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An Analysis of the Sensitivity of a Regional Travel Cost Model to Variations in the Specification of Origin Zones

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AN ANALYSIS OF THE SENSITIVITY OF A REGIONAL TRAVEL COST MODEL TO VARIATIONS IN THE SPECIFICATION OF ORIGIN ZONES

by

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Over the last three decades, the regional travel cost model has emerged as an increasingly useful method for estimating the economic value of access to recreational sites. While considerable effort has been directed toward exploring the many nuances of the travel cost method, the sensitivity of model estimation to the specification of origin zones has rarely been investigated. This paper examines the sensitivity of a travel cost model to variation in the specification of origin zones from which anglers travel to visit a selection of nineteen Montana trout fishing streams.

The study relies upon a data set compiled by the Montana Department of Fish Wildlife and Parks and used in a study by Duffield *et al* (1987). The ZIPFIP computer program was used as a source of census data and to measure travel distance to each site from the zip code in which each trip originates.

A bivariate, double-log travel cost model was estimated using two different zonal specifications. Based upon the goodness of fit of the model, trip prediction, and benefit estimates, the model was found to be sensitive to the specification of origin zones. Zone scheme 1 produced a superior fit and predicted trips more accurately. Estimates of consumer surplus per trip were similar for the two zone schemes when the calculation used actual trips; when predicted trips were used, the estimates differed considerably. Comparisons with the results of the study by Duffield *et al* (1987) confirmed that the specification of origin zones and the method of measuring trip distance affect model estimates.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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CHAPTER 1

INTRODUCTION

Since its inception in the 1940's, the Travel Cost Model (TCM) has evolved into an important tool for the estimation of non-market benefits derived from recreation. Through both theoretical investigations and practical applications, the TCM has undergone continuous refinement. In the last two decades, research focusing on the TCM has appeared with increasing frequency in the natural resource economics literature. While many aspects of the TCM have been investigated, little attention has been directed toward the specification of origin zones from which visitors travel to a given site. This study examines the sensitivity of a regional TCM to variations in the specification of origin zones for trips to a selection of Montana fishing streams.

1.1 Setting for Recreation Valuation

The role of water figures prominently in discussions about factors which have shaped the history of the American

West.[1] Many of the West's most contentious battles have centered on management of this valuable resource in this largely arid region. Disputes over both consumptive uses of water and maintenance of instream flows persist as demands on water resources grow and become increasingly diverse.

Since World War II, water-based recreation has gained significance in American life and, hence, in resource allocation decisions.[2] The U.S. Water Resources Council (1983) has suggested that studies conducted by Federal water resources development agencies include recreation along with more traditional water uses required for water supply, agriculture, flood control, hydropower, and navigation. In Montana, the emergence of the sport of fly fishing has heightened awareness of the impacts of watershed management decisions on fisheries and riverine habitat.

The acknowledgement that recreation legitimately belongs among socially beneficial uses of water resources presents special challenges for the resource planner. The discipline of economics is well-equipped to determine efficient allocations of resources among uses which include market-determined prices. In properly functioning markets, the interaction among those who supply and those who demand goods results in the assignment of prices to the multitudinous

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[1] For recent historical discussions of water and the American West, see Hundley (1996), Wilkinson (1992), and Reisner (1986).

[2] See Knetsch (1974)

goods and services exchanged daily in a market-based economy. This price mechanism guides the rationing of scarce resources among competing demands for their use.

Typically, a value can be assigned to a resource by examining its value as an input in the production of a good which is exchanged on a market. The value of a recreational site as an input to a recreational experience, however, can not be determined so readily.[3] Unlike goods exchanged in markets, natural resources required for the production of a recreational experience are characterized by traits which define a particular type of market failure. If left to private markets, the supply of public goods such as national defense, environmental quality, and recreational areas would be insufficient to meet demand. Generally, governments rely on political processes to provide public goods at a level deemed appropriate for public demand.[4]

Pure public goods are said to exhibit non-excludability and to be non-rival--or indivisible--in consumption. Non-excludability means that individuals cannot be prevented from consuming the good. Consequently, many people, known as free-riders, can consume the good without paying for it. Public

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[3] Gibbons (1986) describes methods for estimating the value of water for a variety of uses.

[4] See the seminal articles on public goods by Samuelson (1954), (1955), and (1958) and the public finance text Musgrove (1959). For a selection of articles addressing various aspects of the public goods problem, see section III in Baker and Elliott (1990).

goods are non-rival in consumption in that consumption of the good by one person does not preclude consumption of the good by another. That is, the marginal cost of providing the good to additional consumers is zero.

Due to these characteristics, public goods will likely be under-supplied by private markets. The costliness or impossibility of excluding free-riders discourages firms from providing public goods; firms would have little incentive to provide services such as national defense or street lighting if they were unable to require payment from beneficiaries of the services. The zero marginal cost resulting from the non-rivalness characteristic implies an optimal price of zero. Since few firms provide goods at a zero price, the provision of public goods by some other means results in a Pareto change by providing benefits at no marginal cost. The degree to which each of these characteristics is present in a public good may vary. Nevertheless, the provision of public goods by private markets will not be optimal.

1.2 Methods of Recreation Valuation

While the matter of inadequate provision of public goods by private markets is often addressed by government, the problem of determining an optimal level of public goods provision persists. In the absence of an effective price mechanism, resolution of this problem requires the development of methods of valuation which may reliably reflect benefits accruing to society.[5]

For the valuation of recreation benefits, the U.S. Water Resources Council (1983) recommends the Unit Day Value (UDV) Method, the Contingent Valuation Method (CVM), and the Travel Cost Method (TCM). The CVM and TCM are considered to be preferable to the UDV which relies on tables of preassigned values for various recreational activities.

Through the employment of survey techniques, the CVM elicits consumers' willingness to pay (WTP) for a good on the hypothetical condition that a market for the good exists. Consumers are asked what they are willing to pay for such things as access to a recreational site. The method is widely used in estimating values for an array of non-market goods.

The TCM, described more fully below, uses costs associated with travel to a given site to estimate a lower bound for individuals' WTP for access to the site. The method has the advantage that it relies on consumers' market behavior to estimate WTP.

Additionally, hedonic pricing techniques are used to estimate the implicit prices of non-market attributes of a market commodity (the implicit price of environmental amenities in housing prices, for example). The hedonic TCM estimates visitors' WTP for individual characteristics of

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[5] Discussions of non-market valuation can be found in Ward and Duffield (1992); Pearce and Turner (1990); Bromley (1986); Desvouges, Smith and McGivney (1983); and Smith (1993a).

recreation sites.[6]

Each of these methods employs various econometric techniques to describe a demand curve for a good, such as recreational site access. Once a demand curve is estimated, consumer surplus, or the net benefits of the recreational site, can be derived. Consumer surplus is the difference between the amount a consumer of a good is willing to pay and the price of the good.[7] Since consumer surplus is also used to estimate the benefits obtained from market goods, a comparison of benefits from market and non-market goods is possible.

It is important to note that benefits derived from recreation do not comprise all of the non-market benefits provided by a recreational site. Values unrelated to direct use of a site also accrue to society. Non-use values include existence, bequest, and option value.[8] These values are derived from the knowledge that a resource exists, that a resource will benefit subsequent generations, and that the resource will be available for future use, respectively. The CVM is used to estimate non-use benefits. An estimate of the total value of a resource should include both use and non-use values.

