birder specialization affects preferences.

Questions in the CMS asked birders to rate a number of considerations on a scale from 1 to 7 by importance for their birding activities. None of the categories showed any significant differences for beginning and intermediate birders on the one hand and advanced and expert birders on the other in the

Table 2-6: Birding Partner

	CMS (birded most in past 12 months) (60)	ABA 1994 (travel in US and Canada) (986, 1217 resp)	McFarlane 1996 (social group relating to current birding) (787)	Butler/Fenton 1986 (visit Pt. Pelee)
Birding partner:				
by yourself				
with knowledgeable birder	63%	alone or w/ family or friends: 75%	69%	
with friend(s)	35%			
with family member(s)	48%		43%	37%
with fellow bird club member	47%		61%	39%
with birding club	8%			
	15%	w/ organized tour: 18%	24% (organized club)	

comparison of means analysis. The findings from the CMS may be interpreted to mean that ABA birders are a more homogenous group of birders than are birders as defined by Kellert (1985) and McFarlane (1994). They thus do not show significant differences in responses that can be regarded as representing different motivations for birding.

Table 2-6 indicates that most birders go birding by themselves. When they go with others it is mostly with family or friends. Similar results have been found in other studies.

When respondents were asked in the qualitative interviews about the positive characteristics of birding experiences, most mentioned seeing a new bird species, followed by unusual or rare species and many species. These three characteristics also ranked among the 5 most important considerations for birding in the CMS. Survey respondents were asked to rate possible considerations for their birding activities by the level of importance on a scale from 1 to 7. Table 2-7 lists the considerations and the mean score in order of importance from the highest to the lowest level. The highest mean score was assigned to "getting outdoors for a chance to enjoy the natural environment." "Being outdoors, appreciating nature" was the most important reason for participating in the Christmas Bird Count for 20% of surveyed participants (Boxall and McFarlane 1993). CMS ABA birders also rank "seeing of new bird species," "the study of birds in their natural habitat," "seeing rare bird species,, and "seeing many different species" very highly. Sixty one percent of visitors to Pt. Pelee National Park indicated that what they liked most about birding at the

Park was "the variety and number of bird species" (Butler and Fenton 1986: 7). Least important for CMS participants was "competing with other birdwatchers." Twenty two percent of respondents indicated that they had participated in a competitive birding event.

Forty percent of survey respondents (Wauer 1991 reports 41%) had served as a guide for birding field trips. This is one way to "help others develop their birdwatching skills," which was ranked 10th among the list of important considerations for birding with a mean score of 4.5 out of 7.

Table 2-7: Considerations for Birding Ranked by Importance

Rank	How important are the following considerations for my birding:	N	Mean
1	to get outdoors for a chance to enjoy the natural environment	60	6.50
2	to see new bird species	60	5.97
3	to study birds in their natural habitat	60	5.82
4	to see rare bird species	60	5.80
5	to see many different species of birds	60	5.75
6	to contribute to the conservation of birds	60	5.48
7	to challenge my birdwatching abilities	60	5.25
8	to add species to a list	60	4.90
9	to get away from everyday problems	60	4.65
10	to help others develop their birdwatching skills	60	4.53
11	to contribute to society's general knowledge and understanding of birds	60	4.17
12	the social interactions with others	59	4.14
13	to be with family or relatives	59	3.59
14	to photograph, draw, or paint birds in their natural habitat	60	2.68
15	to compete with other birdwatchers	60	2.12

Birders are typically very involved in birding and/or conservation, as the number of memberships in birding or conservation organizations indicates. On average, CMS respondents belong to 5.6 such organizations. Besides membership in the American Birding Association, 70% of respondents were members of The Nature Conservancy and 52% were members of Michigan Audubon Society, National Audubon Society, and Whitefish Point Bird Observatory. Sixty percent of Pt. Pelee visitors were members of at least one birding club (Butler and Fenton 1986).

Summary and Conclusion

The binary-choice experiment of birders' site choice, described in Chapter 3, is based on an experimental design with six variables. The present chapter described how the variables were selected using qualitative interviews with birders and how they were related to biodiversity measures. Survey data was analyzed to yield a birder profile, which was supplemented and compared with information from the qualitative interviews and the literature.

For the birders that participated in the qualitative interviews, bird-related factors were the most important determinants of birding activities. An entrance fee was selected as the payment vehicle rather than travel costs in order to avoid having to account for differences in gas mileage of vehicles and types of accommodation. Other payment vehicles, such as contribution for bird habitat, were considered but rejected because birders' conservation concerns and birding activities involved different bird-related considerations. For

environmental conservation contributions see Yen et al. (1996), for bird conservation see McFarlane and Boxall (1996). Abundance categories for bird species were used to help make the connection between the bird-related variables and biodiversity measures. Habitat was included as a variable to determine whether it has an effect on birders' site choice that is distinct from the effect of bird species.

The study revealed a birder profile that shows that birders tend to be married, middle-aged, somewhat more likely to be male than female, well-educated, and from a household with relatively high income. Other birder profiles confirm this general picture. Most birders bird mostly by themselves but many will also go birding with family or friends. Comparisons with other studies reveal that ABA birders tend to be more knowledgeable about birds and more involved in birding than are birders more broadly defined. The average number of species on an ABA birder's lifelist was 590. Eighty percent of respondents identified some or most birds by song or call and the average number of species a birder was able to identify without a field guide was 305. Most birders consider themselves advanced in their home area and intermediate for North America. While there are differences between male and female birders in birding expertise, the only significant differences are that the average female birder can identify fewer species without a field guide and has a lower self-reported level of expertise in the home area than the average male birder. Most ABA birders keep at least one life-list, typically a list of all the birds they have ever seen.

The average birder had been birding for 25 years, took 33 daytrips in a 12-months period, and went on birding vacations more 2-3 times per year. In terms of birder involvement in birding, the average birder belonged to 5.6 bird or conservation organizations, owned 61 bird books, and had 2.8 bird magazine subscriptions.

Female and male birders differed significantly only in terms of the number of species that could be identified without a field guide and by self-reported level of expertise in the home area. Beginning and intermediate birders differed significantly from advanced and expert birders in the number of species they had on their lifelist, the number of birds they can identify without a field guide, the number of bird books they own and the farthest distance they had traveled for birding in the previous 12 months. They did not differ significantly in terms of the average importance rating of a variety of considerations for birding, suggesting that the ABA birders do not differ significantly in terms of their motivation for birding.

Chapter 3

OPTIMAL EXPERIMENTAL DESIGN FOR BINARY-CHOICE EXPERIMENTS

Introduction

Valuing the attributes of non-market goods and services, rather than the goods and services themselves, is becoming an increasingly popular valuation method (Adamowicz et al. 1998, Freeman 1991). A valuation method that can be used for attribute valuation is that of choice experiments. In a choice experiment, respondents are presented with well-articulated attribute descriptions of two or more sites or programs and are then asked which they prefer. In a binary-choice experiment a scenario is presented to respondents which contains information on attributes of a pair of sites or programs (Table 1-1). Each site or program which is part of a scenario is called an 'alternative'. The alternatives differ by the levels of at least one attribute. The question arises with this method as to how to construct the choice scenario such that the respondents' preferences for attributes can be accurately modeled. This chapter compares a recently developed experimental design for binary choice experiments in terms of its efficiency with a traditional approach.

Experimental designs have been used extensively in areas such as product marketing (Lazari and Anderson 1994, Kuhfeld et al. 1994, Louviere and Woodworth 1986) and transportation (Hensher, 1994). However, much of the existing knowledge generated by this research was based on empirical models

that have a continuous dependent variable. Design plans for these types of models are available in the literature (Addelman 1962, Plackett and Burman 1946, Montgomery 1991). Rubey and Lupi (1997) provide an example of a discrete choice model application using an orthogonal design. Because probabilistic choice models, such as the binary-choice model, have a discrete dependent variable such design plans may not be efficient in model estimation (Kanninen 1998, Zwerina et al. 1996).

In a traditional approach to choice experiments, the researcher pre-selects the attributes to be valued and the levels of attributes to be presented to survey respondents (see, for example, Rae 1985). Attributes and their levels can be combined in a random combination scheme or more typically involve the use of a design plan. The experimental design literature offers several methods for combining the pre-selected attributes and attribute levels (Addelman 1962, Plackett and Burman 1946, Abdelbasit and Plackett 1983, Montgomery 1991). Alternative combinations can be created, for example, from the full factorial combination of each of the levels of each attribute. However, as the number of attributes and attribute levels increases, this approach quickly results in a very large number of alternatives. Another approach is a fractional factorial design. This approach uses only a subset of possible combinations of attribute levels and thus limits the number of alternatives. Often orthogonal main-effects plans are used. Orthogonal main-effect plans allow estimation of only the direct effects of variables and ensure that the variables are independent (orthogonal). These plans are applicable when the interaction effects between variables are

expected to be negligible (Addelman 1962). Orthogonal main-effects plans for many different model specifications are available (Addelman 1962, Plackett and Burman 1946, Montgomery 1991).

A traditional binary-choice experiment pre-selects both the number of attribute levels and the attribute levels themselves prior to the design stage (by using pretest results, for example). A design plan, e.g. an orthogonal main-effects plan, may be used as a basis for combining attribute levels or as Zwerina et al. (1996) show an efficient design may be generated using an anticipated parameter vector. Data are collected without changes in attribute levels during data collection. Respondents' actual choices between alternative 1 and alternative 2 provide the final response probabilities. Model efficiency depends on how accurately variable coefficients can be anticipated (e.g. through pre-testing).

The traditional approach contrasts with Kanninen's (1998) optimal experimental design for binary choice experiments. Kanninen's model takes into account a discrete dependent variable and develops criteria for determining the efficiency of the design. Unlike the traditional approach, this approach allows the number of attribute levels and the attribute levels themselves to be part of the design by making them explicit design parameters.

To try and achieve optimality empirically, all variables but one are set at their upper and lower boundaries and the remaining variable, which must be a continuous variable, is sequentially updated during data collection in order to approach the optimal choice probabilities. The number of attributes included in

the design determines the optimal response probabilities for the scenario alternatives. Model efficiency depends on how quickly and how closely the optimal response categories can be approximated.

In this study, bird-watchers' preferences for selected attributes of birding sites provide the application of an optimal binary-choice model design. Kanninen (1998) developed theoretical criteria for an optimal experimental design in the case of a binary-choice setting. The empirical model that is estimated with the data uses sequential updating to approach the theoretical level of model efficiency. Sequential updating requires the collection of data in multiple stages and the upward or downward adjustment of, in this case, one variable in order to approach theoretical efficiency. The goal of this research is to determine whether the theoretical model is practically applicable and whether gains in efficiency are possible relative to a traditional approach. The traditional approach is based on a pre-specified number of levels of attributes and pre-specified values for attribute levels. Data collection is then typically conducted in a single stage. Model efficiency is compared using the criterion of D-optimality. D-optimality is discussed in a later section of this chapter.

The research results show that, as expected, the updated design approximates theoretical design efficiency more closely than a traditional model. The application also points to trade-offs between increases in design efficiency and realism in the choice scenarios. The study application shows that Kanninen's optimal experimental design yields a higher level of efficiency than a traditional approach when little information is available about the unknown

parameters. Ultimately, a researcher who is faced with the decision on whether to adopt a traditional approach or the Kanninen approach must decide whether possible efficiency gains are worth the time and effort that is required for the multiple stages in updating of the continuous variable.

The remainder of the chapter contains sections on experimental design, the theoretical and updated models, research application and findings, and the summary and conclusion. The experimental design section reviews optimal experimental designs in general and with specific reference to the Kanninen approach. The theoretical section contains a description of the random-utility model which forms the theoretical basis for this research. The section on the empirical model describes the specification of a binary-logit model to estimate the relationship between birders' site choice and site attributes. The application explains how the model was applied to birders' preferences for attributes of birding sites. The study findings describe the research results and the chapter concludes with a summary and conclusion section.

Optimal Experimental Design

An optimal experimental design maximizes the statistical information that can be obtained from the data on the basis of design criteria. An experimental design that minimizes the covariance matrix will require fewer observations than would be necessary in the absence of design criteria. Optimal designs are therefore of special interest to researchers who are trying to estimate models with small sample sets.

Standard optimality measures are “A-efficiency” and “D-efficiency” (or D-optimality”)(e.g. Zwerina et al. 1996, Alberini 1995, Kuhfeld et al. 1994). Both measures can be derived from the covariance matrix. A-efficiency minimizes the average variance of the parameter estimates. A-efficiency has the drawback that its measure changes with recodings of the design matrix (Zwerina et al. 1996). D-optimality is achieved by maximizing the determinant of the Fisher information matrix³ (Kanninen 1998).

D-optimality has become a commonly used design criterion (Kanninen 1998, Zwerina et al. 1996, Kuhfeld et al. 1994, Alberini, 1995) and may be generated by using computer-based algorithms (Zwerina et al. 1996, Cook and Nachtsheim 1980). Kanninen (1998) analytically developed the requirements for D-optimality of binary-choice experiments.⁴ Unlike other approaches, the number of attribute levels as well as the levels themselves are part of the design.

Kanninen’s solution for a D-optimal design depends only on the number of attributes included in the design. Once the number of attributes has been selected, maximization of the determinant of the Fisher information matrix will yield the choice probabilities necessary for D-optimality (Kanninen 1998).

D-optimality for binary-choice models with a binary logit specification and negligible interaction effects requires only that all attributes but one be set at their extreme values following an orthogonal main-effects plan. The number of attributes determines the necessary choice probabilities to meet design

³ The Fisher information matrix inverted and its sign reversed yields the covariance matrix for the maximum likelihood estimators.

⁴ Zwerina et al. (1996) generate D-optimal designs by minimizing D-error using an algorithm.

efficiency. Attribute levels of the updating or balancing variable, the variable whose levels were not set by the main-effects plan, are selected to obtain the required choice probabilities. The design-balancing variable must therefore be a continuous variable and Kanninen (1998 p. 4) suggests that price "should be able to take any value that some portion of the experimental respondents might consider reasonable for a particular choice being offered".

The conditions Kanninen derived for D-optimality in a binary-choice experiment require a researcher to determine the upper and lower bounds for attribute levels to be included in the experimental design and the continuous variable that must be sequentially updated in the course of data collection to try and attain the choice probabilities that achieve theoretical D-optimality.

Random-Utility Model

The random-utility model forms the utility-theoretic underpinning for the research application. The random-utility model is a model that emphasizes the choice among a set of alternative bundles of attributes for a single choice occasion. In the context of recreational site choice, the model is particularly suitable when individuals choose between sites with different attribute levels (Bockstael et al. 1991). Thus, it is possible to model resource users' site choice as a function of the differences in site attribute levels.