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[6] See Brown and Mendelsohn (1984).

[7] For presentations on welfare economics, see Ward and Duffield (1992); Desvouges, Smith and McGivney (1983); and O'Connell (1982).

[8] See Krutilla (1967) and Walsh, Loomis, and Gillman (1984).

1.3 The Travel Cost Model

The notion of using travel costs as a proxy for price in describing a demand function for a recreational site was first suggested by Harold Hotelling in a letter to the United States Forest Service in 1947.[9] In that letter, Hotelling proposed that license plates of the cars in the parking lots at National Parks be surveyed to establish a relationship between visitation rates and travel distances for park visitors. The idea of using travel distance to represent price in a demand function was appealing because of its exploitation of the complementary link between a non-market good--access to a recreational site--and market goods required for travel.

The TCM was more extensively developed by Clawson and Knetsch in Economics of Outdoor Recreation (1966). The model requires data on travel costs, visitation rates from various locations, travel distances from visitors' homes to the recreational site, and population of the areas from which the visitors travel. A demand curve for access to the site is derived using travel costs as a proxy for price and the number of observed site visits to represent quantity demanded.

The TCM relies on some key assumptions. First, travel costs represent the visitors willingness to pay for access to the site. This assumption requires that fishing at a given site is the sole purpose of the trip. Second, travel time is costly. Time spent traveling is time not earning income or

[9] See Hotelling (1947)

participating in other activities. Omission of the cost of travel time results in an underestimation of benefits. Third, tastes and preferences and variable travel costs--including the opportunity cost of travel time--are constant across origin zones. In other words, recreationists at different distances from a site will respond similarly to changes in the cost of accessing the site. Fourth, time spent at the site is the same for all visitors. Fifth, there is no unobserved demand or capacity restriction due to congestion. These assumptions will be discussed in greater detail along with assumptions pertaining to model estimation.

To establish origin zones for site visitation, concentric circles emanating from the recreational site are defined. The areas between the concentric circles comprise the set of origin zones from which the site visits originate. Figure 1-1 displays an example of a set of origin zones for a site in Montana. Observed site visits are aggregated according to origin zone and the cost of travel and the average round-trip distance from each zone are calculated. Using zonal population and visitation data, visitation rates from each zone can then be determined.

Using ordinary least squares (OLS) or another regression technique, a "first stage" demand curve is estimated by expressing annual visitation as a function of travel distance from each zone. Given the relationship between visitation and travel distance established in the "first stage" demand curve,

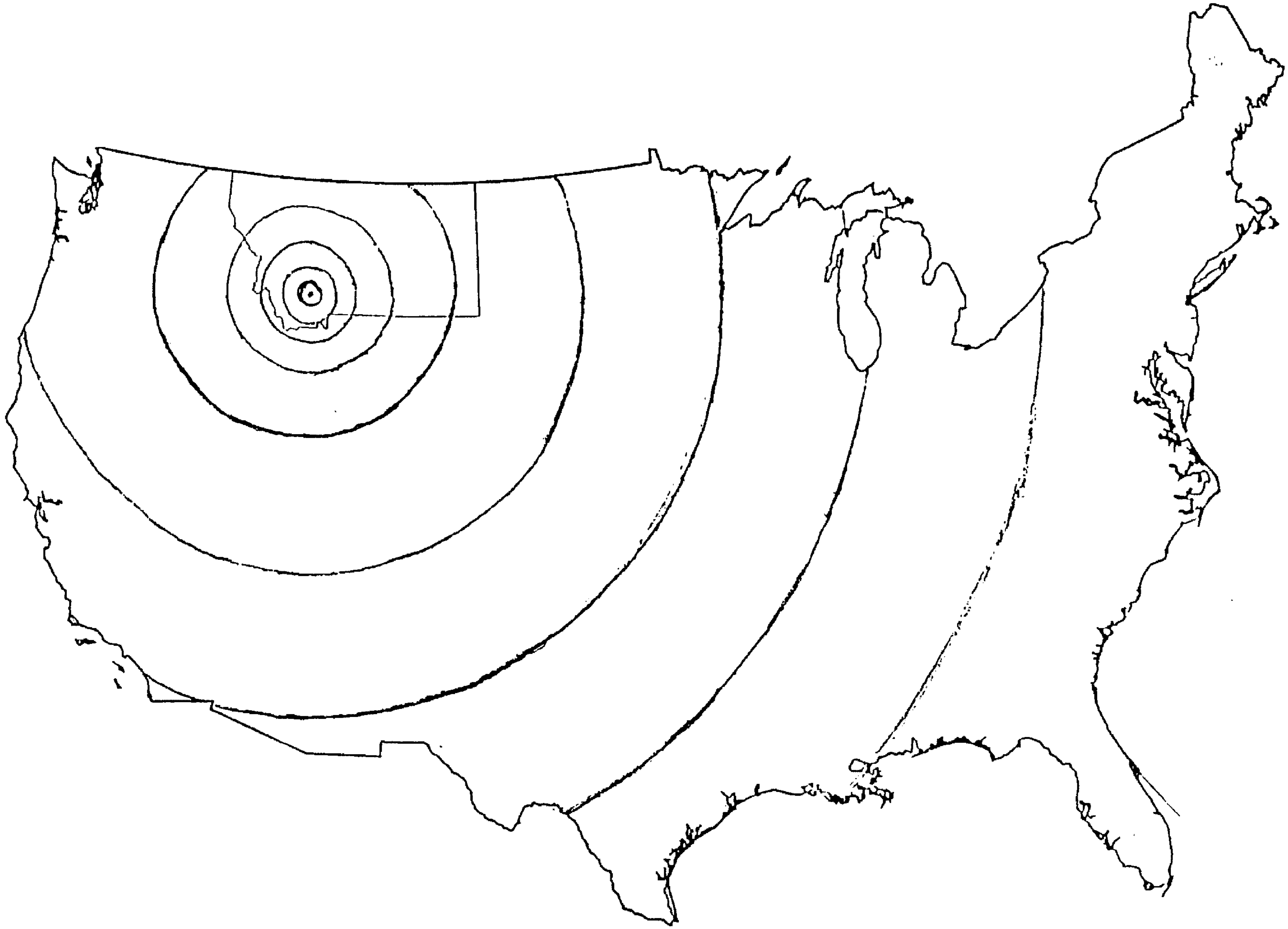

FIGURE 1-1: Example of a set of origin zones for a Montana site.

and assigning variable costs of travel to travel distance (in terms of both out-of-pocket expenses and the opportunity cost of time spent travelling), a "second stage" demand curve is estimated by calculating visitation when travel costs are increased by a constant amount for each origin zone.[10] These increased travel costs represent a hypothetical increase in admission price to a particular site. From this more familiar demand curve, net benefits derived from visitation to the recreational site can be estimated.

1.4 Purpose and Organization of Paper

The purpose of this paper is to examine the sensitivity of a regional TCM to variations in the specification of origin zones. It is expected that, as with other aspects of model specification, the specification of zonal schemes affects the results of benefit estimation. To test this hypothesis, data on visitation by fishermen will be used to estimate the net benefits of fishing for nineteen Montana fishing streams. The data set was compiled and used in previous studies by Duffield, Loomis, and Brooks (1987), Neher (1989), and Holliman (1993). Two zone schemes will be defined and benefit estimates using each scheme will be compared. Results will also be compared with those reported in the study by Duffield *et al* (1987).

[10] This step requires the assumption that tastes and preferences are homogeneous across origin zones--one of the fundamental assumptions of the TCM.

This paper is organized as follows:

Chapter 2 Review of Literature

This chapter discusses issues pertaining to the specification of a TCM as reflected in the literature. A discussion of the zoning schemes used in this study is included.

Chapter 3 Data Sources

The sources and preparation of the data are described in this chapter. A description of the ZIPFIP program is included.

Chapter 4 Model Estimation and Benefit Estimation

Diagnostic tests, the predictive power of the model, and benefit estimation are reported in this section. Results of the two zonal specifications are compared along with the results of the study by Duffield *et al* (1987).

Chapter 5 Conclusion

This chapter summarizes the results reported in the study. The chapter also includes suggestions for further investigation.

CHAPTER 2

REVIEW OF LITERATURE

Research efforts exploring the various aspects of the TCM have spawned an extensive body of literature and have led to the acceptance of the TCM as an important valuation technique in natural resource economics. This growing body of literature reflects the increasing scrutiny to which the various facets of TCM model specification have been subjected. The specification of origin zones in the regional TCM, however, has drawn little attention. This chapter reviews the literature pertaining to the specification of a TCM, including the definition of origin zones, and discusses the method of calculating net economic benefits used in this study.

2.1 Model Specification

Specification of a TCM requires consideration of the same factors which are common to the modeling of any demand function: the selection of the set of explanatory variables and the functional form of the demand equation.

Selection of Variables. The dependent variable in the TCM has been measured in terms of visits to a site and time spent at the site. McConnell (1975, 1992) contends that user-days is not an appropriate measure of quantity because the amount of time spent at the site is unrelated to the cost of travel to the site.[11] This study defines the dependent variable in terms of per capita site visits from an origin zone. The definition is consistent with the definition used by Duffield *et al* (1987) and allows for comparisons with that study.

Clawson and Knetsch, in an early work describing the TCM (Clawson and Knetsch (1966)), specified a bivariate model which described variations in visitation rates as a function of variations in travel distance. Numerous subsequent TCM studies have demonstrated that travel distance, the proxy for price, is the most significant variable in explaining visitation to a recreational site. In a stepwise analysis of a superset of the data used in this study, the parameter for travel cost was found to account for 85.72% of the variation in a model containing four explanatory variables yielding an R-square of .8694 (Neher (1994)). The travel distance parameter in this study will reflect the round-trip distance of automobile travel between the trip origin and destination site for trips made for the sole purpose of fishing at the site. Further discussion regarding travel distance and the

[11] Kealy and Bishop (1986) argue that on-site time should be included in the demand equation.

cost of travel will be provided in a subsequent section.

In addition to the proxy parameter for price--travel distance--TCM's frequently include several other variables which may explain variations in visitation to a site. For modeling a demand function, economic theory suggests the inclusion of variables representing income, price and availability of substitutes, and commodity attributes as well as socio-demographic variables. Inclusion of these variables in a TCM is often problematic due to measurement and data collection difficulties--particularly for sites which attract visitors from great distances.

Many TCM's include a variable representing income. Knetsch (1974) discusses the difficulty in selecting an appropriate variable to represent income. Perhaps because of this difficulty, the income variable was found to be insignificant in the study by Duffield *et al.*

The price and availability of substitutes are frequently included in models of demand functions for many commodities. The identification of substitutes for sites which attract visitors from great distances in a TCM, however, presents a formidable challenge. Those visiting Montana fishing streams from distant states may have hundreds of substitute sites from which to choose. Gathering data on each set of substitutes for each of thousands of visitors would be an extremely difficult task. In Duffield *et al* (1987), an index of substitute sites was constructed which used travel distances and trout catch information for Montana streams which serve as substitute sites for a given site. The variable for this index, which captures only a small portion of the relevant substitute sites for visitors from distant states, was not found to be significant.[12]

Theoretically, variations in demand for a good are explained in part by variations in the quality of the good. Certainly, demand for access to fishing sites in Montana is determined by particular site attributes. "Blue ribbon" streams such as the Madison River and Rock Creek enjoy fine reputations among anglers that are due to qualitative factors which include the scenic beauty of the surrounding landscape, water quality, and characteristics of the fish which inhabit the waters. Contributions of site attributes to site demand have been estimated for fish species (Vaughan and Russell (1982)), stream flow (Neher (1989), Loomis and Creel (1992)), and water quality (Caulkens, Bishop, and Bouwes (1986)). Duffield *et al* (1987) included site attribute variables which measured scenic quality, access, and stream characteristics. Of the eleven parameters estimated, none were found to be significant. As Ward and Duffield (1992) observe, modeling changes in site quality is difficult because measures of quality frequently do not correspond to individuals'

[12] See Cling (1989) and Smith (1993) for discussions regarding the omission of variables representing the price of substitutes.

perceptions of quality.[13]

Due to the difficulties of adequately modeling demand with these variables and because the travel distance parameter explains such a large portion of the variation in the dependent variable, a bivariate TCM will be used in this study. While a bivariate model is appropriate for the purposes of this study, it is important to note that excluding variables may have consequences. Pindyck and Rubinfeld (1991) describe how the omission of relevant variables may yield biased estimates when the included and excluded variables are correlated.[14]

Functional Form. This study will employ the double-log functional form as specified by Duffield *et al* (1987). Subsequent examinations of the functional form for the Montana stream data set by Duffield (1988) and Holliman (1993) suggest that the double-log form minimizes heteroscedasticity, provides a better fit of the data, and predicts trips better than other specifications. The double-log form is also advantageous because it can be interpreted as a demand elasticity and it eliminates the chance of predicting a negative number of trips.

The model to be estimated in this study is specified as

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[13] Ward and Duffield (1992) page 265.

[14] An alternative specification including dummy variables for each site is presented in Appendix F. The dummy variables provide a basis for inferences regarding relative site quality and substitutability among the sites.

follows:

$$\ln(VISITS_{ij}/POP_i) = \beta_0 + \beta_1 \ln(DIST_{ij}) + e_{ij}. \qquad (1)$$

Where:

$VISITS_{ij}$ = Observed fishing trips from origin I to site j
POP_i = Population of origin I
$DIST_{ij}$ = Round-trip distance from origin I to site j
e_{ij} = Error term

2.2 Specification of Origin Zones

No a priori basis exists for specifying origin zones for a TCM.[15] Clawson and Knetsch (1966) suggest that the definition of origin zones is largely determined by the extent of the market and the geographic distribution of visitors to a site.[16] They argue that the number of origin zones should be sufficient to trace out a demand curve while avoiding a large number of zero observations caused by specifying an excessive number of zones.

Clawson and Knetsch classified recreational sites in three categories: user-oriented; resource-based national

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[15] The alternative to the zonal TCM, the individual model, estimates the number of site-visits made by an individual. While it avoids the problem of heteroscedasticity and assumptions regarding homogeneous tastes and travel costs, the individual model does not consider participation levels for site-visits. For this reason, benefits can be overestimated. See Brown, Sokus, Chou-Yong, and Richards (1983).