An indirect utility function, V , for a resource user j choosing site A can be defined as:

$$V_j(Q_j, M_j - P_j)$$

where:

Q_A = a vector of specific attributes of birding sites

P_A = the cost associated with visiting site A

M_j = income of user j

All terms of the utility function that do not vary across scenarios do not influence the individual's choice between alternatives and are therefore not part of the consumer's choice calculation when the utility function is linear in the parameters. M_j therefore, drops out of the model. In the application presented below, all costs except the entrance fee for visiting possible birding sites are assumed to be equal across alternative sites and the difference in cost of visiting, $P_A - P_B$ is therefore equal to the difference in entrance fees between site A and site B as faced by individual j. For the remainder of this chapter the entrance fee will be folded into the site attributes and thus P_A and P_B will become part of the vector Q_A and Q_B .

In the random-utility model, it is assumed that an individual selects the alternative that maximizes his or her utility. Thus, in a binary-choice setting, when a resource user faces the decision of which site to visit from a set of two possible alternatives, a constrained utility-maximizing resource user chooses the site that gives the higher level of utility. Individual j will choose site A over site B if:

$V_A(Q_A)$ exceeds $V_B(Q_B)$.

An error term, ε_j , is added to the model for estimation purposes. Individual j will then choose site A if:

$$V_A(Q_A) + \varepsilon_A > V_B(Q_B) + \varepsilon_B. \quad \text{Equation 1}$$

The probability of individual j choosing site A can be expressed as:

$$P(A) = P\{V_A(Q_A) + \varepsilon_A > V_B(Q_B) + \varepsilon_B\}. \quad \text{Equation 2}$$

The empirical model described in the next section translates the theoretical model above into a model one can estimate econometrically.

Empirical Model⁵

The model is estimated using a binomial logit model specification for a linear utility function. The utility function is assumed to have random errors with an extreme value distribution. Following these assumptions, the probability of respondent j choosing alternative A is given by:

$$P(A_j) = P_j = \frac{\text{Exp}(\theta_j)}{1 + \text{Exp}(\theta_j)} \quad \text{Equation 3}$$

Typically, it is assumed that the vector of attributes of the birding sites, Q , enter the utility function linearly and thus:

$$\theta_j = \beta_1(q_{1j}^A - q_{1j}^B) + \beta_2(q_{2j}^A - q_{2j}^B) + \dots + \beta_m(q_{mj}^A - q_{mj}^B) \quad \text{Equation 4}$$

$(q_{mj}^A - q_{mj}^B)$ represents the difference in the level of site attribute m between site A and site B faced by respondent j .

⁵ The notation and much of the exposition in this section follows Kanninen (1998).

The model is estimated by maximizing the log-likelihood function:

$$\ln L = \sum_{j=1}^n y_j \ln P(A_j) + (1 - y_j) \ln(1 - P(A_j)) \quad \text{Equation 5}$$

$y_j = 1$ when respondent j prefers site A and $=0$ otherwise.

D-optimality is achieved by maximizing the determinant of the Fisher information matrix. The resulting value will be referred to as the "D-optimality score" in the remainder of the chapter. The Fisher information matrix is:

$$I = \begin{pmatrix} \sum w_j & \sum w_j x_{1j} & \cdots & \sum w_j x_{mj} \\ & \sum w_j x_{1j}^2 & \cdots & \sum w_j x_{1j} x_{mj} \\ \cdot & & \ddots & \vdots \\ & & & \sum w_j x_{mj}^2 \end{pmatrix} \quad \text{Equation 6}$$

where:

$$w_j = P_j(1 - P_j), \quad x_{ij} = q_{ij}^A - q_{ij}^B. \quad \text{Equation 7}$$

The determinant of the information matrix is then computed as:

$$\text{Det}(I) = \sum_{i=1}^n \sum_{j=i+1}^n \cdots \sum_{k=i+1}^n \sum_{l=k+1}^n w_i w_j \cdots w_k |X_{i,j,\dots,k}^* X_{i,j,\dots,k}^{*'}| \quad \text{Equation 8}$$

The summation covers all combinations, $i \dots k$, of the total observations, n , and

$X_{i,j,\dots,k}^*$ is a matrix of those combinations of observations.

Kanninen (1998) has demonstrated that this can be rewritten as:

$$\text{Det}(I) = \left(\frac{1}{\beta_1 \beta_2 \cdots \beta_m} \right)^2 \sum_{i=1}^n \sum_{j=i+1}^n \cdots \sum_{k=i+1}^n \sum_{l=k+1}^n w_i w_j \cdots w_k |\Theta_{i,j,\dots,k}^* \Theta_{i,j,\dots,k}^{*'}| \quad \text{Equation 9}$$

$\theta_1 = \alpha_1 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_m x_m$, $\theta_j = \beta_j x_j$ for $j = 2, \dots, m$, and $\theta_{m+1} = 1$.

Θ^* is a matrix composed of combinations of observations on the θ 's.

Equation 10 must be maximized to achieve the optimal solution. In this expression, the determinant alone would be maximized when the θ 's take on extreme values. Since the empirical model is based on attribute level differences and an underlying utility function that is linear, these differences should be as large as possible. This can be achieved by choosing the opposite extreme values for the attribute levels in the choice scenarios according to a 2^m orthogonal main-effects experimental design plan. Maximization of $P_j(1 - P_j)$ alone would require P_j to be equal to 0.5. Thus the maximization must find a balance between these opposing forces. The solution can be derived mathematically and depends on the number of attributes used. (Kanninen 1998)

There are similarities between the maximization solution and the 2^m orthogonal fractional factorial experimental designs. For all but one of the attributes, the standard experimental design plan can be used to set attribute levels at their extreme values. Experimental design plans may use different notation to indicate alternative attribute levels. For a design with attributes of only two levels pluses (+) and minuses (-) may be used or positive ones (+1) and negative ones (-1) to distinguish between the two possible attribute levels. Thus, the upper bound may be set when the design calls for (+) or (+1), and the lower bound when the design calls for (-) or (-1). The remaining attribute is used to balance the design to achieve the calculated response probabilities. Optimal choice probabilities depend only on the number of attributes.

Table 3-8 illustrates the use of an orthogonal main-effects plan for the study application. A 2^6 design plan (Montgomery 1991) was selected for six attributes with two levels. The design plan was used for alternative A in each of the eight scenarios. Alternative B was created by selecting the opposite attribute level from that given for alternative A. Each of five variables was assigned to a column. The sixth column is labeled 'split' to indicate that the balancing variable (entrance fee) will be used to try and approximate the optimal 70-30 split in choice probabilities for a 2^6 design. A (+) corresponds to a desired 70% choice probability and a (-) corresponds to a desired 30% choice probability.

Table 3-8: Experimental Design Plan

Scen*	Alt*	Warblers	Abundance	Other	Rare	Habitat	Split
1.	A	-	-	-	+	+	+
	B	+	+	+	-	-	-
2.	A	+	-	-	-	-	+
	B	-	+	+	+	+	-
3.	A	-	+	-	-	+	-
	B	+	-	+	+	-	+
4.	A	+	+	-	+	-	-
	B	-	-	+	-	+	+
5.	A	-	-	+	+	-	-
	B	+	+	-	-	+	+
6.	A	+	-	+	-	+	-
	B	-	+	-	+	-	+
7.	A	-	+	+	-	-	+
	B	+	-	-	+	+	-
8.	A	+	+	+	+	+	+
	B	-	-	-	-	-	-

* Scen = scenario; Alt = alternative. Design based on Montgomery (1991)

This optimal binary-choice design still requires some knowledge of the attribute levels in order to set all but one of the attributes at their boundary values and to obtain starting levels for the balancing variable. However, this approach to experimental design is more flexible than traditional approaches with pre-selected variables because it uses updating of the balancing variable to approach the optimal response probabilities.

Application

For the present research, Kanninen's (1998) optimal experimental design approach was applied to a binary-choice experiment in which birders were surveyed regarding their site and program preferences. Qualitative research (see Chapter 2) revealed the main attributes of birding sites that birders care about. Among these, six attributes were selected for the choice setting: the number of warbler species, the number of rare or unusual species, the number of other species, abundance category of warblers (indicating how likely birders are to see a species), habitat diversity, and site entrance fee as the balancing variable.

The next section discusses how qualitative interviews were used to help set the initial levels of each of the attributes.

Setting initial attribute levels

The optimal design requires boundary levels to be set for five of the six attributes and starting values for the balancing attribute, the sixth attribute.

Bird-Related Attributes

Birders are usually familiar with bird checklists, which are available for many popular birding sites. These checklists present the names of all the species, often with abundance categories, that have been sighted at particular birding locations. Entire checklists could not be used for the research as it would make the experimental design process too complicated. However, in order to maintain some of the complexity of information contained in a checklist, warblers and rare or unusual species were considered separate attributes from the general attribute of "the number of bird species." This specification was based on the finding that most respondents have a particular preference for warblers, and for species that are rare or unusual for a specific area in general.

Bird lists from birding sites in Michigan and Pt. Pelee, Ontario, were used to set attribute levels (Boettner et al. 1983, Evers and Granlund 1991, Friends of Point Pelee and Pelee Island Winery 1994, Graham 1997, Jones 1990, Lerg undated, McWhirter 1997, Smith et al. undated, The Nature Conservancy undated, U.S. Department of Interior 1991 and 1979, Sault Naturalists undated). The number of species in the "warbler", "rare or unusual", and "other species" categories were counted for each list to learn what a realistic range of species numbers

would be for birding sites that survey participants might visit. The lists also provided information about abundance categories.

Some lists gave detailed information such as the seasonal distribution of each species (Graham 1997). The type of information varied across lists, but most lists provided at least the names of species and their abundance category. The abundance categories were either the set consisting of "abundant," "common," "uncommon," "occasional," and "rare," or the set consisting of "common," "uncommon," and "rare." Other categories used in some lists included "accidental," and "vagrant."

The bird lists that were used for the present research are the lists for Point Pelee, Ontario (Friends of Point Pelee and Pelee Island Winery 1994, Graham 1997); Whitefish Point (Evers and Granlund 1991), Seney Wildlife Refuge (U.S. Department of Interior 1991, Jones 1990), Shiawassee Wildlife Refuge (U.S. Department of Interior 1979), Rose Lake (Lerg undated), Lansing Area (McWhirter 1997, Berrien County (Smith and Witkoske undated), Sault Ste. Marie Area (Sault Naturalists undated), Genesee County and For-Mar Nature Preserve and Arboretum (Boettner et al. 1983), and Grand Mere. The list for Grand Mere was constructed from a listing of species for Grand Mere and abundance categories taken from a list for Berrien County (Grand Mere forms part of the Berrien County list).

The total number of species listed for a given site ranged from 166 species at For-Mar to 357 species at Pt. Pelee. Five lists were analyzed in more detail, Whitefish Point, Seney Wildlife Refuge, Shiawassee Wildlife Refuge,

Rose Lake, and Grand Mere. When the lists were split into "early spring" and "late spring," the range was 104 to 224 species. The lowest total number of species was set at 85 and the highest at 274 species. This range covers a realistic range of number of bird species that may occur in one day at a site in the spring.

The range for the number of *rare or unusual species* was selected based on the five lists that were studied in more depth. An experienced birder provided information to determine which species would be considered rare or unusual in the study area in Michigan (Johnson). The number of *rare or unusual species* for each of the five sites ranged from 7 to 38 in the early spring season. Because *warbler* species appear in a separate category, no warbler species should be included in the count of *rare or unusual species*. A range of 5 to 30 is therefore a reasonable range for the number of *rare or unusual species*.

The number of wood-warbler species found at the five sites ranged from 4 to 32. Since rare or unusual warblers would also be included under *rare or unusual species*, they were eliminated from the list. A range of 5 to 25 *warbler* species (not including rare or unusual species) was selected for the scenarios.

Bird checklists may differ in the type of abundance information they provide for bird species listed at a site. Most checklists use abundance categories for spring, summer, fall, and winter. But they may also provide more detailed additional information such as the number of birds observed at different times of the year (Evers and Granlund 1991). Since the abundance categories "rare", "uncommon", and "common" were available or could be constructed for all

sites, the boundary values for *abundance category* were set at “rare” and “common” for the choice setting. Because “rare” was also used to designate species not typically found in the area, some confusion between the two concepts was expected and respondents were alerted to the two different meanings of “rare”. A change in terminology was contemplated but rejected because this term is commonly used for both concepts and birders are familiar with it.

Habitat

Habitat was designated as “forest with edge” habitat for the low, homogeneous habitat level and as “forest, wetlands, open water with sandy-gravel shoreline” for the high, diverse habitat level. The homogeneous habitat was selected as forest with edge because warbler species are specifically included in the scenarios and they require forest habitat.

Estimation of main effects requires that there be no significant interaction effects between the selected variables. In order to create scenarios with a high total number of species and with homogeneous habitat as a realistic alternative, edge habitat, where one habitat type changes to a different type, was added to the forest habitat. It was felt that respondents might reject a scenario in which a high number of species dwells in a habitat of only forest. Forest habitat and a transitional habitat from forest to some other habitat(s) increase the probability that a diverse number of species can be found.

While most of the birders who were interviewed did not have a problem conceiving of low habitat diversity and a large number of species, a few birders commented that this combination of attribute levels was unrealistic. However, they were still able to perform the required choice task.

Entrance fee

While public birding sites usually do not have an entrance fee, some public sites and most private sites that birders visit have entrance fees. Entrance fee is therefore not an unreasonable variable to include in an estimation of birders' choices among sites or program attributes.

Pre-tests were conducted with 20 birders to determine how the fees should initially be set. Eight of the pre-tests included testing of the entire survey instrument. Pre-test participants were asked which of the two sites in scenario 8 they preferred, what their maximum WTP for each of the two sites was, and how high the fee for their preferred site would have to be set for them to switch to the other site.

Scenario 8 was chosen because it has all of the attributes set at the high level for one site and all of the attributes set at the low level for the other site. It is reasonable to assume that if all attributes are "goods" rather than "bads," then all respondents would prefer the site with all high levels and would provide a higher WTP than for any of the other scenarios. This provided an upper limit to WTP for birding sites in this study.

The question about the dollar amount for the preferred site that would make a respondent switch to another site was included in the pre-test to determine whether respondents had truly given their maximum WTP for the preferred site. In almost all cases, the respondent gave a higher amount for the switch price than they stated as their maximum WTP. Therefore, the switch price reflects more accurately respondents' "true" maximum WTP.

In pre-test interviews 9-17, which were conducted by telephone, respondents had previously been sent by mail (e-mail or regular mail) 3 or 4 scenarios with pairs of birding site descriptions. Each respondent received scenario 8 and 2 or 3 additional randomly selected scenarios. Respondents were asked to report their maximum WTP for each site and, given their WTP, which site they preferred.

Respondents were also asked the entrance fee (dollar amount) for scenario 8 site A (all high attribute levels) at which they would switch to site B (all low attribute levels). In 6 of the 9 cases, dollar amounts higher than the previously stated maximum WTP were indicated. In three cases, respondents indicated that they would prefer to not go birding if the entrance fee exceeded their maximum WTP.

In three telephone pre-test interviews, respondents were asked which site out of each of three pairs they would prefer if both sites charged an entrance fee of \$10. The fee for the preferred site was subsequently raised and/or the fee for the non-preferred site lowered until the respondent chose the initially non-preferred site.