[16] Smith and Kopp (1980) have argued that some of the assumptions of the TCM are less likely to apply as visitors from greater distances are included. These assumptions include: a single objective as the sole purpose of the trip; the time spent at the site being constant for all visitors; and the mode and corresponding costs of travel.

sites; and intermediate type. User-oriented sites are local facilities typically supporting activities such as golf, tennis, swimming, picnicking, walking, and softball. Resource-based recreation areas feature outstanding resources which often are quite distant from most users. Activities associated with these resources include sightseeing, hiking, camping, scientific and historical interest, hunting, and fishing. Intermediate areas fall somewhere in between these two and are typically non-remote destination sites appropriate for weekend trips.

Since they attract visitors from great distances, the Montana stream sample in this study is most similar to the resource-based national site category described by Clawson and Knetsch. In their examples of resource-based national sites they cited studies of visitation to the Grand Canyon, Glacier, and Shenandoah National Parks. For these studies, they defined the origin zones as follows:

less than 100 miles
100-300 miles
300-500 miles
500-1,000 miles
1,000-1,500 miles
1,500-2,000 miles
greater than 2,000 miles

This study will adopt the same zoning scheme in modeling visitation for the Montana stream sample. This zone scheme will be referred to as Zone Scheme 1.

The zonal scheme in the study by Duffield *et al* (1987) approximated a set of concentric circles by defining trip origins as single or multiple counties for in-state visits and single and multiple states for visits originating outside of Montana. For example, the nearest origin zones were individual counties either containing the site or adjacent to the county containing the site. More distant origin zones were formed by clustering counties. Similarly, individual states neighboring Montana served as origin zones while more distant states were clustered. The same distance was assigned to each site visit originating from within an origin zone. Chapter three contains a discussion of the computer program used in this study which provides a more precise method of measuring trip distances for each visit.

In his examination of the sensitivity of TCM estimates to variation in the specification of origin zones, Sutherland (1982) considered visitation by boaters to a collection of lakes in the Pacific Northwest. He aggregated his trip origin data by defining two sets of concentric circles, at 10-mile and 20-mile intervals from the recreation site. His criteria for comparing the effect of the zonal specification included: the coefficient of determination; estimates of consumer's surplus per trip; and trip prediction at zero price. Using a double-log functional form, he found that the mean R^2 for the 10- and 20-mile origin zone specifications were .627 and .643, respectively. Mean estimated consumer surplus per trip for each zonal specification were $55.93 and $81.76 and mean predicted trips at zero price were 256 and 248, respectively.

Actual trips were 166. These zone schemes yielded similar estimates for many sites but quite dissimilar estimates for some sites. Based on these criteria, Sutherland concluded that model estimation is sensitive to the specification of origin zones. He attributed the differences between the two schemes to the loss of degrees of freedom resulting from the aggregation of observations into larger zones.

This study will follow Sutherland's method for comparing zonal specifications by doubling the number of origin zones in Zone Scheme 1. Zone Scheme 2 will be specified as follows:

less than 50 miles	750-999
50-99	1,000-1,249
100-199	1,250-1,499
200-299	1,500-1,749
300-399	1,750-1,999
400-499	2,000-2,499
500-749	greater than 2,500 miles

If the results match those of Sutherland (1987), doubling the number of origin zones can be expected to produce estimates of the coefficient of determination and trip prediction which differ between the two zone schemes.

2.3 Cost of Travel

Estimating the benefits provided by a site requires the conversion of travel distance to variable travel costs. Because the price of travel is not directly observed, some assumptions are necessary to estimate a unit cost of travel. The soundness of these assumptions affect the accuracy of benefit estimates since the assignment of travel costs has a direct effect on benefit estimates.

Travel costs take two forms: expenditures associated with travel and the opportunity cost of travel time.

Variable costs of travel Numerous TCM studies follow the procedures for assigning out-of-pocket costs for travel recommended by the U.S. Water Resources Council (1983). This method relies on the U.S. Department of Transportation's (DOT) estimates for costs of vehicle operation. These estimates are based on the variable operating costs of new vehicles in an urban setting. The DOT estimate for operating a large vehicle is 15.2¢ per mile or 5.2¢ per mile per passenger based on an average of 2.76 passengers per vehicle.

Duffield *et al* sought information regarding travel expenditures as part of their Montana angler survey. By regressing reported variable transportation costs on reported round-trip distance, they determined that 22.4¢ per mile served as a conservative estimate of variable travel costs per passenger.[17] The reported cost estimate is preferable to the DOT estimate because the DOT estimate is based on new cars operated in an urban setting. Quite likely, vehicles used on fishing trips would be less fuel efficient cars closer to the national average of 7.4 years old driven under harsher road conditions. The estimate of the variable cost of travel used in this study is 22.4¢ per mile.

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[17] Ninety eight percent of the survey respondents reported that they traveled by personal vehicle.

Opportunity Cost of Travel Time. Two prominent early works on TCM (Knetsch (1963) and Cesario and Knetsch (1970)) discuss the downward bias of benefit estimates resulting from models which omit travel time from the model. Many TCM studies use some portion of the wage rate to serve as a proxy for the opportunity cost of time spent away from work or not engaged in other leisure activities.[18] In one influential effort, Cesario (1976) estimated that the cost of travel time fell between one-fourth and one-half of the wage rate. Following Cesario, the U.S. Water Resources Council (WRC) has suggested that one-third the wage rate be used in TCM benefit estimates. The TCM literature reflects the considerable effort devoted to improve on Cesario's method.[19] Consensus regarding a more appropriate method, however, is yet to emerge.

In their survey, Duffield *et al* (1987) inquired about anglers' willingness to pay to shorten their reported travel time by one-half. An analysis of their responses revealed that the opportunity cost of travel time for respondents was

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18 A particularly troublesome aspect regarding the cost of travel time concerns assumptions about the utility or disutility derived from travel to a recreation site. To the extent that recreators perceive travel as pleasant or burdensome, travel time may be considered less or more costly.

19 McConnell and Strand (1981) and Smith, Desvouges, and McGivney (1983) have attempted to determine the appropriate portion of the wage rate which represents the opportunity cost of travel time for recreation. Other efforts (Bockstael, Strand, and Hanemann (1987) and McKean, Johnson, and Walsh (1995)) have addressed the generally unrealistic assumption that recreators substitute time and money at the margin.

approximately one-fifth of the reported household wage rate ($2.06 per hour). This rate corresponds to 4.6¢ per mile (assuming an average travel speed of 45 miles per hour).

To avoid multicolinearity in the zonal TCM, variables for variable travel cost and travel time are typically combined in one travel cost term. This study uses the estimate developed by Duffield *et al* which combines the estimate for the variable cost of travel (22.4¢ per mile) with the cost of travel time (4.6¢ per mile) to produce an estimate of 27¢ per mile for the cost of travel.

2.4 Estimation of Benefits

Benefits will be estimated by the same method employed by Duffield *et al* (1987). In that study, the first stage demand curve was directly integrated for each origin-zone pairing with the upper level of integration defined as that distance which drives visitation to less than one.[20] This upper level was approximated as the sum of the maximum observed distance and the observed distance for the current origin-zone pairing. The net benefit for a given site is equal to the population-weighted sum of the net benefits for each zone multiplied by the cost of travel per mile (27¢). The steps for this procedure are detailed in Chapter 4.

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[20] Menz and Wilton (1983) have shown that this first-stage method produces the same results as a more conventional method which calculates consumers surplus from a second-stage demand curve.

CHAPTER 3

DATA SOURCES

The data used for model estimation in this study pertain to fishing pressure on 19 Montana waters for 1985. The data were obtained from two sources. The fishing pressure data were drawn from the database used in the TCM study of fishing in Montana by Duffield *et al.* (1987). Census data and travel distances were obtained through the ZIPFIP database package developed by the Economic Research Service of the U.S. Department of Agriculture (USDA 1992). This chapter will discuss the sources of the data and the process of transformation required to produce data sets suitable for the estimation of the regional TCM.

3.1 Fishing Pressure Data

The database on fishing pressure in this study is a subset of the database developed for a TCM study of fishing activity on forty-eight rivers, streams, and tributaries in Montana for the year 1985 (Duffield *et al* (1987)). That database was compiled from the Montana Statewide Angling

Pressure Mail Survey (McFarland 1989) conducted by the Montana Department of Fish, Wildlife and Parks (DFWP) from 1982-1985 and a subsequent telephone survey in 1985.

The DFWP mail survey consisted of a questionnaire sent to random samples of 1,500 resident and 100 non-resident Montana fishing license holders each month. The questionnaire was sent within one month of the purchase of the fishing license and requested information regarding the location of the angler's fishing activity, the number of fish caught and kept, the main purpose of the trip, the round-trip distance traveled, the number of days spent at the site and the angler's location of residence. To reduce memory bias, in 1984, the survey mailings, or waves, were changed from monthly to semi-monthly during the months of high fishing pressure (May to October). In 1985, the samples of residents and non-residents were doubled to 3,000 and 250 per month, respectively. For 1985, the response rate for residents was 41% (15,277 of the 36,969 surveys mailed) and 48% (3,834 of the 7,914 surveys mailed) for non-residents. For the 19 rivers and streams[21] considered in this study, 1,269 responses were received from residents and 1,043 from non-residents. Descriptions of these 19 rivers and streams are contained in Table 3-1 along with the number of visits to each of the waters. The location of each of the 19 waters in the study can be found on the map in figure 3-1.

[21]The East Gallatin was excluded due to low visitation.

TABLE 3-1: 19 MONTANA WATERS[1]

RIVER NUM	RIVER	DEFINITION	ZIP CODE/ TOWN	#VISITS
1	Beaverhead	Mainstem	59725/Dillon	133
2	Big Hole	Mainstem	59743/Melrose	179
3	Bitterroot	Mainstem to confluence of E. and W. Forks	59840/Hamilton	64
4	Blackfoot	Mainstem	59823/Bonner	99
5	Boulder	Mainstem	59011/Big Timber	50
6	Bighorn	Mainstem	59034/Hardin	161
7	Upper Clark Fork	Mainstem above Milltown	59722/Deer Lodge	69
8	Middle Clark Fork	Mainstem Milltown to Paradise	59801/Missoula	112
9	Upper Flathead	Mainstem Flathead Lake to confluence of S. Fork	59912/Columbia Falls	53
10	Gallatin	Mainstem	59730/Gallatin Gateway	216
11	Kootenai	Mainstem	59923/Libby	93
12	Madison	Mainstem	59729/Ennis	441
13	Missouri	Mainstem Holter to Cascade	59421/Cascade	246
14	Rock Creek	Mainstem (near Missoula)	59825/Clinton	89
15	Smith	Mainstem	59485/Ulm	34
16	Stillwater	Mainstem (near Absarokee)	59001/Absarokee	93
17	Swan	Mainstem	59826/Condon	27
18	Upper Yellowstone	Mainstem Springdale to Gardner	59047/Livingston	24
19	Mid. Yellowstone	Mainstem Springdale to confluence with Bighorn	59101/Billings	106

[1] Source: Duffield *et al* (1987, table 1.) and author.