The above information was used to set entrance fees used in the survey instrument. Birders in the pre-test indicated that most sites they visit for birding do not charge an entrance fee. The birders who had paid entrance fees for birding sites such as state parks, Pt. Pelee National Park, Detroit Metro Park, stated that they consider the fees nominal. Most fees reported by birders do not exceed \$5 per day. The daily fees would be even lower for senior citizens and when seasonal or annual passes are purchased and several trips are made to the same site. For this reason, the fee for the site that the pre-tests indicated was the less desirable site was set at \$1. The adjustment to generate a 70-30 split therefore required adjusting the entrance fee for the more desirable site. If a site was clearly preferred by pre-test respondents and had a high number of variables set at the high level, the fee was set at a high level. The highest level chosen was \$25 for scenario 8 site A. This site has all variables set at the high level and a targeted choice probability of 70% of the respondents. The highest reported WTP for this site ranged from \$0 (respondents were not willing to pay an entrance fee to go birding) to \$75. The other high levels that were set for entrance fees ranged from \$5 for a site that was not clearly preferred by pre-test respondents but required a 70% choice probability, to \$21 for two sites that had more than half of the non-fee characteristics set at the high levels, and were preferred by all respondents in the pre-test. One of the sites required a 70% choice probability and the other a 30% choice probability.

Only a few pre-test observations were available for all scenarios, with the exception of scenario 8. The researcher had to use some judgment to set the

initial entrance fees. In only one of the scenarios was a higher fee set for the site alternative that ended up with a lower fee at the end of data collection. In all other scenarios, the site alternative that started with a higher entrance fee also had the higher fee after the interviews were concluded. For the single scenario where the fees moved in the opposite direction from what was anticipated, birders had not shown a clear preference for one or the other site alternative in the pre-tests. This illustrates that the pre-tests were a good indicator of site preference.

Survey

Members of the American Birding Association listed under areas 488 and 489 in the membership directories for 1996, 1997, and 1998 were sent a letter describing the research and informing them that they would be contacted to participate in a personal interview (American Birding Association 1996, 1997, 1998). Members whose telephone numbers were not available were asked to return a postcard with their telephone number. Sixty members of the American Birding Association in the Lansing area were personally interviewed. Adjusting for birders who had moved out of the area, had not returned a postcard with their telephone number, individuals who were unable to schedule an interview during the interviewing period, and three individuals who refused to be interviewed when contacted by telephone, the response rate was 82%.

For details about the questionnaire see chapter 2. The questionnaire was administered the same way to each respondent. Respondents' clarification questions were handled in a uniform manner. Each respondent was presented with all 8 pairs of alternatives and asked to choose between the two sites in each pair. The order in which the scenarios were presented to the respondents was randomly selected.

Updating

After each interview, or after several interviews that were scheduled closely together, the entrance fees presented in the scenario alternatives and the choice of birding sites from each pair were recorded in a table. Table 3-9 and Table 3-10 is the actual table used for the updating process. The table headings included not only the scenarios (indicated by a number) and alternative sites (labeled either A or B), but also the targeted choice probabilities. The rows beginning with 'I' followed by a number represent the different interviews. Cell entries correspond to the entrance fees that were presented to the interviewee and bold figures designate the respondent's choice of the preferred alternative. Rows beginning with '%' show the actual choice probabilities for the interviews that were conducted. The percentages (in bold) are calculated based on the number of respondents out of the total number of interviewed respondents who chose a given alternative. As long as the trend was in the direction of the desired 70-30 split, the entrance fees were

Table 3-9: Sequential Updating of Entrance Fee⁶

	1A 70 %	1B 30 %	2A 70 %	2B 30 %	3A 30 %	3B 70 %	4A 30 %	4B 70 %	5A 30 %	5B 70 %	6A 30 %	6B 70 %	7A 70 %	7B 30 %	8A 70 %	8B 30 %
I1	1	21	1	16	1	21	11	1	1	5	11	1	1	11	25	1
I2	1	21	1	16	1	21	11	1	1	5	11	1	1	11	25	1
I3	1	21	1	16	1	21	11	1	1	5	11	1	1	11	25	1
I4	1	21	1	16	1	21	11	1	1	5	11	1	1	11	25	1
I5	1	21	1	16	1	21	11	1	1	5	11	1	1	11	25	1
I6	1	21	1	16	1	21	11	1	1	5	11	1	1	16	25	1
I7	1	21	1	16	1	21	11	1	1	5	11	1	1	16	25	1
I8	1	21	2	12	2	17	11	1	3	5	11	1	1	20	25	1
I9	1	21	2	12	2	17	11	1	3	5	11	1	1	20	25	1
I10	1	21	2	20	2	17	20	1	10	5	11	1	1	20	25	1
I12	1	21	2	20	2	17	20	1	10	5	11	1	1	20	25	1
I13	1	21	2	20	2	17	20	1	10	5	11	1	1	20	25	1
I14	1	28	2	25	2	17	30	3	16	3	18	2	1	30	25	1
I15	1	28	2	25	2	17	30	3	16	3	18	2	1	30	25	1
I16	1	28	2	25	2	17	30	3	20	3	18	2	1	30	25	1
I17	1	28	2	25	2	17	30	3	20	3	18	2	1	30	25	1
I18	1	28	2	25	2	17	30	3	20	3	18	2	1	30	25	1
I19	1	28	2	25	2	17	30	3	20	3	18	2	1	30	25	1
I20	1	28	2	25	2	17	30	3	20	3	18	2	1	30	25	1
I21	1	28	2	25	2	17	30	3	20	3	18	2	1	30	25	1
I22	1	28	2	25	2	17	30	3	28	3	25	2	1	30	25	1
I23	1	28	2	25	2	17	30	3	28	3	25	2	1	30	25	1
I24	1	28	2	25	2	17	30	3	28	3	25	2	1	30	25	1
I25	1	28	2	25	2	17	30	3	28	3	25	2	1	30	25	1
I26	1	28	2	25	2	17	30	3	28	3	25	2	1	30	25	1
I27	1	28	2	25	2	17	30	3	28	3	25	2	1	30	25	1
I28	1	30	2	27	2	17	30	3	28	3	25	2	1	30	28	1
I29	1	30	2	27	2	17	30	3	28	3	25	2	1	30	28	1
I30	1	30	2	27	2	17	30	3	28	3	25	2	1	30	28	1
%	52	48	38	62	31	69	45	55	52	48	52	48	55	45	80	20

⁶ Heading numbers designate scenario and letters the alternative within the scenario. The number in the first column indicates the number of the interview. The second heading row represents optimal response probabilities. Cell entries are the entrance fees that were presented to the respondents in the scenarios. The percentages (in bold) are calculated based on the number of respondents out of the total number of interviewed respondents who chose a given alternative (indicated by bold cell entry).

Table 3-10: Sequential Updating of Entrance Fee (continued)

	1A 70 %	1B 30 %	2A 70 %	2B 30 %	3A 30 %	3B 70 %	4A 30 %	4B 70 %	5A 30 %	5B 70 %	6A 30 %	6B 70 %	7A 70 %	7B 30 %	8A 70 %	8B 30 %
I31	1	30	2	27	2	17	30	3	28	3	25	2	1	30	28	1
I32	1	30	2	27	2	17	30	3	28	3	25	2	1	30	28	1
I33	1	30	2	27	2	17	30	3	28	3	25	2	1	30	28	1
I34	1	30	2	27	2	17	30	3	28	3	25	2	1	30	28	1
I35	1	30	2	27	2	17	30	3	28	3	25	2	1	30	28	1
I36	1	30	2	27	2	17	30	3	28	3	25	2	1	30	28	1
I37	1	30	2	27	2	17	30	3	28	3	25	2	1	30	28	1
I38	1	30	2	27	2	20	30	3	28	3	28	2	1	30	28	1
I39	1	30	2	27	2	20	30	3	28	3	28	2	1	30	28	1
I40	1	30	2	27	2	20	30	3	28	3	28	2	1	30	28	1
I41	1	30	2	27	2	20	30	3	28	3	28	2	1	30	28	1
I42	1	30	2	27	2	20	30	3	28	3	28	2	1	30	28	1
I43	1	30	2	27	2	20	30	3	28	3	28	2	1	30	28	1
I44	1	30	2	27	2	20	30	3	28	3	28	2	1	30	28	1
I46	1	30	1	30	2	20	30	3	28	1	29	1	1	30	28	1
I47	1	30	1	30	2	20	30	3	28	1	29	1	1	30	28	1
I48	1	30	1	30	2	20	30	3	28	1	29	1	1	30	28	1
I49	1	30	1	30	2	20	30	3	28	1	29	1	1	30	28	1
I50	1	30	1	30	2	20	30	3	28	1	29	1	1	30	28	1
I51	1	30	1	30	2	20	30	3	28	1	29	1	1	30	28	1
I52	1	30	1	30	2	24	30	1	28	1	29	1	1	30	30	1
I53	1	30	1	30	2	24	30	1	28	1	29	1	1	30	30	1
I54	1	30	1	30	2	24	30	1	28	1	29	1	1	30	30	1
I55	1	30	1	30	2	24	30	1	28	1	29	1	1	30	30	1
I56	1	30	1	30	2	24	30	1	28	1	29	1	1	30	30	1
I57	1	30	1	30	2	24	30	1	28	1	29	1	1	30	30	1
I58	1	21	2	12	2	17	11	1	3	5	11	1	1	20	25	1
I59	1	30	1	30	2	24	30	1	28	1	29	1	1	30	30	1
I60	1	30	1	30	1	28	30	1	30	1	30	1	1	30	30	1
%	52	48	33	67	24	76	51	49	41	59	54	46	53	47	83	17

maintained. If they were moving in the opposite direction, the entrance fees were changed by increasing the fee of the site that appeared to be selected at a higher-than-desired percentage.

Only two pre-test respondents indicated a willingness-to-pay of more than \$25 for the birding site that had all high levels of non-fee attributes. It was determined that an entrance fee of \$30 was close to the limit of realistic fees. This decision was based on the pre-test results for WTP and the fact that birders do not have to pay for most of the birding sites they visit, especially ones located within day-trip driving distance.

The entrance fees were updated a total of 11 times for a total of 30 scenarios. Individual scenarios were updated between two and six times. By the time all 60 of the interviews were conducted, prices for one of the alternative sites in each scenario had reached the \$30 threshold for all but one scenario (Table 3-9). The scenario that had not reached the threshold was close to the desired target split with choice probabilities of 76% and 24%. Three of the scenarios had splits that were moving in the opposite direction of the desired split. One scenario came close to achieving the opposite choice probabilities for the alternative sites with 67% of the respondents selecting the site that was supposed to be selected 30% of the time.

Findings

A binary logit model was estimated using LIMDEP Version 7.0 (Greene, 1995) to obtain coefficients for the site attribute differences (Table 3-11). The binary logit model estimates the probability of choosing site A given the differences in the independent variables. The variable differences are defined as attribute level A minus attribute level B.

Table 3-11: Estimated Model Results

Variable	Estimated Coefficient (Standard Error)
No. of warblers	0.033 (0.007)
No. of rare species	0.027 (0.005)
No. of other species	0.0057 (0.001)
Abundance of warblers	0.27 (0.10)
Habitat	0.23 (0.10)
Entrance fee	-0.029 (0.0074)
-Log Likelihood Fct.	293.15
% Correctly Predicted	64%

All of the estimated coefficients were significant (95% confidence) and had the expected sign (Table 3-11). The probability of choosing a site increases with the number of warblers, rare or unusual species, other species, higher abundance of warblers (as indicated by abundance categories), higher levels of diversity of habitat, and decreases as the entrance fee to the site is increased. [The estimation results will be discussed further in Chapter 4.]

Design Comparison

One of the goals of this study was to compare the efficiency of a traditional binary-choice experiment with that of the approach developed by Kanninen (1998). Model efficiency depends on the unknown parameters, the β 's. The best and only estimates we have for the β 's are the binary-logit model

estimates, $\hat{\beta}$. Therefore, in the model comparisons $\hat{\beta}$ is used to compute model efficiency.

Kanninen developed her optimal design for binary-choice experiments analytically. The theoretical level of design efficiency cannot be reached with the empirical model because the β 's are not known. However, using the updating approach, efficiency of the empirical model will approach the theoretical model efficiency. In the application described here, efficiency improvements were constrained.

The theoretical optimal design assumes a linear utility function which resulted in the requirement of setting the attribute levels at their extreme boundaries. In one of the scenarios, respondents were asked to select a site from two alternatives where the boundary values for one of the site's attributes made the site so desirable that the entrance fee would have had to be set so high to achieve the desired response probabilities to increase the fees beyond any respondent's experience. The alternative sites would have required a difference of \$72 in entrance fees to achieve the optimal 70-30 split. It is likely that many respondents would have rejected a scenario with entrance fees at levels beyond respondents' experience. While the entrance fee differences that would have been required to obtain the desired choice probabilities in the other cases were lower, they ranged from \$24 to about \$59 (Table 3-12), the \$30 cut-off point was selected for this study to maintain the realism of the choice scenarios.

There are three design matrices to evaluate, the theoretical design matrix with the optimal entrance fees, the updated design matrix with the actual entrance fees presented to respondents, and the traditional design matrix with pre-selected entrance fees. For the theoretical design matrix the fee differences were calculated that would have been necessary to obtain the desired choice probabilities for site A in each of the scenarios (Table 3-12). The coefficient estimates, the attribute differences, and the desired choice probabilities for selection of site A were entered into a spreadsheet. The fee difference was adjusted until the desired choice probability was obtained using the following logit equation:

$$P(A) = \frac{e^{\left(\sum_{i=1}^g \hat{\beta}_i x_i\right)}}{1 + e^{\left(\sum_{i=1}^g \hat{\beta}_i x_i\right)}} .$$

Prior to data collection, two entrance fees, \$1 and \$11, were selected as fees that would have been used had a traditional approach been taken.⁷ The selection was based on pre-test information about birders' maximum WTP for visiting the alternative birding sites. These entrance fees were entered into the experimental design to calculate fee differences for each scenario (Table 3-12). The difference in average absolute entrance fees and the difference in entrance fees that resulted from the updating process of the empirical model are provided in Table 3-12 for comparison.

⁷ The difference in the pre-selected entrance fees for the traditional design was 10. Therefore -10 or +10 were entered into the design matrix according to the design plan.