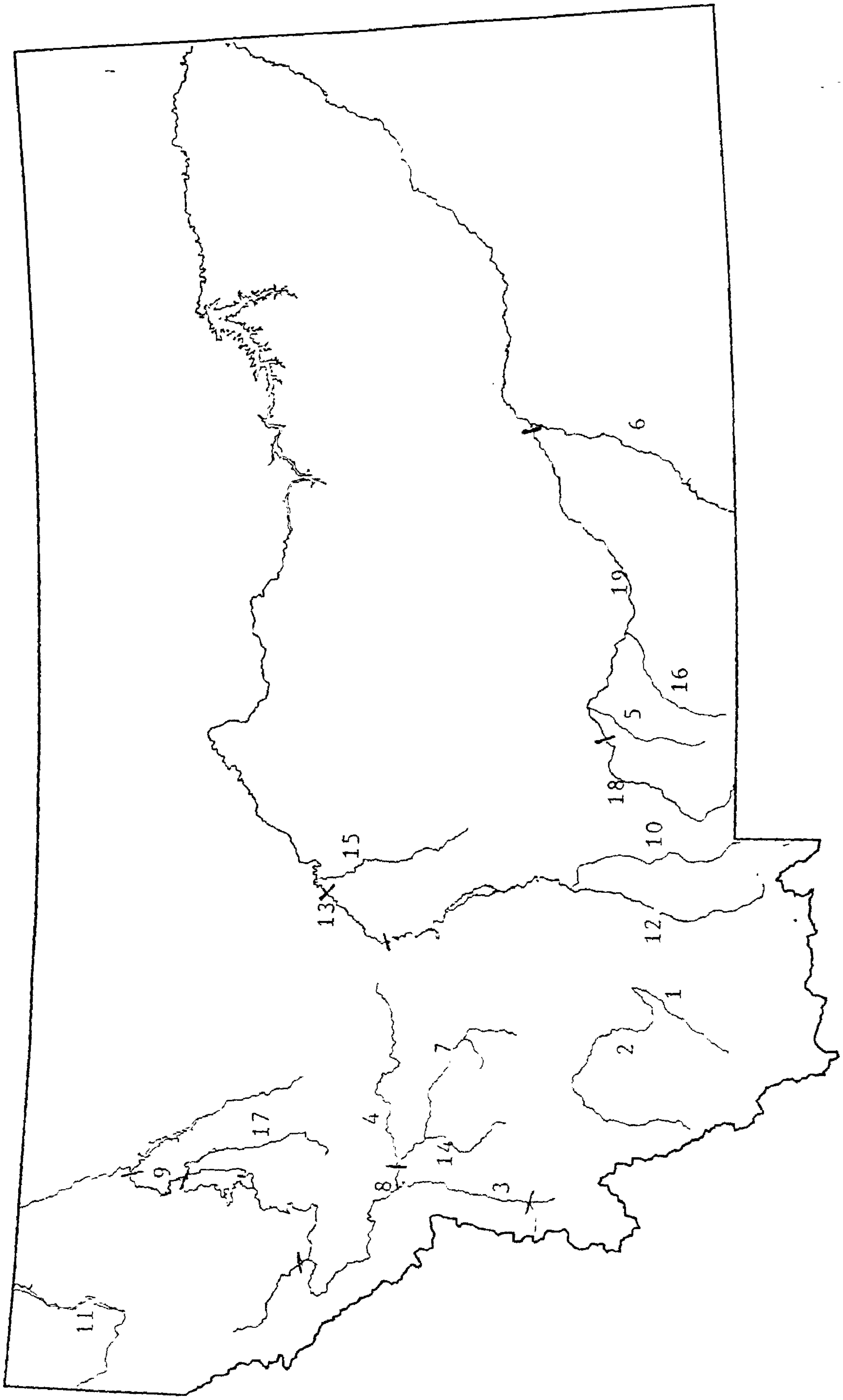

FIGURE 3-1: 19 MONTANA WATERS

These surveys were sorted to remove those responses which indicated that the license holder had not fished during the survey period (wave); that the license holder had fished at more than one site; or that fishing was not the primary purpose of the trip. The deletion of these records from the database is in accordance with a fundamental procedure for implementing the TCM: in order for the cost of travel to be interpreted as a proxy for the price of visiting a site, travel costs must be limited exclusively to those costs required to gain access to a particular site. In the case of multiple destination trips, the allocation of travel costs among the various destinations would be highly problematic. Elimination of these records from the database results in an understatement of site benefits.

A telephone survey of 1,600 residents and 400 non-residents was administered by the DFWP from September through October of 1985 to supplement the database used in the Net Economic Value of Fishing in Montana study. In this survey, socio-economic data and information regarding travel costs and site characteristics and activities were gathered. This data was appended to the data on origin zones, travel time and costs and fishing sites. The overall response rate was 75%.

As mentioned previously, the database used in this study is a subset of the database developed for the study by Duffield *et al* (1987). This subset consists of fishing pressure on the 19 rivers and streams for 1985. To produce this subset, a short SPSS program was created which selected the 19 rivers and streams from the 1985 fishing pressure database and included fields for an angler's residence status, the zip code of the angler's residence, an angler identification number and a river code for the river visited. The database was then modified so that records of multiple fishing days by one particular angler on the same river during the same wave were aggregated into one multi-day fishing trip. This method of aggregation was chosen to provide a consistent measure of the units of quantity in the TCM demand function (site visits). The method probably is appropriate for non-resident anglers; visits to a fishing site during the same wave probably took place during the same trip. However, it is likely that it understates the number of trips for residents living close to a site who may make several trips to a site during a wave.

3.2 ZIPFIP

ZIPFIP (USDA 1992) is a program which allows the manipulation of census and locational data at the ZIP code and county levels. It is used in this study to calculate a round-trip distance between the origin and destination of each angler's fishing trip and to estimate the population of each zone in the TCM.

One of the advantages of this study over previous TCM studies is the accuracy of the measurement of the distance traveled by each angler. This is made possible by the ability of ZIPFIP to estimate road distances between two ZIP codes. The database of geographic locations for each ZIP code was developed by the U.S. Department of Agriculture, U.S. Forest Service Outdoor and Wilderness Group and MELISSA Data Corporation. ZIPFIP uses latitude and longitude pairings of the origin and destination ZIP codes and a "circuity factor" (a correction for the deviation of road distance from the straight distance between the two locations) to calculate road distances.

ZIPFIP also contains data from the 1990 census at the ZIP code level. The program provides a scaling option to convert the data to correspond to a particular year. For this study, the data was scaled to 1985 levels. ZIPFIP has the capability of using this database to generate estimates of population for each zone. It accomplishes this by aggregating ZIP codes located in a specified zone and reporting the number of households in each ZIP code in the zone. A dBASE program was created to estimate the population of each zone by calculating the total number of households in each zone and multiplying this sum by the average number of individuals per U.S. household (2.66) as estimated by the U.S. Census Bureau.

3.3 Preparation of Data for Model Estimation

Several steps were required to prepare the data for estimation of the various specifications of the TCM examined in this study. The main steps were: calculating round-trip distances between origins and destinations of fishing trips; aggregating the records of fishing trips into the appropriate zones for each river; and compiling the data on visitation, population of origin zone and distance traveled for each river/zone pairing.

In order to calculate the distance traveled for each fishing trip, it was necessary to assign a ZIP code to each trip destination. This was done by selecting the ZIP code corresponding to an area on the river subjected to high fishing pressure. (Table 3-1 includes the ZIP code assigned to each river and the location of the ZIP code.) This method presents problems for accurately measuring the distance traveled on a fishing trip. Most rivers in Montana stretch for considerable distances and offer many sites which attract anglers. It is likely that many anglers residing in the same ZIP code as that assigned to a particular river might travel several miles to fish a different section of the river. The calculated distance of these trips, however, would be zero miles. On the other hand, someone residing on the banks of the same river but in a different ZIP code may have a calculated fishing trip distance of several miles. To a certain extent, these disparities between calculated and actual distance traveled would cancel each other out. The problem, of course, diminishes considerably for fishing trips originating from more distant locations. One way of more accurately measuring distance traveled would be to inquire on the survey about the specific fishing destinations on each river and assigning ZIP codes to these locations.

Once these ZIP codes were assigned, the data for each river was loaded into a spreadsheet. These spreadsheets were loaded into ZIPFIP so that round-trip distances could be calculated. The data in the spreadsheets were disaggregated further to correspond to the zones specified by the zoning schemes. The number of visits and the average round-trip distance traveled were calculated for each river/zone pairing. These figures were loaded into a table along with the data on population for each origin zone calculated by ZIPFIP. The resulting data set contained fields for number of visits, average round-trip distance traveled and population for each river/zone pairing for the 19 rivers and streams. Appendix A presents tables of the visitation, distance, and population data for each river/zone pairing.

TABLE 3-2: DESCRIPTIVE STATISTICS FOR VARIABLES OF ZONE SCHEMES 1 AND 2

VARIABLE N.	DESCRIPTION	MEAN	STD.DEV.	MIN.	MAX.	
Visits	Zonal Agg'ed Trips-(1)	18.46	28.366	1	200	124
Visits	Zonal Agg'ed Trips-(2)	10.45	18.357	1	154	219
Pop	Zonal Agg'd Pop(000)-(1)	35,148	37,467	74	.1185E+6	124
Pop	Zonal Agg'd Pop(000)-(2)	22,387	32,590	8	.1927E+6	219
Vpc	Zonal Agg'd Visits/Pop-(1)	.0685	.1913	.916E-5	1.345	124
Vpc	Zonal Agg'd Visits/Pop-(2)	.1108	.4188	.749E-5	3.778	219
Dist	Zonal Agg'd Avg R-T Dist-(1)	1,826	1,623	27	6,913	124
Dist	Zonal Agg'd Avg R-T Dist-(2)	1,729	1,574	3	6,913	219
Lvpc	Log of Vpc-(1)	-6.8866	3.3064	.916E-5	1.3245	124
Lvpc	Log of Vpc-(2)	-6.6869	3.3202	-11.802	1.3291	219
Ldist	Log of Dist-(1)	6.8316	1.4565	3.295	8.8412	124
Ldist	Log of Dist-(2)	6.7551	1.5046	1.098	8.8412	219
Sumdays	Sum of days for each visit in each wave	1.87	1.49	1	18	2,337

CHAPTER 4

MODEL AND BENEFIT ESTIMATION

To assess the effect of varying the definition of origin zones on the regional TCM, the model was estimated using the two zoning schemes described in Chapter 2. These estimates were then used to calculate net benefits for fishing on the 19 waters. This chapter includes: a discussion of the estimates generated by the model; the diagnostic tests performed on these estimates; the predictive power of the model; and a comparison of the net benefits calculated for each zoning scheme with the results of the study by Duffield *et al* (1987).