Table 3-12: Difference in Entrance Fees for Alternative Designs

Scenario	Theoretical Model	Final Fee for Updated Model	Average Fee for Updated Model	Traditional Model
1	-54.67	-29	-26.50	10
2	-72.15	-29	-23.00	10
3	-24.15	-27	-17.33	-10
4	51.24	29	23.93	-10
5	37.05	29	18.24	-10
6	52.67	29	20.62	-10
7	-49.23	-29	-25.84	10
8	59.25	29	25.88	10

Design Efficiency

To compare the efficiency of the updated model with the traditional model relative to the theoretical model, D-optimality scores were computed for all three models. It was expected that the theoretical model would have the highest D-optimality score reflecting the fact that Kanninen derived the efficiency criteria for the theoretical model. The D-optimality score for the updated model, the model that uses the collected data, was expected to be lower compared to the theoretical model because the optimal entrance fees were not known. By updating the balancing variable the model will approach the theoretical level of optimality. The closer the final choice probabilities will be to the optimal choice probabilities the closer the updated model will be to the theoretical D-optimality score. It was expected that the D-optimality score for the updated model would exceed the D-optimality score for the traditional model. The choice probabilities were adjusted for each scenario of the updated model while the two entrance fees that were selected for the traditional approach were assigned according to

the main-effects plan for all scenarios. The D-optimality score for the traditional model was then computed using the pre-selected entrance fees. The efficiency of the design will depend on how the entrance fee is set. More extensive pre-testing is likely to improve design efficiency. The D-optimality results are presented in Table 3-13.

Table 3-13: Normalized D-optimality Scores

Model	D-optimality Score ⁸
Theoretical model	1
Updated model	.91
Traditional model	.25

The results show that the D-optimality scores of the theoretical model and the updated model are fairly close. The updated design matrix achieves 91% efficiency relative to the theoretical design matrix. This suggests that while an optimal design cannot be reached with the estimated updated model, it is possible to come close to the optimal results by updating the balancing variable. Comparisons of the relative D-optimality scores indicate that the updated model with its approach of sequentially adjusting the entrance fees comes much closer to the theoretical score than the traditional model.

D-optimality is a concept that applies to overall efficiency of the model design. This does not imply that the model with the highest level of model efficiency also has the lowest variance for the individual coefficient estimates (Table 3-14). The relative variance for the entrance fee has implications for the

⁸ The D-optimality scores were normalized by setting the score for the theoretical model equal to one.

precision of the welfare measures. Precision of the welfare measures using the traditional model will be lower relative to those using the updated model because the entrance fee coefficient will be in the denominator and the coefficient variance is more than twice the variance for the updated model.

Table 3-14: Coefficient Variances

	Theoretical Model	Updated Model	Traditional Model
Entrance fee	0.0000120	0.0000541	0.0001238
Warblers	0.0000411	0.0000515	0.0000310
Rare species	0.0000269	0.0000291	0.0000207
Other species	0.0000011	0.0000011	0.0000008
Abundance category	0.0112765	0.0103784	0.0126705
Habitat	0.0110241	0.0101243	0.0126705

The D-optimality score for the traditional model is a function of the pre-selected entrance fee difference. If a particularly “bad” entrance fee differential was selected for the traditional model, it would look worse in comparison to the updated model. To address this concern, D-optimality scores for several alternative entrance fee differences were computed, 15, 20, 25, 40,50,60.

Table 3-15: D-Optimality Scores For Selected Fee Differences

Pre-Selected Entrance Fee	D-optimality Score⁸
\$10	.25
\$15	.51
\$20	.82
\$25	.72
\$40	.46
\$50	.31
\$60	.20

The results are presented in Table 3-15. The highest D-optimality score was achieved for a \$20 fee difference but the relative efficiency was still lower than that of the updated model, 82% versus 91%.

A possible explanation for this finding is that under the traditional approach, preselected fees are assigned across all scenarios according to the design plan and the updated model allows adjustments in the fee separately for each scenario.

The updated model has several caveats. The model is based on a linear utility function. Linearity may not be realistic for the application, however, and it is not possible to test for non-linearity. The experimental design is based on the existence of boundary values for the attributes. If boundary values cannot be identified the model cannot be used and if boundary values change the study results will lose efficiency. The extreme boundary levels may also create unrealistic scenarios because there is no middle ground. In reality respondents may not be faced choices between the extreme site attributes that are generated by the optimal experimental design.

Despite these caveats, the D-optimality scores for the alternative design matrices suggest the usefulness of the updating approach, particularly in cases where little information is available about the unknown parameters and where time and/or budget constraints exist and small samples must be used. In the end, the researcher must decide whether efficiency gains through more extensive pre-testing in conjunction with a traditional approach is worth the time,

effort, and money relative to the 'costs' involved in using the sequential updating approach used in this study.

Summary and Conclusion

Model efficiency may be an important criterion for model selection in cases where sample size is limited due to budgetary or other constraints. The results of this study show that optimal experimental designs that allow for updating of a continuous variable provide efficiency gains relative to traditional binary-choice experiments that use pre-determined attribute levels.

Choice experiments are typically based on an orthogonal main effects plan where attributes and attribute levels are specified in advance. The model that forms the basis of this application only requires that upper and lower bounds be placed on attribute levels. The requirements for an optimal binary-choice design then involve setting all but one attribute at the upper or lower boundary levels according to an orthogonal main effects plan and using the remaining attribute as a design-balancing variable.

Respondents to the survey used in this research were asked to select one alternative from a pair of scenarios. Each alternative in a pair has, thus, a certain probability of being selected by any one respondent. The split for the choice probabilities that are required for optimality of the design are determined by the number of attributes in the experiment. The probability to be assigned to an alternative is based on the experimental design plan for the balancing variable.

The balancing variable is sequentially adjusted in the data-collection stage to achieve the required choice probabilities for each alternative in a pair.

While theoretical design efficiency cannot be reached empirically because model parameters are unknown, the sequential updating approach may closely approximate theoretical design efficiency if prior information exists or can be collected on the possible size of the coefficients and if updating is possible. One strength of Kanninen's approach is that it is not necessary to know the true coefficients prior to data collection. It is sufficient to know the response probabilities, which are determined solely by the number of attributes in the design. Updating of the balancing variable is then used to try and approach the optimal response probabilities.

To explore the implications of Kanninen's approach, the optimal binary-choice design with sequential updating was applied to bird watching. A survey instrument was developed whose valuation portion consisted of an arrangement of 8 pairwise comparisons of birding sites with 6 attributes. The surveys were administered in personal interviews. The design-balancing variable was an entrance fee to a birding site. The frequency of updating of the entrance fee depended on how closely together the interviews were scheduled and on how the actual choice probabilities behaved relative to the desired probabilities. A constraining factor was the upper threshold of \$30 that was placed on the entrance fees. Any higher amount was felt to be too unrealistic for a daily entrance fee to go birding for one day.

Model efficiency was measured by D-optimality scores. D-optimality scores were calculated for the updated model, the theoretical model, and a traditional model based on pre-selected entrance fees. Comparisons of relative model efficiencies showed that the updated model closely approximates the theoretical model efficiency, as compared to the traditional model.

The results of this study underscore the efficiency gains that are possible by sequentially updating attribute levels of the design-balancing variable relative to using a model with pre-determined attribute levels. These efficiency gains must be balanced against the increased administrative time and money costs required for tracking choice probabilities and adjusting attribute levels. These costs may not weigh very highly in cases where small samples must be used and efficiency gains are prized. The study also underscored the trade-off between efficiency gains and realism in the choice scenarios. By setting attribute levels at their extreme boundaries, optimal choice probabilities may require values for the balancing variable that respondents consider unrealistic.

In this pilot study personal interviews were conducted with a small number of respondents (60). Personal interviews are not feasible on a large-scale because of the time, cost, and effort that would be required. A mail-survey that could be conducted in several waves, to be able to update the balancing variable, could save on money cost and effort involved. It would be time-intensive, however, because of the turn-around time involved in administering mail surveys. A telephone survey may be a good alternative when the survey is not very long and scenarios can be related to the respondent during the

interview. Where the latter is not possible a combination of a mail- and telephone-based survey may be feasible. Scenarios with all but the balancing variable entries could be mailed prior to the telephone interview and updating of the balancing variable could proceed between sets of interviews.

Chapter 4

BIRDER PREFERENCES AND BIODIVERSITY INDICATORS

Introduction

Natural and social scientists and environmental activists have identified many reasons for preserving biodiversity. These include the contribution of biodiversity to the proper functioning of ecosystems, nutrient cycling, watershed protection, and recreational values (McNeely 1988). Yet the world has witnessed rapid rates of species extinction (Lovejoy 1986). While exact numbers are not available for the rate of extinction of species, "the number of extinctions that might be expected by the end of the century..." range "... from hundreds of thousands to over a million" (Lovejoy 1986: 14). High rates of species extinction thus motivate a large part of the extensive literature on biodiversity (Ryan 1992). Habitat protection to preserve species receives the most emphasis in the literature (Burley 1988). But in order to preserve a large variety of species, it is necessary to know where the most critical areas for biodiversity are (Bibby et al. 1992, McNeely et al. 1990, Reid and Miller 1989). The selection of areas that receive "protected" status thus becomes important (Barbier et al. 1994, Jenkins Jr. 1988, Burley 1988). Protected areas have also become attractive places for people to visit for outdoor recreation purposes, such as birding. The issue of which areas to designate as "protected" has been taken up by researchers and protected-area managers, as they are dealing with questions of the size and management of protected areas, conflicts between human uses of the protected

area resources (eco-tourists and local populations) and the preservation of species, carrying capacity, and sustainable use of protected areas (Reid and Miller 1989, McNeely et al. 1990, Reid et al. 1993).

The economic significance of biodiversity is also recognized in the literature (Pearce and Moran 1994, Pearce 1993, Swaney and Olson 1992, McNeely 1988, Haneman 1988, Randall 1988). The preservation of species and the required habitat have value not only because of the ecological benefits mentioned above, but also because individuals and society enjoy the recreational benefits provided by biodiversity (Barbier et al. 1994, Norton 1988). The fact that biodiversity has both social and scientific value raises the question of how to select areas for protection that will yield the “correct” level of biodiversity. Biodiversity indicators have been suggested as a basis for selecting habitat areas for protected status (e.g. species richness; Scott et al. 1987). Researchers have also tried to use people’s preferences for biodiversity to devise conservation incentive schemes, payment schemes for conservation, coordination of international conservation efforts, action plans, strategies, and charters (Reid and Miller 1989, McNeely et al. 1990, Cooper 1991, Gray 1991, Schücking and Anderson 1991, Bibby et al. 1992, Ryan 1992, Swingland 1993). For a general description of how to value biodiversity see Steffens and Hoehn (1997) and for a contingent valuation study of endangered species see Jakobsson and Dragun (1996). This study asks whether biodiversity is a significant factor in birders’ choice of birding sites, and whether there is a significant relationship between birder preferences and the biodiversity levels of

sites. Birders derive pleasure from observing birds in the wild and thus represent a group that enjoys the recreational benefits of natural resources (Kerlinger 1995a and 1995b, Wiedner and Kerlinger 1990, Jacquemot and Fillion 1987, Kellert 1985). For the purposes of this study, the aspect of biodiversity that is examined is limited to bird diversity.

This research application of birds and birding is motivated by several considerations. First, birds are considered good indicators of biodiversity because they exist throughout the world, are sensitive to environmental changes, and more is known about their distribution and taxonomy than is known about other elements of ecosystems (McNeely et al. 1990). Second, bird-related data are available for a large number of birding sites. Third, access to a database of birders was provided the American Birding Association (ABA); such data is not available for other potential biodiversity indicators. A group of ABA members were selected as the resource-user group for this study.

ABA birders in Central Michigan were interviewed to obtain preference information for six attributes of birding-sites. These site attributes are: the number of warblers, the number of rare or unusual species, the number of other species, the abundance of warblers, habitat, and entrance fee to the birding site. The disaggregated attribute information was used to compute seven aggregated biodiversity indicators.

The collected data was analyzed by specifying a binomial logit model. The empirical models that are estimated are the user-preference model and models using alternative biodiversity indicators. The study investigates whether

biodiversity as an aggregate measure of bird-related attributes of birding sites is a significant factor for birders' choice of a birding site.

The study also tested the hypothesis that the models with the biodiversity indicators are not significantly different from the user-preference model with the site attributes. This hypothesis suggests that biodiversity indicators substitute for the more complex information contained in the disaggregated user-preference model.

The biodiversity measures for the birding sites can be decomposed into measuring biodiversity of different types of bird species. The disaggregated model distinguishes between warblers, rare species, and other species.

Comparison of a decomposed measure of biodiversity versus an aggregated measure of biodiversity was only possible for the given dataset in the case of species richness. The decomposed model breaks species richness (total number of species) down into number of warblers + number of rare species + number of other species. The aggregate and decomposed models for species richness were compared to show whether the decomposed model has a better fit (percent correctly predicted responses) than the aggregate model. For the other biodiversity indicators, the dataset does not include variability in the subcategories comparable to variability for the site to make the comparison between an aggregated biodiversity model with a decomposed biodiversity model meaningful. The difference in these biodiversity indicators relative to species richness is that they are driven by considerations of abundance and evenness of distribution in addition to the number of species. However, in this

dataset warblers and rare species are always in the same abundance category at any one site and other species are evenly divided into three groups. Thus, the biodiversity indicators for each subcategory of birds would be dominated by species richness.

Ecologists have suggested using biodiversity indicators to select areas for protected status (e.g. Scott et al. 1987). In cases where resource user preferences are to be taken into consideration in addition to an ecological measure for biodiversity to select areas for protection, a biodiversity indicator that fits user-preference data better than another would be preferred. The model specifications with the different biodiversity indicators were compared in terms of percent correctly predicted responses to determine whether one or several indicators perform(s) better than others.

The biodiversity-indicator models were also estimated using site attributes that are included in the user-preference model but are not (directly) bird-related attributes, i.e. entrance fee, habitat. The expanded models were compared to the biodiversity models in terms of goodness-of-fit.

Natural-resource decision makers may be interested in knowing how much birders value changes in the levels of birding-site attributes, including levels of biodiversity. The empirical model can be used to estimate birders' marginal willingness to pay (WTP) for attributes of birding sites, including biodiversity, and total WTP for a site with certain site characteristics. Meaningful estimates for WTP would, however, require a larger-scale study than was

available for this research; WTP was therefore not calculated in the present study.

The rest of this chapter is organized as follows: biodiversity indicators are explained in general, then the empirical model is introduced, this is followed by a description of the model application to birding, the results of the study, and the summary and conclusion. The section on the application explains how the attributes were selected, how information about biodiversity indicators was obtained and incorporated into the study, and how the biodiversity indicators that were selected for the study were computed.

Biodiversity Indicators

No unique and universally accepted definition of biodiversity has emerged from the ecological literature on the meaning and measurement of biodiversity, which dates back to the 1950's (Reid et al.1993). Biodiversity may be defined in terms of genetic diversity (i.e., variation in genetic material), species diversity (i.e., variability across species), and ecosystem diversity (i.e., the variability in the ecological complexes which form habitat for species) (McNeely 1988, Pearce and Moran 1994, Reid and Miller 1989). For the purposes of this study, biodiversity is defined as species diversity. Species diversity can be measured in different ways. While species diversity is synonymous with species abundance (species richness) for some (McNeely 1988), others include distributional considerations as well (Pearce and Moran 1994, Williams et al. 1993). For recent approaches to selecting optimal biodiversity preservation strategies see

Weitzman (1992), Solow et al. (1993), and Solow and Polasky (1994). These latter approaches focus on species extinction while this study takes a broader approach to include species that are not threatened or endangered (see also Scott et al. 1987).