4.1 Model Estimation

The model estimated in this study is the first-stage demand function for a bivariate regional TCM. As discussed in

Chapter 2, the double-log specification was selected as the functional form for the model used in this study. The specification of the model estimated appears in equation (1).

$$\ln(VISITS_{ij}/POP_i) = \beta_0 + \beta_1 \ln(DIST_{ij}) \qquad (1)$$

Where:

$VISITS_{ij}$ = Observed fishing trips from origin zone i to site j
POP_i = Population of origin zone i
$DIST_{ij}$ = Round-trip distance from origin zone i to site j

As presented in Chapter 2, Zone Scheme 1 described seven origin zones for each river destination. In cases where there were no visitors from an origin zone, the zone was combined with the neighboring zone nearer to the site which contained site visitors. This was done to avoid gaps in the set of concentric zones emanating from the recreation site. The resulting "super zone" contained the total population and number of visitors of the combined zones.

The results of the model estimation using Zone Scheme 1 follow:

$$\ln(VISITS_{ij}/POP_i) = 7.6946 - 2.1473 \ln(DIST_{ij}) \qquad (2)$$

(t)	(14.771)	(-28.787)
[se]	[.5209]	[.0746]

Adj R^2 = .8706 F = 828.672 N = 124

The coefficient for round-trip distance--the proxy for price in the TCM--displays the expected negative sign indicating that the rate of visitation declines as distance from the site--or the price of accessing the site--increases. The coefficient can be interpreted to mean that a one percent change in distance implies a 2.1473 percent change in the visitation rate. This relationship is displayed graphically as a scatter plot in Figure 4-1. The plot suggests that the double-log specification is the appropriate functional form for the model. The t-statistics show that both coefficients are significantly different from zero. The adjusted R^2 value of .8706 is quite high suggesting that a large portion of the variation of the visitation rate is explained by the model. This value for adjusted R^2 appears to be particularly high considering that this is a bivariate model; hence, variation in the log of the travel distance variable explains 87% of the variation in the log of the visitation rate.

The model was estimated again using Zone Scheme 2. As previously described, these zones were derived by halving the zones in Zone Scheme 1 in the manner suggested by Sutherland (1982) to test the sensitivity of the TCM to variations in the specification of origin zones. The results of this estimation

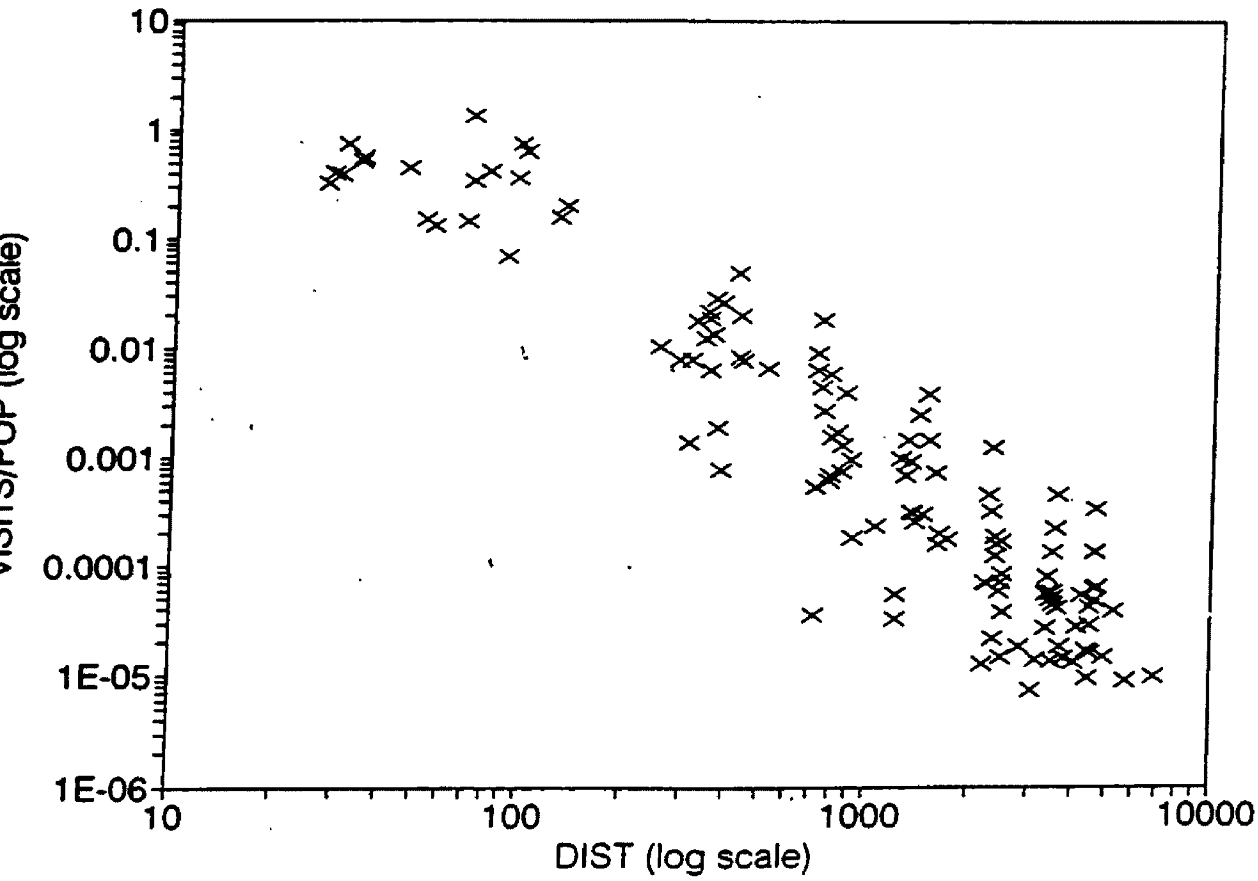

Figure 4-1: Plot of ln(VISITS/POP) on ln(DIST) for Zone Scheme 1

follow:

$$\ln(VISITS_{ij}/POP_i) = 7.0372 - 2.0317 \ln(DIST_{ij}) \quad (3)$$

(t)	(17.395)	(-34.751)
[se]	[.4046]	[.0585]

Adj R^2 = .8470 F = 1207.64 N = 219

Again, the coefficient for round-trip distance displays the expected negative sign and is highly significant. A one percent change in distance implies a change in the visitation rate of 2.0317 percent. The scatter plot in Figure 4-2 presents the relationship between round-trip distance and the visitation rate. Though not as high as that calculated for Zone Scheme 1, the adjusted R^2 is quite high at .8470. The higher t and F statistics are related to the lower standard errors which very likely are a result of the greater number of observations used to estimate the model (219 observations for Zone Scheme 2 as opposed to 124 for Zone Scheme 1).