Commonly used ecological measures of biodiversity are species richness, the Shannon index (also called Shannon-Wiener index or Shannon's H), and the Simpson index (Pielou 1975). Four additional biodiversity indicators, described in Magurran (1988), were used in this study: the Margalef, Menhinick, McIntosh, and Berger-Parker indices. The seven biodiversity indicators are described in more detail below.

Empirical Model

A respondent's choice of which of two birding sites to visit can be modeled as a binary-choice problem. The respondent is asked to choose one of two alternative sites. The alternative sites differ in the level of at least one of the attributes. A utility-maximizing respondent will choose the site that gives him or her the greater level of utility, assuming that the travel costs, including entrance fee, across sites is constant. The utility function is assumed to have a random error with an extreme value distribution.

Individual j will choose site A over site B if:

$$V_A(Q_A) + \varepsilon_A > V_B(Q_B) + \varepsilon_B . \quad \text{Equation 10}$$

where for site A or site B depending on subscript:

V_j = indirect utility of respondent j

Q_j = vector of site attributes facing respondent j

ε_j = random error term

The probability of individual j choosing site A can be expressed as:

$$P(A) = P\{V_A(Q_A) + \varepsilon_A > V_B(Q_B) + \varepsilon_B\}. \quad \text{Equation 11}$$

A user-preference and several biodiversity-indicators models were specified. The user-preference specification models utility as a function of six attributes of a birding site. For respondent j at anyone site indirect utility is:

$$V_j = f(\text{warb}, \text{abun}, \text{rare}, \text{oth}, \text{hab}, \text{fee}) \quad \text{Equation 12}$$

where:

warb = number of warblers

abun = abundance category for warbler species

rare = number of rare or unusual species

oth = number of other species (other than warblers or rare or unusual species)

hab = dummy variable for diversity of habitat (= 1 if high level of diversity, = 0 otherwise)

fee = daily entrance fee

The underlying utility function for the preference model using six attributes of a birding site is:

$$V_i = \text{warb}_i \beta_1 + \text{abun}_i \beta_2 + \text{rare}_i \beta_3 + \text{oth}_i \beta_4 + \text{hab}_i \beta_5 + \text{fee}_i \beta_6 + \varepsilon_i \quad \text{Equation 13}$$

where the variables for respondent j at site i are defined as above and ε = random error term.

Alternatively, the model was specified with differenced biodiversity indicators (biodiversity indicator k for site A minus biodiversity indicator k for site B).⁹ The biodiversity-indicator model is a nonlinear function of the bird-related attributes of the preference model (number of warblers, number of rare species, number of other species, and (except for species richness) abundance).¹⁰

For any given site:

$$\text{BIO}_k = f(\text{warb}, \text{abun}, \text{rare}, \text{oth}) \quad \text{Equation 14}$$

where BIO_k is any one of the k biodiversity indicators. In the case of species richness 'abun' does not enter the biodiversity indicator. Species richness, BIO_s , is computed as follows:

$$\text{BIO}_s = \text{warb} + \text{rare} + \text{oth}. \quad \text{Equation 15}$$

The other biodiversity indicators are a more complicated function of the four bird-related attributes and they are described in the section "Computation of Biodiversity Indicators".

The following function was estimated:

$$V_{kj} = \text{BIO}_{kj} \gamma_k + v_{kj} \quad \text{Equation 16}$$

where BIO is defined as above and j indicates the individual respondent.

⁹ In this case: $\theta_j = \beta_k (\text{BIO}_{kj}^1 - \text{BIO}_{kj}^0)$.

¹⁰ See the section on "Information for Biodiversity Indicators" for details on how the biodiversity indicators relate to preference information and "Computation of Biodiversity Indicators" on how they were computed.

In the study application a scenario described two alternative birding sites in terms of birding-site attributes. The respondents were asked to select their preferred birding site from the pair of sites. In the event that they did not like either of the sites, respondents were asked to choose the site they disliked less. A binomial logit model specification with an underlying linear utility function was selected for estimation.¹¹ The random error is assumed to follow an extreme value distribution. Following these assumptions, the probability of respondent j choosing site A is given by:

$$P(A_j) = \frac{\text{Exp}(\theta_j)}{1 + \text{Exp}(\theta_j)} \quad \text{Equation 17}$$

where: $\theta_j = \beta_1(q_{1j}^1 - q_{1j}^0) + \beta_2(q_{2j}^1 - q_{2j}^0) + \dots + \beta_m(q_{mj}^1 - q_{mj}^0)$

$P(A_j)$ = probability of respondent j choosing site A from the pair of sites.

The right-hand side variables are the differenced levels of site attributes (level of attribute i at site A minus level of attribute i at site B, for $i = 1, \dots, m$).

The log-likelihood function for the alternative model specifications is:

$$\ln L = \sum_{j=1}^n [y_j \ln P(A_j) + (1 - y_j) \ln(1 - P(A_j))] \quad \text{Equation 18}$$

$y_j = 1$ when respondent j prefers site A and $=0$ otherwise.

¹¹ A random-effects probit model did not show significant individual effects to warrant a panel-data approach to the multiple individual responses contained in the data set.

Application

The data for this study were obtained from a survey of Michigan birders that was conducted in the fall of 1998. Sixty members of the American Birding Association in the Lansing area were interviewed for this study; usable data were obtained from 58 respondents. Each birder was presented with eight different pairs of scenarios and thus eight observations were obtained from each respondent for a total of 464 usable observations.

Selection of Attributes

Individual interviews were conducted with birders to learn more about their birding activities, particularly their birding trips. Structured and semi-structured interviews, using ethnographic interviewing techniques, were used to determine attributes that may influence birding-site choice.

Six site-specific variables were selected for this study. They are: number of warbler species, abundance of warbler species, number of rare species, number of other species, habitat, and entrance fee. Birder interviews revealed that the number of species that could be found at birding sites, the chance to see rare or unusual species, and the diversity of habitat were important site-specific determinants for site selection. The chance of seeing life-birds, that is, bird species never seen before by a respondent, was also an important attribute but was not included in the study because it had the chance of heavily dominating respondents' choice. There may also have been too many

respondents who had seen all of the species occurring in Michigan. These respondents would thus have rejected a scenario that mentioned a life-bird. The majority of the birders interviewed also particularly enjoyed seeing migratory warblers because of their colorful plumage in the spring. An entrance fee was selected as a site-attribute in order to model monetary trade-offs (Buchanan et al. 1998).

Because warblers and rare species would be part of the total number of species at the site, the three species-related attributes selected for the study design were designated as, "warblers," "rare," and "other species." The presence of these three attributes, as well as habitat and the probability of having warblers at the site was expected to increase the probability that a site would be selected. An increase in the entrance fee for a site was expected to reduce the probability that a site would be chosen.

Information for Biodiversity Indicators

The attributes that were presented to respondents in the survey as part of the site descriptions are only sufficient to calculate the species richness indicator of biodiversity (warblers+ rare species + other species). The other biodiversity indicators require knowledge of the number of individual birds per species. The scenario descriptions of the birding sites that were presented to respondents contained information only about the number of species and the abundance categories but did not include information about the number of

individual birds per species. Therefore, to calculate the biodiversity indicators, other than species richness, additional information was needed.

The abundance category for a species provides a birder with information about the likelihood of having a species occur at a site (Smith et al. undated). This is similar information to the number of individual birds per species, from which birders can also infer the likelihood of having a species occur at a site (Evers and Granlund 1991). To create the link between abundance and individual birds per species, survey respondents were presented with an equivalency chart (Table 4-16) that presented them with information about how a given abundance category relates to the number of birds per species.

This information was then used to calculate the biodiversity indicators. Thus, while the number of birds per species was only mentioned by interview respondents in connection with seeing large flocks of birds, this variable was included in the study design to allow calculation of the biodiversity indices.

The connection between an abundance category and the probability of observation has been documented in the literature (ABA 1995, Smith et al. undated). An approximate correspondence between the number of birds per species and an abundance category can also be deduced from the literature (Evers and Granlund 1991).

Publications are available for birders who are interested in obtaining information on the bird diversity they are likely to find at different birding sites (Wauer 1993, Jones 1990, Kitching 1976). Some of the publications are bird charts themselves or contain bird charts (e.g. Friends of Point Pelee & Pelee Island Winery

1994, Evers and Granlund 1991, U.S. Department of Interior 1991, Jones 1990).

Bird charts typically list the names of the bird species to be found at the site by season and give an abundance category (abundant, common, uncommon, occasional, or rare).

The range of attribute levels for the survey scenarios were selected based on actual ranges of the attribute at Michigan birding sites for which bird charts were available. Five charts were analyzed in more detail, Whitefish Point (Evers and Granlund 1991), Seney Wildlife Refuge (U.S. Department of Interior 1991), Shiawassee Wildlife Refuge (U.S. Department of Interior 1979), Rose Lake (Lerg undated), and Grand Mere. With the help of an experienced birder, the charts were split into birds that occur at the sites in early and in late spring (Johnson). The numbers of warblers, rare or unusual species, and other species were then summed for the different sites and a range set for each attribute. The birding consultant also identified rare or unusual species for each chart. A range of 5-30 species was set for rare or unusual species, 5-25 for warblers, and 75-201 for other species.

The data required for the calculation of the biodiversity indicators was generated by matching the abundance categories to numbers of birds per species as indicated by the equivalency chart. Several of the bird charts and information from the breeding bird survey were used to develop the equivalency chart (Sauer 1997, ABA 1995, Evers and Granlund 1991, Smith et al. undated).

The bird list for Berrien County explained abundance categories in terms of the likelihood of seeing species a certain percent of the time (Smith et al.

undated). Other bird lists (Jones 1990, for example) explain abundance categories in terms of the individual birds per species, e.g. abundant: likely to be seen in large numbers, and/or the likelihood/difficulty of observing the species, e.g. common: usually seen in proper habitat. A birding trip description in 'Winging It' provided percentages to indicate the likelihood of observing species on a given birding tour (ABA 1995). The Berrien County list used percentages of trips on which one would see the species (Smith et al. undated).

The percentage ranges differed across sources. For this study a percentage range of less than 20% was assumed to be the likelihood of observing rare or unusual species and was assumed to be the lowest level of the abundance categories for warblers and other species. The highest level was set at the 80-100% range used in the Berrien County list. For the likelihood of having other species occur at the site, the number of other species was divided into three categories, roughly corresponding to the categories, "rare," "uncommon," and "common." The categories were assigned the ranges of less than 20%, 21-79%, and 80-100%, respectively.

To construct the biodiversity indices, the abundance categories/ likelihood of having the species occur at the site was translated into the number of birds per species. The Whitefish Point bird chart relates the abundance categories to the number of individual birds per species recorded in a 7-10 day period. The breeding bird survey also provides categories for individual birds per species.¹² The numbers used here are based on a crude calculation of dividing the

Whitefish Point numbers by 7 or 10. The cut-off point was randomly set at 101. It was felt that most species are not seen in numbers greater than 101 per species on most days. Exceptions would be certain species during peak migration days at points where migratory birds tend to congregate. The numbers that resulted are similar to (combined) categories used in the breeding bird survey. The breakdown by category and the equivalencies for abundance category, likelihood of species occurrence, and number of birds per species is given in Table 4-16.

Table 4-16: Equivalencies

Abundance Category	Explanation in words	Chance of having species at site	Number of birds of the same species
Common	usually seen in proper habitat	80-100%	31-101
Uncommon	present, but not certain to be seen	21-79%	4-30
Rare	rarely seen	less than 20%	1-3

Computation of Biodiversity Indicators¹³

The seven selected biodiversity indicators are divided into two types: 1) species richness indicators and 2) indices based on the proportional abundance of species. Within the latter group, biodiversity indicators can further be distinguished as information index or dominance index.

¹² The breeding bird survey data is generated on the basis of counts along a survey route with 50 points where birds are counted during 3-minute intervals.

¹³ In order to calculate the biodiversity indicators H' , is defined as the midpoint of the abundance category (i.e. 'birds per species'). H' is calculated by multiplying the number of species in each abundance category by their respective abundance category midpoint and summing the results.

Species Richness Indicators:

1. Species Richness:

Species richness is the simplest of the biodiversity indicators. Its calculation is straight forward; it is the total number of species. Species richness in this study ranged from 85 to 275.

2. Margalef's Index:

Margalef's index, as well as Menhinick's index (described below), is a diversity index that incorporates the distribution of species abundance. It has been found that this is a "more sensitive measure of environmental disturbance than species richness alone" (Magurran 1988, 11). It is calculated using the formula:

$$(S - 1)/\ln N$$

where S = number of species and N = total number of individuals at the site.

3. Menhinick's Index:

Menhinick's index is easy to compute, as is Margalef's index (described above). It is calculated as : $S / \sqrt{N}$

where S and N are defined as above.

Indices Based On the Proportional Abundances of Species:

These indicators do not provide as much information as species abundance models, but by providing a single indicator they allow comparisons across communities when one model does not fit all of the selected communities.

The indicators take both evenness (how evenly individuals are distributed across the different species) and species richness into account. Because they do not assume a particular underlying abundance distribution, these indicators can be considered non-parametric (Magurran 1988). These indicators include:

1. Shannon's H:

Shannon's H is a heterogeneity measure that takes evenness of distribution into account. It is derived from information theory. The formula for the calculation of Shannon's H is: $-\sum_i p_i \cdot \ln p_i$,

where p_i = proportion of birds per species i in the total population of birds.

$p_i = \frac{n_i}{N}$ where n_i = number of birds per species i , and N = total number of birds.

2. Simpson's index:

Simpson's index is a dominance measure. Rather than providing a measure of species richness, it gives more weight to the abundance of the common species than it does to other species. The Simpson's index is computed

as follows: $\sum_i \frac{n_i(n_i - 1)}{N(N - 1)}$,

where n_i and N are defined as above. The Simpson index decreases as the level of diversity increases. The Simpson index is therefore usually expressed as $1 - D$ or as $1/D$. The Simpson index was computed as $1/D$ in this study.

3. McIntosh's Index:

The McIntosh's index is calculated as follows: $U = \sqrt{\sum n_i^2}$, where n_i is defined as above. This index is not a dominance indicator but can be converted

into one by calculating: $\frac{N - U}{N - \sqrt{N}}$, where U is the McIntosh index and N is the

same as above. The latter calculation will be used as the McIntosh's index in this study.

4. Berger-Parker Index:

The Berger-Parker index reports the proportional importance of the most abundant species and is calculated as: $N_{\max} / N$, where $N_{\max}$ = the number of individuals in the most abundant species and N is defined as above. As with the Simpson index, the Berger-Parker index increases as biodiversity decreases. The inverse of the above formula will therefore be used as the Berger-Parker index in this paper. The Berger-Parker index is also a dominance index.

The values of the different biodiversity indicators are listed in Table 4-17 and in Table 4-18 for each of the alternatives in the eight different scenarios. The entries in the tables illustrate that all of the biodiversity indicators move in the same direction (with the exception of the Menhinick's index in scenario 7). This finding is consistent with examples using indices for species richness, Margalef, Simpson, Shannon's H, Berger-Parker reported in Magurran (1988, 63, 67). Magurran also shows that sites ranked by their level of diversity using different indices produce rankings that are not significantly different (using the Spearman rank correlation coefficient) for indicators of the same type, either species-richness type or dominance/evenness type. The Simpson, McIntosh, and Berger-Parker indices are dominance indicators, Shannon's H is a heterogeneity index, and all others are species-richness indicators.

Table 4-17: Biodiversity Indicators for Scenario Alternatives (Scenarios 1- 4)

	Alt1 a	Alt1 b	Alt2 a	Alt2 b	Alt3 a	Alt3 b	Alt4 a	Alt4 b
Species Richness	110	231	105	236	85	256	130	211
Margalef	14.17	25.83	13.53	26.97	10.76	29.42	15.63	24.28
Menhinick	2.35	2.69	2.25	3.03	1.71	3.36	2.10	2.79
Shannon's H	3.96	4.99	3.94	4.89	3.94	4.89	4.31	4.83
Simpson	42.18	130.95	41.80	113.11	44.81	110.14	66.41	106.78
McIntosh (U)	0.863	0.923	0.862	0.917	0.867	0.916	0.891	0.914
Berger-Parker	33.26	111.44	33.11	92.20	37.35	87.95	58.11	86.59

Table 4-18: Biodiversity Indicators for Scenario Alternatives (Scenarios 5 - 8)

	Alt5 a	Alt5 b	Alt6 a	Alt6 b	Alt7 a	Alt7 b	Alt8 a	Alt8 b
Species Richness	236	105	231	110	211	130	256	85
Margalef	27.14	12.62	26.57	13.92	24.12	16.73	28.62	10.95
Menhinick	3.11	1.71	3.05	2.19	2.72	2.75	2.97	1.84
Shannon's H	4.86	4.26	4.85	4.02	4.86	4.03	5.02	3.86
Simpson	108.64	64.70	108.27	46.62	111.28	43.72	132.72	40.30
McIntosh (U)	0.915	0.889	0.915	0.870	0.916	0.866	0.923	0.860
Berger-Parker	87.35	57.35	87.20	38.11	91.44	33.86	112.20	32.50

Table 4-19: Spearman Rank Correlation Coefficients

	Species Richness	Margalef	Menhinick	Shannon's H	Simpson	McIntosh (U)	Berger-Parker
Species Richness		1.00**	0.95**	0.84**	0.81**	0.81**	0.81**
Margalef	1.00**		0.95**	0.84**	0.81*	0.81*	0.81*
Menhinick	0.95**	0.95**		0.70*	0.67*	0.67*	0.67*
Shannon's H	0.84**	0.84**	0.70*		0.99**	0.99**	0.99**
Simpson	0.81*	0.81*	0.67*	0.99**		1.00**	1.00**
McIntosh (U)	0.81*	0.81*	0.67*	0.99**	1.00**		1.00**
Berger-Parker	0.81*	0.81*	0.67*	0.99**	1.00**	1.00**	

**Correlation is significant at the 99% confidence

*Correlation is significant at the 95% confidence

The Spearman rank correlation coefficients for the biodiversity indicators using the differenced biodiversity indicators for the alternative sites and a ranking of site differences for the eight scenarios used in this study are presented in Table 4-19. All of the correlation coefficients are significant at either 95 or 99% confidence. The 99% confidence level was achieved for correlations among indicators of the same type, species richness type or dominance type, with the exception of the Menhinick index.

Results

As previously discussed, respondents were given eight pairwise choice scenarios and were asked to choose one site from each pair based on the information provided for attributes of birding sites.

A binomial logit model was estimated that included the six attributes as explanatory variables. In this disaggregated case, all of the estimated coefficients had the expected sign. The bird-related attributes, number of warblers, number of rare or unusual species, number of other species, and abundance category for warblers all had positive coefficients, as did habitat. The coefficient for the entrance fee was negative, as expected. All of the coefficient estimates were significant. The coefficient estimates and the standard errors for the birder preference model are reported in Table 4-20 as the disaggregated case.

Table 4-20: Binomial Logit Results for Disaggregated Case

Reported are coefficient estimates with standard errors in parentheses

Variable	Disaggregated Case
No. of warblers	0.033** (0.007)
No. of rare species	0.027** (0.005)
No. of other species	0.0057** (0.001)
Abundance of warb.	0.27** (0.10)
Habitat	0.23* (0.10)
Entrance fee	-0.029** (0.0074)
Log Likelihood Fct.	-293.15
Correctly Predicted Responses (total)	64%
(site A)	56%
(site B)	72%

* significant at 95% confidence level; ** significant at 99% confidence level

The table reveals that birders are more likely to choose a birding site the more warbler species, rare species, and other species can be found at the site. The abundance category for warblers differed across sites from which respondents selected their preferred site. This indicates that the degree to which birders can be sure of having warblers at the birding site is important for birding site selection. Birders are also more likely to select a birding site that has a more diverse habitat. Survey respondents care about habitat independent of the diversity of species that can be found at the site. Habitat is a significant variable but it is not correlated with the number of species, some scenarios had diverse habitat combined with less species diversity for one alternative while the other alternative had a less diverse habitat but more species.

As a measure of goodness of fit, the percentage of correctly predicted responses is also reported in Table 4-20 (Greene 1993). The disaggregated model correctly predicted 64% of the actual choices. This means that in 64% of the total cases the model predicted that respondents choose A when they indeed chose A and predicted that respondents choose B when they indeed chose B. The total cases of correctly predicted responses for A and B was broken down by correctly predicting selection of site A and correctly predicting selection of site B.

Respondents were provided with supplemental information about the correspondence between abundance categories, which were part of the valuation scenario, and the number of individual birds per species for the given categories. This information was used to compute the seven different biodiversity indicators as described above.

Table 4-21 reports the results for the estimated models using the alternative biodiversity indicators. For all of the models reported in the table, all coefficient estimates had the expected sign. All of the coefficient estimates were significant. With the exception of the model specification using the Menhinick index, the percentages of correctly predicted responses were 59% for the biodiversity-indicator model specifications. The Menhinick model showed 58% correctly predicted responses. The significance of the estimates with the expected sign indicates that the aggregate measure of biodiversity indicators explains site choice well. The goodness-of-fit measures are almost identical and

the loglikelihood values are also very similar. This suggests that preference cannot be given to anyone of the biodiversity indicators.

When the biodiversity-indicator models were estimated with the entrance fee and alternatively with the entrance fee and habitat (also entrance fee, habitat, and abundance category for species richness) included as independent variable(s), the coefficients for the added variables were not significant for any of the models (except habitat when three variables were added to species richness) and the entrance fee did not have the expected negative sign for most model specifications (see Appendix B). The goodness-of-fit measures, percent correctly predicted total responses, were identical for the different functional forms across individual indicators. The biodiversity-indicator model specification with only the indicators was therefore used in this study.

It cannot be concluded from this finding that entrance fee, abundance of warblers, and habitat are not important. The disaggregated model shows they are significant in site choice and jointly they add 6% to the percent correctly predicted responses.

The disaggregated model performed better than the aggregated models using alternative biodiversity indicators, 64% correctly predicted responses for the disaggregated model versus 59% for the aggregated models (58% for Menhinick indicator). Comparison of the aggregate biodiversity indicator models versus decomposition of the models is only reasonable for the species richness model. Species richness can be decomposed into number of warblers + number of rare species + number of other species. The other biodiversity indicators are

computed using an equivalent to abundance categories expressed in numbers of individual birds. In this study an abstraction from the real world involved assigning all warblers at a site to the same abundance category. Rare species were assumed to always be in the rare abundance category and other species were evenly split into three abundance categories. Because of this simplification decomposing the other biodiversity indicators by warblers, rare, and other species would eliminate much of the depth that is contained in the aggregate indicator by giving undue emphasis to species richness rather than reflect the degree of evenness of distribution and abundance.

A loglikelihood-ratio test for the biodiversity-indicator model using species richness, as the restricted model, and the decomposed species richness model, using number of warblers, number of rare species, and number of other species, as the unrestricted model rejects the restrictions. The loglikelihood statistic of 10.59 exceeds the critical value for a chi-squared distribution at 95% confidence with 2 degrees of freedom. This indicates preference for the decomposed model.

The biodiversity-indicator model results show that birders care about biodiversity as measured by the indicators when making choices about birding sites. In order to compare the user preference model, the disaggregated model, with the alternative biodiversity-indicator models, a likelihood ratio test was specified for the species richness indicator and a Vuong test for the remaining six indicators. Because the species richness indicator is nested in the disaggregated model the likelihood ratio test was performed.

Table 4-21: Binomial Logit Results for Alternative Model Specifications
Reported are coefficient estimates with standard errors in parentheses

Variable	Disaggregated	Species Richness	Margalef	Menhinick	Shannon's H	Simpson	McIntosh	Berger-Parker
Biodiversity Index		0.004** (0.0008)	0.034** (0.0071)	0.427** (0.0971)	0.513** (0.1085)	0.008** (0.0014)	9.412** (1.9751)	0.008** (0.0017)
No. of warblers	0.033** (0.007)							
No. of rare species	0.027** (0.005)							
No. of other species	0.0057** (0.001)							
Abundance of warb.	0.27** (0.10)							
Habitat	0.23* (0.10)							
Entrance fee	-0.029** (0.0074)							
Log Likelihood Fct.	-293.15	-309.32	-309.90	-311.56	-310.12	-310.78	-309.90	-310.49
Correctly Predicted	64%	59%	59%	58%	59%	59%	59%	59%
site A	56%	59%	59%	45%	59%	59%	59%	59%
site B	72%	59%	59%	70%	59%	59%	59%	59%

* significant at 95% confidence level; ** significant at 99% confidence level

The remaining models are not nested and the Vuong test as a non-nested test is applicable. The likelihood ratio test is a test of restrictions on the disaggregated model. The restrictions are that the number of warblers, the number of rare species, and the number of other species can be summed and thus have the same coefficient, and the coefficients on abundance category of warblers, habitat and entrance fee are zero. The Vuong test allows testing of the hypothesis that the birder preference model and the alternative biodiversity-indicator models are not significantly different.

The likelihood ratio test statistic is computed as:

$$LR = -2(\ln L_r - \ln L_u)$$

where:

$\ln L_r$ = the restricted loglikelihood function,

$\ln L_u$ = the unrestricted loglikelihood function.

The statistic is distributed as a chi-square with 5 degrees of freedom and takes on a critical value of 11.07 at the 95% confidence level. The likelihood ratio test statistic for the species richness restrictions is 32.24 and therefore the restrictions are rejected at the 95% confidence level. This gives preference to the unrestricted model, the disaggregated model where all six site attributes enter the utility function separately.

The Vuong statistic is computed as follows:

$$V = N^{1/2} \bar{m} / s_m$$

$$m_i = y_i [\ln P(A_1)_i - \ln P(A_2)_i] + (1 - y_i) [\ln(1 - P(A_1)_i) - \ln(1 - P(A_2)_i)]$$

where:

$$P(A_1)_i = \frac{\exp(x_i' \beta)}{1 + \exp(x_i' \beta)}$$

$$P(A_2)_i = \frac{\exp(z_i' \gamma)}{1 + \exp(z_i' \gamma)}$$

x_i = vector of the site differences in attributes from the disaggregated model with its coefficient estimate β ,

z_i = vector of alternative specifications of the site differences in biodiversity indicator with its coefficient estimate γ ,

N =number of observations,

$\bar{m}$ =sample mean,

s_m =standard deviation for the sample of m_i s.

Table 4-22: Vuong Statistics for Alternative Model Specifications

Model Specification using:	Vuong Statistic
Margalef Index	2.96
Menhinick's Index	2.94
Shannon's H	2.97
Simpson Index	3.05
McIntosh Index	2.94
Berger-Parker Index	3.02

The Vuong statistic has an asymptotically standard normal distribution with a critical value of 1.96 at a 95% confidence level (Vuong 1989). The results of the Vuong test for the alternative biodiversity-indicator model specifications are reported below.

The Vuong-test results show that the hypothesis of no significant differences between the birder-preference specification and the six alternative biodiversity-indicator specifications can be rejected. As a directional test (Greene 1995), the positive sign of the test statistic indicates that the model specifications using the six site attributes separately in the utility function are favored over the biodiversity specifications. This supports the findings from the goodness-of-fit measure of correctly predicted responses which indicated that the birder preference specification is preferable, 64% correctly predicted responses as compared to 59% (58% for the Menhinick specification) for the biodiversity-indicator model specifications. The log-likelihood values for the two specifications also indicate a preference for the user-preference model (see Table 4-21).

While ecological biodiversity indicators as an aggregate measure explain birder site choice well, birders care about the composition of bird diversity as indicated by the preference for the disaggregated user- preference model over the aggregated biodiversity-indicator model and as reflected in the rejection of the aggregate model restriction for species richness relative to the decomposed species richness model.

Because the questionnaire asked respondents to choose one of two alternative sites for eight different scenarios, it is possible that an individual's responses to the eight scenarios are correlated, in which case a panel-data approach for estimation might be more appropriate than a cross sectional approach. The data set was thus subsequently analyzed using a random-effects probit model. This model takes the possible correlation across an individual's responses into account by adding an error term for the individual effect. As part of the model output, ρ , the correlation between the individual's responses, can be generated. The fact that ρ was not significant (95% confidence) indicated that there were no significant random effects due to multiple individual responses. This model is therefore not reported here.

Summary and Conclusion

Birder preferences for six attributes of birding sites were modeled as a binary-choice experiment, using an underlying linear utility function. The data for the application was obtained from personal interviews with birders in Michigan. Birders were presented with eight pairs of birding site descriptions. The birders were asked to choose one site from each pair. The site descriptions contained information on the number of warblers, the number of rare or unusual species, abundance category of warblers, the number of other species, habitat, and the entrance fee.

A binomial logit model was estimated for this disaggregated model. All of the coefficient estimates were significant and had the expected signs. The goodness-of-fit measure of correctly predicted responses was 64%.

The birder survey also provided information that allowed for the calculation of biodiversity indicators for the birding sites. The biodiversity indicators used were species richness (number of species), Margalef, Menhinick, Shannon's H, Simpson, and Berger-Parker. The first three indicators are species-richness-type indicators, the remaining four are indices of the proportional abundance of species (heterogeneity indices, taking into account both evenness of distribution and species richness).

Binomial-logit model specifications with the alternative biodiversity indicators as an explanatory variable were estimated. The biodiversity-indicator model specifications had a goodness-of-fit of 59% correctly predicted responses (58% for the Menhinick biodiversity index).

Significant coefficients on the independent variables and coefficient signs of the expected direction suggest that biodiversity as an aggregate measure is a significant factor in explaining birders' site choice and that the probability of choosing a birding site increases with the level of biodiversity, as measured by the selected biodiversity indicators.

Specifications for the biodiversity-indicator models that include the entrance fee and habitat (and in addition a specification for the species richness model that also includes abundance of warblers) yield coefficients for the additional variables that are not significant (except habitat in the species

richness model that includes abundance). This does not suggest that those variables are not important to birders' site choice. The variables are significant in the disaggregated model of user preferences.

Decomposition of the biodiversity indicators by warblers, rare species, and other species is only reasonable for the given data in the case of species richness. The decomposed model is preferred to the aggregate model for species richness.

A nested test for the species richness indicator and a non-nested test for the remaining six biodiversity indicators, the Vuong test, was conducted to test the hypothesis that the alternative biodiversity-indicator models are preferable to the user preference model. The test results lead to a rejection of the hypothesis.

No preference can be given to any one indicator or to any specific type of biodiversity measure (species richness or heterogeneity) for selection of an area for protected status that would consider birder preferences as a selection criterion. All of the coefficients for the biodiversity indicators are significant and the alternative models have the same (or almost the same for the Menhinick model) goodness-of-fit measures.

Biodiversity is significant in explaining birders' site choice, as indicated by the significant coefficients on the biodiversity-indicator variables, and the biodiversity-indicator model has a fairly good fit compared to the user-preference model. Thus, while the biodiversity-indicator and the user-preference models are not equivalent, as birders care about the composition of biodiversity, the aggregate biodiversity measures indicate user preferences relatively well

APPENDICES

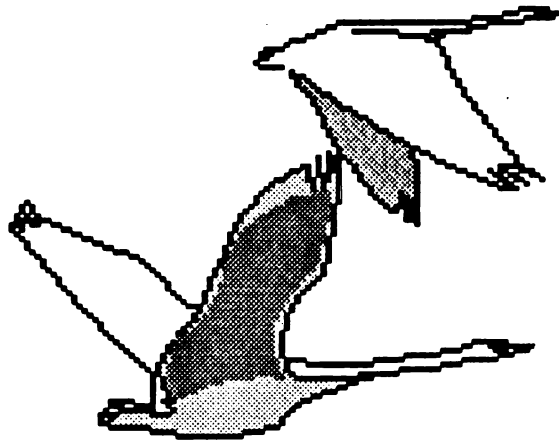
APPENDIX A

QUESTIONNAIRE

1998

Michigan Birder Study

Michigan Birders' Preferences
for
Birding Site Characteristics



Department of Agricultural Economics
Michigan State University
East Lansing MI 48824

CONSENT FORM

The interview is held to develop a birder profile and learn more about birders' choices of birding sites. The research will try to identify characteristics of different types of birders and their trade-offs between characteristics of different birding sites.

The session will last about ½ hour to 45 minutes. Participation is completely voluntary and can be terminated at any time. Answers to any questions can be refused. Names are not recorded and the information provided will be treated with strict confidentiality.

Questions can be addressed to the researcher at any time, before, during or after the session. Karin Steffens can be contacted at Michigan State University, Department of Agricultural Economics: (517) 355-8529.

(interviewee)

(date)

YOUR BIRDING ACTIVITIES

Here are a few questions about the kind of birding you like to do. It will be helpful to answer them before the interview.

Thank you very much.

Karin Steffens
(Project Manager)

Please enter a '0' if the question does not apply to you.

1. What is the farthest, in miles, that you have ever traveled for a birding daytrip*.
_____ MILES ONE WAY
2. How many birding daytrips* did you take this past spring, that is during March, April, and May?
_____ TIMES
3. How many birding daytrips* did you take during the past 12 months?
_____ TIMES
4. How many of these birding daytrips were in Michigan?
_____ TIMES
5. How many bird species are on your Michigan life list?
_____ BIRD SPECIES
6. How many bird species are on your ABA area or North America life list?
_____ ABA BIRD SPECIES
_____ NORTH AMERICA SPECIES
7. How many bird species are on your world life list?
_____ BIRD SPECIES
8. How many bird books do you own
_____ BOOKS
9. How many subscriptions to bird/birding magazines do you have?
_____ SUBSCRIPTIONS
10. How many bird species can you identify by sight in North America without a field guide?
_____ SPECIES

* A daytrip is a trip where you leave and return on the same day, that is, you are not staying overnight.

1998 Birding Questionnaire

This questionnaire is designed to help me learn about how birders view different features of their birding activities.

I will be asking about your birding activities, what you enjoy most about birding, and which characteristics of birding are important to you. The information collected will be used to show what kinds of trade-offs different birders make when faced with decisions about which birding site to visit. You were selected to participate in this study because of your interest in and knowledge of birds.

Section I: First I would like to ask you some questions about your birding activities.

Q. 1 In just a couple of sentences, how were you first introduced to birding?

Q. 2 What do you find most enjoyable about birding?

Q. 3 Other than observing birds at a feeder, for how many years have you been actively birding?
_____ years

Q. 4 Did you get a chance to fill out the questions I had mailed to you?

1 Yes 2 No

|

Collect questionnaire

Go through mailQ questionnaire

The following questions ask you about birding vacations, trips where you stay at least one night.

Q. 15 How often do you take vacations where birding is your primary activity?

(Prompt: How many weekend trips did you take and how many longer trips? Try and remember where you went.)

- 1 never
- 2 less than every 5 years
- 3 about every 3- 5 years
- 4 about every 1-2 years
- 6 2 or 3 times a year
- 7 4 or 5 times a year
- 8 more than 6 times a year

Q. 16 What is the farthest distance, one way, (or destination) you have traveled in the past 12 months where the primary purpose of the trip was birding? *(Write in or prompt)*

- 1 more than 500 miles ?
- 2 more than 300 miles ?
- 3 more than 200 miles ?
- 4 more than 100 miles ? 5 more then 50 miles ?
- 6 20-50 miles?
- 7 less than 20 miles?

Next, I will ask you some questions about your birding skills and bird lists.

Q. 17 Thinking about your overall birding skills in your home area, would you rate yourself

- 1 as a Beginning birder,
- 2 an Intermediate birder,
- 3 an Advanced birder, or
- 4 an Expert birder

Q. 18 How about for North America, how would you rate your overall birding skills at that level?

- 1 Beginning,
- 2 Intermediate,
- 3 Advanced, or
- 4 Expert birder

Q. 19 Which of the following best describes how much you rely on sound when birding: would you say you

- 1 Don't use sound at all
- 2 Follow sound for visual identification
- 3 Identify some birds by song or call
- 4 Identify most birds by song or call

Q. 20 Do you keep a birdlist?

1 Yes go to next 2 No go to 22

Q. 21 Now I will read you different types of lists birders may keep. For each one, please tell me whether you keep this type of list. (Stop reading list if R. indicates that those are the only lists R. has)

- 1 all birds ever seen
- 2 ABA area (if R. not familiar with ABA area: essentially North America)
- 3 United States
- 4 backyard
- 5 home county
- 6 other county
- 7 Michigan
- 8 other state(s)
- 9 other country
- 10 daylist
- 11 triplist

Do you keep any other type of list?

1 Yes go to next 2 No go to 22

(If yes,) what type of list is it? _____

So much for skills and lists. Now, I would like to find out about resources you use.

Q. 22 I will read you a list of birding or conservation organizations, please tell me for each one whether you are a member. (Stop reading when R. indicates those are the only memberships.)

- 1 American Birding Association
 - 2 Capital Area Audubon Society
 - 3 Cornell Lab. of Ornithology
 - 4 Kalamazoo Audubon Society
 - 5 Michigan Audubon Society
 - 6 National Audubon Society
 - 7 Sierra Club
 - 8 The Nature Conservancy
 - 9 Whitefish Pt. Bird Observatory
 - 10 World Wildlife Federation
 - 11 Do you belong to any other birding or conservation organization?
(If yes) which one? (Record answer)
-

Q. 23 I will now list some possible birding partners, please tell me which of those you have birded with most of the time in the past 12 months. The categories are not exclusive and you may choose more than one category.

- 1 By yourself
- 2 With a knowledgeable birder
- 3 With a friend or several friends
- 4 With one or more family members
- 5 With one or more fellow bird club members (but not as part of an organized outing)
- 6 With a birding club or nature/natural history organization as part of an organized outing
- 7 With none of the above (who is your birding partner_____)

I have just a couple of general questions about your birding.

Q. 24 Did you participate in a birding activity, such as the Christmas Bird Count or the Breeding Bird Survey, to promote knowledge and understanding about birds in the past 12 months?

- 1 Yes 2 No

Q. 25 Have you ever participated in a competitive birding event such as a Big Day or Big Year?

- 1 Yes 2 No

Q. 26 Have you ever served as a guide for organized birding field trips?

- 1 Yes 2 No

Section II: Birding Sites

In this next section I am presenting you 8 pairs of birding sites and would like you to tell me for each pair which birding site you prefer. In some cases you may not like either of the sites. If that is the case, I would like you to tell me the site with the characteristics that you find more acceptable or less unacceptable.

Here is the information sheet for you to look over (*provide information sheet*).

For the purposes of this study, it was necessary to simplify the information on the birding sites from what some birders may want to know about a site before deciding on whether to visit the site or not.

Let me give you some information about the birding sites. I will be repeating some of what you have read.

All sites have the following characteristics:

1. There is a trail system in place which provides **easy viewing access** in habitats where birds can be expected to be found.
2. The sites are **closed to motorized vehicles and mountain bikes** and **hunting and fishing are not allowed** at the sites.
3. **Bird checklists are not available.**
4. The **number of visitors** to the site is about the same for all sites. You will see some people on the trails, most of them will be birding.
5. The sites are **about the same distance** from your home. (*If asked how far: not any farther than you are willing to travel for a daytrip*).

Q. 27 Are you familiar with birding sites that have the features I just mentioned?

- 1 Yes
- 2 No

I will spend a few minutes to explain the site descriptions to you. Please look at the following table (*Point to top page and relevant items for respondent to follow along.*) In the upper part of the table you see information on the number of species recorded in the spring over the past 10 years, and in the lower part of the table the number of species you can expect at the site on a spring day.

The sites differ in the following ways:

- there are different numbers of warbler species,
- and there are different numbers of rare/unusual species, rare/unusual species are species not usually found in your area,
- you will also find different numbers of other species, that is species that are neither warblers nor rare/unusual species,
- when you add up these three categories you get the total number of species, which also varies across the sites,
- there are different abundance categories, designated by a capital letter. The abundance category only varies for warbler species which is why it is represented in its own column. The other codes are listed in the far left column .

At some sites the warblers appear in low numbers, that is indicated by the letter R, and at other sites they appear in high numbers, indicated by C. The abundance category for rare/unusual species is always R. Other species are evenly divided, into thirds, among the abundance categories, R, U, and C. The abundance codes are explained at the bottom of the sheet. R stands for rarely seen, U for present but not certain to be seen, and C for usually seen in proper habitat.

I would like you to note that there is a difference between a rare/unusual species and R as an abundance category. R as an abundance category just means that there are not many individuals of a species in this category found at the site in the spring. The species may be C, common, or U, uncommon, at other times of the year or at other sites.

- the habitat varies across the sites. Here I would like you to be aware that the less diverse habitat may still harbor a large number of bird species because it includes edge habitat where the forest habitat gradually changes to a different type of habitat.
- and different entrance fees are charged. The entrance fees are used to maintain the site for birds and birding. The difference in entrance fees does not reflect differences in services other than the characteristics listed in the table.

Q. 28 Do you have any questions about the site descriptions?

- 1 Yes (*follow up on questions*)
- 2 No

I would like to come back to the Information sheet for a minute. Please, look at the table in the middle of the sheet. (*Point to the relevant items*)

For the purposes of this study each abundance category is directly related to an expert's chance of seeing the species in that category at the site on a given day in the spring and it is also directly related to the number of individual birds that are present at the site on any given day in the spring. Your chance of seeing a bird may differ from a birding expert's chance because of differences in birding skills, for instance. To illustrate the relationships, for species in the abundance category C, which means: birds are usually seen in proper habitat, a birding expert's chance of seeing a species in that category at the site on a day in the spring is between 80 and 100%, and there will be between 31 and 101 individuals of the species at the site that day. Similarly you find the correspondence for species in the abundance categories U (uncommon) and R (rarely seen).

Q. 29 Thinking about your chance of seeing a species at a birding site, when you go birding would you be most interested in knowing the abundance category for the species, a birding expert's chance of seeing the species at the site, or the number of individual birds per species per day?

- 1 abundance category
- 2 expert's chance of seeing species
- 3 number of individuals

I would like you to consider a daytrip in the spring. Suppose, that this is the first birding trip for the season. It is a nice day, no rain is in the forecast. Assume that you have to decide between two areas that you have never visited before. Now, please review the birding site descriptions and tell me which site you prefer and why.

(After each site choice ask: Would you be interested in visiting your preferred site?)

		Site A	Site B	REASON	Yes	No
30	Scenario 1	☐	☐		☐	☐
31	Scenario 2	☐	☐		☐	☐
32	Scenario 3	☐	☐		☐	☐
33	Scenario 4	☐	☐		☐	☐
34	Scenario 5	☐	☐		☐	☐
35	Scenario 6	☐	☐		☐	☐
36	Scenario 7	☐	☐		☐	☐
37	Scenario 8	☐	☐		☐	☐

Q. 30 Now, I will read you a list of the birding site characteristics that appeared in the scenarios I just showed you. For each one, please tell me on a scale from 1-7, where one is not at all important, and 7 is very important, how important each one was for your choice of birding site.

	not at all imp.	1	2	3	4	5	6	very imp.
how important were warblers	1	2	3	4	5	6	7	
and how important were	1	2	3	4	5	6	7	
rare/unusual species								
how about the total number of	1	2	3	4	5	6	7	
species								
and the type of habitat given	1	2	3	4	5	6	7	
in the table?								
the entrance fees, how	1	2	3	4	5	6	7	
important were they								
and finally, how important	1	2	3	4	5	6	7	
were the abundance codes								

Next, I would like you to take a few minutes to fill out the following list of questions on how important a variety of considerations are for your birding activities. (Provide importance sheet)

Thank you very much.

In order to determine how representative our findings are with a larger group of birders than I am able to interview, we need you to fill out the following questions about yourself.

(Provide socio-demographic sheet) Thank you very much.

Section IV: Debriefing Questions

To conclude the interview, I would like to ask you a handful of questions about the birding site descriptions.

Overall, before reading the definitions of the terms used in the section on the choice of birding sites, how familiar were you with the terms?

VERY FAMILIAR FAMILIAR NOT FAMILIAR NOT AT ALL
FAMILIAR

Overall, how difficult or how easy was it for you to choose one site from each pair?

VERY EASY EASY DIFFICULT VERY DIFFICULT

Please, describe what was difficult about the choices?

When you selected a site from each pair of birding sites, did you look at the information on the species recorded in the spring over a 10-year period or the species you can expect at the sites on a spring day?

10-YEAR COUNT EXPECTED NO. OF SPECIES

How did the abundance category or categories enter into your choice of a birding site?

One last question:

What is the most you have ever paid for a daily entrance fee to go birding?

\$ _____

Thank you very much for your participation. Do you have any comments or questions about this interview?

Information Sheet

You are going on a **birding daytrip** in the **spring**. This is your **first birding trip of the season**. It is a **nice day**, no rain is in the forecast. Assume that you have to decide between two areas that **you have never visited before**.

All sites have the following characteristics:

- A trail system is in place which provides **easy viewing access** in habitats where birds can be expected to be found.
- The sites are **closed to motorized vehicles and mountain bikes** and **hunting and fishing are not allowed** at the sites.
- Bird **checklists** are not available.
- The **number of visitors** to the site is about the **same** for all sites.
- The sites are about the **same distance** from your home.

Terms in these columns have the same meaning in this study:

Abundance	Explanation in words	Birding expert's chance of seeing species at the site	Number of birds of the same species
C (common)	usually seen in proper habitat	80-100%	31-101
U (uncommon)	present, but not certain to be seen	21-79%	4-30
R (rare)	rarely seen	less than 20%	1-3

Rare/unusual species*: These species are not typically seen in your area.

Rare/ unusual species fall into the 'R' abundance category.

* **Note:** There is a difference between a rare/unusual species and R(are) as an abundance category. R as an abundance category just means that there are not many individuals of this species found at the site in the spring. The species may be common or uncommon at other times of the year or at other sites.

Other species: Other species are species that are neither warblers nor rare species. These species are evenly divided between the three abundance classes (common, uncommon, rare).

Number of species you can expect to have at the site in one day: some species have been seen at the site in the past 10 years but occur only infrequently at the birding site and they may not be at the site every day in the spring.

Habitat: The habitat may be very diverse (forest, wetlands, etc.) or less diverse (forest with edge). The less diverse habitat may still harbor a large number of bird species because it includes edge habitat where the forest habitat gradually changes to a different type of habitat.

Entrance fee: Entrance fees are charged at both sites to maintain and enhance the site for birds and bird-watching. The different fees do not reflect differences in services other than the characteristics listed in the table.

Q. 31 Different birders enjoy different things about birding. Please, indicate how important the following considerations are for your birding by circling the appropriate category.

For my birding ...		Level of Importance						
		not at all impor tant						very impor tant
		1	2	3	4	5	6	7
1	to study birds in their natural habitat is	1	2	3	4	5	6	7
2	to see rare bird species is	1	2	3	4	5	6	7
3	to get outdoors for a chance to enjoy the natural environment is	1	2	3	4	5	6	7
4	to challenge my birdwatching abilities is	1	2	3	4	5	6	7
5	to compete with other birdwatchers.....	1	2	3	4	5	6	7
6	the social interactions with others is.....	1	2	3	4	5	6	7
7	to contribute to society's general knowledge and understanding of birds is	1	2	3	4	5	6	7
8	to see new bird species is	1	2	3	4	5	6	7
9	to add species to a list is	1	2	3	4	5	6	7
10	to get away from everyday problems is..	1	2	3	4	5	6	7
11	to help others develop their birdwatching skills is	1	2	3	4	5	6	7
12	to photograph, draw, or paint birds in their natural habitat is.....	1	2	3	4	5	6	7
13	to be with family or relatives is	1	2	3	4	5	6	7
14	to see many different species of birds is	1	2	3	4	5	6	7
15	to contribute to the conservation of birds is.....	1	2	3	4	5	6	7

Section III: Sociodemographic Information

Q. 32 What is your gender?

- 1 Female
- 2 Male

Q. 33 What is your age group?

- 1 less than 20
- 2 20-29
- 3 30-39
- 4 40-49
- 5 50-59
- 6 60-69
- 7 over 69

Q. 34 What is your marital status?

- 1 Single
- 2 Married

Q. 35 What is your current or highest level of education?

- 1 Some high school
- 2 High school graduate or equivalent
- 3 Some college
- 4 Associate's degree
- 5 Bachelor's degree
- 6 Master's degree
- 7 Doctorate

Q. 36 Are you retired?

- 1 Yes
- 2 No

Q. 37 Do you have an occupation that allows you to spend some (or all) of your work-time birding?

- 1 Yes
- 2 No

Q. 38 Do you have any children less than 5 years of age?

- 1 Yes
- 2 No

Q. 39 What was your approximate 1997 pre-tax household income?

- 1 Under \$20,000
- 2 \$20,000-39,999
- 3 \$40,000-59,999
- 4 \$60,000-79,999
- 5 \$80,000-99,999
- 6 \$100,000-120,000
- 6 Over \$120,000

Interviewer Observations

Overall attitude of the respondent:

- 1 enthusiastic participation
- 2 cooperative
- 3 slightly resistant
- 4 very resistant

Overall understanding of the tasks required:

- 1 very good understanding
- 2 good understanding
- 3 some problems in understanding
- 4 substantial problems in understanding

Difficulty/Ease in choosing from pairs of scenarios:

- 1 generally easy
- 2 some minor difficulties (mark # scenario(s) if possible: _____)
- 3 some major difficulties (mark # scenario(s) if possible: _____)
- 4 generally difficult

Level of acceptance of entrance fee as payment vehicle:

- 1 no problem (e.g. no comments or questions about entrance fee)
- 2 minor problem (R. accepts entrance fee after minor comments or clarification)
- 3 major problem (R. has major reservations about entrance fee but completes tasks as specified)
- 4 rejection of entrance fee (R. rejects tasks, refusing to choose between sites because of entrance fee)

Level of effort made by R. to give meaningful answers (esp. to scenario choices):

- 1 substantial effort (R. weighs characteristics in scenario and takes time thinking about answers)
- 2 some effort (R. takes some time but gives up on some tasks)
- 3 lacking effort (R. gives up on tasks that require more than basic effort, refuses serious consideration)

Comments:

1 Which site do you prefer?

	Site A		Site B	
	Number of species	Abundance category	Number of species	Abundance category
Species recorded in the spring over the past 10 years	5	R*	25	C*
	30		6	
	75		201	
	1/3 in least abundant category (R)*			
	1/3 in middle abundance category (U)*			
On a spring day, you can expect this many species at the site	1/3 in most abundant category (C)*		231	
	Total number of species (warblers + rare/unusual + other)			
	110			
	Warbler species	0-1	22-23	
	Rare/unusual	3	0-1	
Habitat	Other species	36-39	99-102	
	Expected total	39-43	121-126	
	forest, wetlands, open water with sandy-gravel shoreline		forest with edge	
Entrance fee	\$1		\$28	

* R = rarely seen; U = present but not certain to be seen; C = usually seen in proper habitat

2 Which site do you prefer?

	Site A		Site B	
	Number of species	Abundance category	Number of species	Abundance category
Species recorded in the spring over the past 10 years	Warbler species		5	C*
	Rare/unusual species (R)*		30	
	Other species:		201	
	1/3 in least abundant category (R)*			
	1/3 in middle abundance category (U)*			
On a spring day, you can expect this many species at the site	1/3 in most abundant category (C)*		236	
	Total number of species (warblers + rare/unusual + other)			
	Warbler species	2-3	4-5	
	Rare/unusual	0-1	6-7	
	Other species	36-39	99-102	
Habitat	Expected total	38-43	109-114	
		forest with edge	forest, wetlands, open water with sandy-gravel shoreline	
Entrance fee		\$2	\$25	

* R = rarely seen; U = present but not certain to be seen; C = usually seen in proper habitat

3 Which site do you prefer?

	Site A		Site B	
	Number of species	Abundance category	Number of species	Abundance category
Species recorded in the spring over the past 10 years	Warbler species		25	R*
	Rare/unusual species (R)*	C*	30	
	Other species:		201	
	1/3 in least abundant category (R)*			
	1/3 in middle abundance category (U)*			
On a spring day, you can expect this many species at the site	1/3 in most abundant category (C)*			
	Total number of species (warblers + rare/unusual + other)	85	256	
	Warbler species	4-5	2-3	
	Rare/unusual	0-1	3	
Habitat	Other species	36-39	99-102	
	Expected total	40-45	104-108	
		forest, wetlands, open water with sandy-gravel shoreline	forest with edge	
Entrance fee		\$1	\$21	

* R = rarely seen; U = present but not certain to be seen; C = usually seen in proper habitat

4 Which site do you prefer?

	Site A		Site B	
	Number of species	Abundance category	Number of species	Abundance category
Species recorded in the spring over the past 10 years	Warbler species	C*	5	R*
	Rare/unusual species (R)*		5	
	Other species:			
	1/3 in least abundant category (R)*		201	
	1/3 in middle abundance category (U)*			
On a spring day, you can expect this many species at the site	1/3 in most abundant category (C)*			
	Total number of species (warblers + rare/unusual + other)		211	
	Warbler species	22-23		0-1
	Rare/unusual	6-7		0-1
	Other species	36-39		99-102
Habitat	Expected total	64-69		99-104
		forest with edge		forest, wetlands, open water with sandy-gravel shoreline
Entrance fee		\$30		\$3

* R = rarely seen; U = present but not certain to be seen; C = usually seen in proper habitat

5 Which site do you prefer?

	Site A		Site B	
	Number of species	Abundance category	Number of species	Abundance category
Species recorded in the spring over the past 10 years	Warbler species		25	C*
	Rare/unusual species (R)*		5	
	Other species:		75	
	1/3 in least abundant category (R)*			
	1/3 in middle abundance category (U)*			
	1/3 in most abundant category (C)*			
On a spring day, you can expect this many species at the site	Total number of species (warblers + rare/unusual + other)		105	
	Warbler species	0-1		22-23
	Rare/unusual	3		0-1
	Other species	99-102		36-39
	Expected total	102-106		58-63
Habitat		forest with edge		forest, wetlands, open water with sandy-gravel shoreline
Entrance fee		\$16		\$3

* R = rarely seen; U = present but not certain to be seen; C = usually seen in proper habitat

6 Which site do you prefer?

	Site A		Site B	
	Number of species	Abundance category	Number of species	Abundance category
Species recorded in the spring over the past 10 years	Warbler species	25	5	C*
	Rare/unusual species (R)*	5	30	
	Other species:	201	75	
	1/3 in least abundant category (R)*			
	1/3 in middle abundance category (U)*			
On a spring day, you can expect this many species at the site	1/3 in most abundant category (C)*			
	Total number of species (warblers + rare/unusual + other)	231	110	
	Warbler species	2-3	4-5	
	Rare/unusual	0-1	3	
	Other species	99-102	36-39	
Habitat	Expected total	101-106	43-47	
		forest, wetlands, open water with sandy-gravel shoreline	forest with edge	
Entrance fee		\$18		\$2

* R = rarely seen; U = present but not certain to be seen; C = usually seen in proper habitat

7 Which site do you prefer?

	Site A			Site B		
	Number of species	Abundance category		Number of species	Abundance category	
Species recorded in the spring over the past 10 years	Warbler species			25	R*	
	Rare/unusual species (R)*			30		
	Other species:			75		
	1/3 in least abundant category (R)*					
	1/3 in middle abundance category (U)*					
On a spring day, you can expect this many species at the site	1/3 in most abundant category (C)*			130		
	Total number of species (warblers + rare/unusual + other)					
	Warbler species	4-5		2-3		
	Rare/unusual	0-1		3		
	Other species	99-102		36-39		
Habitat	Expected total	103-108		41-45		
		forest with edge		forest, wetlands, open water with sandy-gravel shoreline		
Entrance fee		\$1		\$30		

* R = rarely seen; U = present but not certain to be seen; C = usually seen in proper habitat

8 Which site do you prefer?

	Site A		Site B	
	Number of species	Abundance category	Number of species	Abundance category
Species recorded in the spring over the past 10 years	Warbler species	C*	5	R*
	Rare/unusual species (R)*		5	
	Other species:		75	
	1/3 in least abundant category (R)*			
	1/3 in middle abundance category (U)*			
On a spring day, you can expect this many species at the site	1/3 in most abundant category (C)*		85	
	Total number of species (warblers + rare/unusual + other)			
	Warbler species	22 to 23		0 to 1
	Rare/unusual	3		0 to 1
	Other species	99 to 102		36 to 39
Habitat	Expected total	124 to 128		36 to 41
		forest, wetlands, open water with sandy-gravel shoreline		forest with edge
Entrance fee		\$25		\$1

* R = rarely seen; U = present but not certain to be seen; C = usually seen in proper habitat

APPENDIX B

BINOMIAL LOGIT REGRESSIONS

Table B-23: Biodiversity Indicators And Other Variables

Reported are coefficient estimates with standard errors in parentheses

Variable	Disaggregated	Species Richness	Species Richness	Margalef	Menhinick	Shannon's H	Simpson	McIntosh	Berger-Parker
Biodiversity Index		0.004** (0.001)	0.004** (0.001)	0.035** (0.0087)	0.420** (0.120)	0.505** (0.128)	0.008** (0.002)	9.233** (2.307)	0.008** (0.002)
No. of warblers	0.033** (0.007)								
No. of rare species	0.027** (0.005)								
No. of other species	0.0057** (0.001)								
Abundance of warb.	0.27** (0.10)	0.177 (0.097)							
Habitat	0.23* (0.10)	0.193* (0.097)	0.187 (0.096)	0.164 (0.096)	0.153 (0.095)	0.161 (0.096)	0.162 (0.096)	0.161 (0.096)	0.162 (0.096)
Entrance fee	-0.029** (0.0074)	-0.004 (0.005)	-0.003 (0.005)	-0.001 (0.005)	0.0002 (0.005)	0.0007 (0.005)	0.001 (0.005)	0.0009 (0.005)	0.001 (0.005)
Log Likelihood Fct.	-293.15	-305.64	-307.32	-308.43	-310.26	-308.67	-309.26	-308.44	-308.99
Correctly Predicted	64%	59%	59%	59%	58%	59%	59%	59%	59%
site A	56%	59%	59%	59%	58%	59%	59%	59%	59%
site B	72%	59%	59%	59%	58%	59%	59%	59%	59%

* significant at 95% confidence level; ** significant at 99% confidence level

Table B-24: Biodiversity Indicators and Entrance Fee

Reported are coefficient estimates with standard errors in parentheses

Variable	Disaggregated	Species Richness	Margalef	Menhinick	Shannon's H	Simpson	McIntosh	Berger-Parker
Biodiversity Index		0.004** (0.001)	0.034** (0.009)	0.419** (0.120)	0.497** (0.128)	0.006** (0.002)	9.093** (2.307)	0.007** (0.002)
No. of warblers	0.033** (0.007)							
No. of rare species	0.027** (0.005)							
No. of other species	0.0057** (0.001)							
Abundance of warb.	0.27** (0.10)							
Habitat	0.23* (0.10)							
Entrance fee	-0.029** (0.0074)	-0.002 (0.005)	-0.0005 (0.005)	0.0006 (0.005)	0.001 (0.005)	0.002 (0.005)	0.001 (0.005)	0.002 (0.005)
Log Likelihood Fct.	-293.15	-309.22	-309.90	-311.56	-310.09	-310.70	-309.86	-310.44
Correctly Predicted	64%	59%	59%	58%	59%	59%	59%	59%
site A	56%	59%	59%	45%	59%	59%	59%	59%
site B	72%	59%	59%	70%	59%	59%	59%	59%

* significant at 95% confidence level; ** significant at 99% confidence level

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