4.2 Diagnostic Tests

An important step in model estimation includes subjecting the model to diagnostic tests to determine whether the model conforms to the assumptions of the OLS method. Of special interest are those diagnostic tests which analyze the

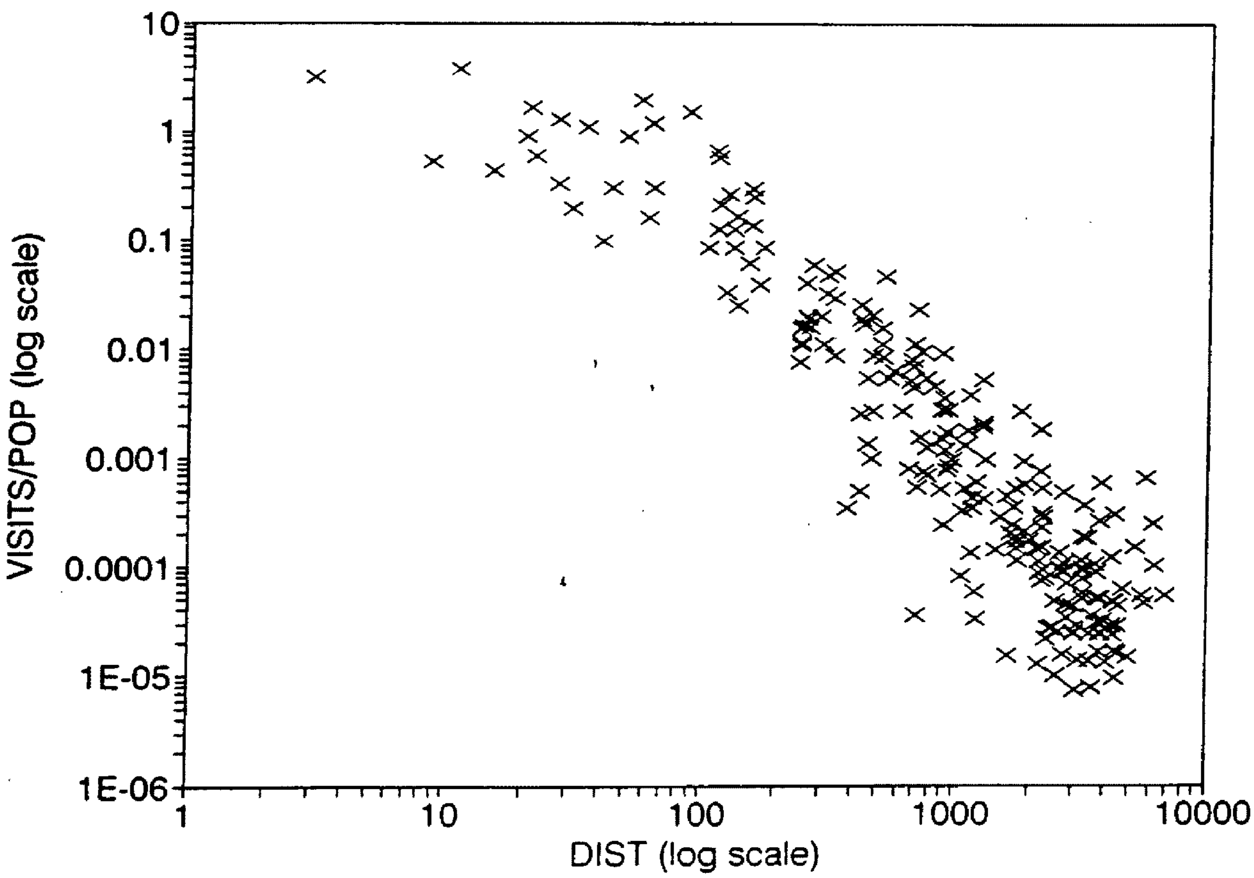

Figure 4-2: Plot of ln(VISITS/POP) on ln(DIST) for Zone Scheme 2

residuals to confirm that the model adheres to the assumptions of normality and homoscedasticity.

The normality assumption holds that the error term is normally distributed around a mean of zero. In other words, influences on the dependent variable which are excluded from the model--and, consequently, reflected in the error term--are not systematically related to the dependent variable. Plots of the residuals in Figures 4-3 and 4-4 show that generally the assumption of normality is valid. Results of the Jarque-Bera test confirm the validity of the normality assumption.[22]

A common problem afflicting models which use cross-sectional data, such as the TCM, is violation of the assumption of homoscedasticity--or constant variance of the residuals. The consequences of non-constant variances of the residuals--or heteroscedasticity--are OLS parameter estimators which are unbiased and consistent but not efficient.[23] As a result, inferences derived from t and F tests and confidence

[22] Jarque and Bera (1987).

[23] Estimators are unbiased, consistent, and efficient when the expected value of the estimator is equal to the parameter itself; the probability distribution of the estimator approaches the true parameter as the sample size increases; and the estimator has minimum variance, respectively. See Pindyck and Rubinfeld (1991) for a discussion of these terms.

```
HISTOGRAM - ERR1
  PCT.    N
 0.395   49  I
 0.379   47  I
 0.363   45  I                    XXXXXXXXXX
 0.347   43  I                    XXXXXXXXXX
 0.331   41  I                    XXXXXXXXXX
 0.315   39  I                    XXXXXXXXXX
 0.298   37  I                    XXXXXXXXXXXXXXXXXXXX
 0.282   35  I                    XXXXXXXXXXXXXXXXXXXX
 0.266   33  I                    XXXXXXXXXXXXXXXXXXXX
 0.250   31  I                    XXXXXXXXXXXXXXXXXXXX
 0.234   29  I                    XXXXXXXXXXXXXXXXXXXX
 0.218   27  I                    XXXXXXXXXXXXXXXXXXXX
 0.202   25  I                    XXXXXXXXXXXXXXXXXXXX
 0.185   23  I                    XXXXXXXXXXXXXXXXXXXX
 0.169   21  I                    XXXXXXXXXXXXXXXXXXXX
 0.153   19  I          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.137   17  I          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.121   15  I          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.105   13  I          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.089   11  I          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.073    9  I          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.056    7  I          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.040    5  I          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.024    3  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.008    1  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
             I---------I---------I---------I---------I---------I---------I
            -3.60     -2.40     -1.20    -0.283E-14  1.20      2.40      3.60
```

Figure 4-3: Histogram of standardized residuals for Zone Scheme 1

```
HISTOGRAM - ERR1
  PCT.      N
 0.443     97  I
 0.425     93  I
 0.406     89  I
 0.388     85  I
 0.370     81  I                    XXXXXXXXXX
 0.352     77  I                    XXXXXXXXXX
 0.333     73  I                    XXXXXXXXXX
 0.315     69  I                    XXXXXXXXXX
 0.297     65  I                    XXXXXXXXXXXXXXXXXXXX
 0.279     61  I                    XXXXXXXXXXXXXXXXXXXX
 0.260     57  I                    XXXXXXXXXXXXXXXXXXXX
 0.242     53  I                    XXXXXXXXXXXXXXXXXXXX
 0.224     49  I                    XXXXXXXXXXXXXXXXXXXX
 0.205     45  I                    XXXXXXXXXXXXXXXXXXXX
 0.187     41  I                    XXXXXXXXXXXXXXXXXXXX
 0.169     37  I                    XXXXXXXXXXXXXXXXXXXX
 0.151     33  I                    XXXXXXXXXXXXXXXXXXXX
 0.132     29  I                    XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.114     25  I          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.096     21  I          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.078     17  I          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.059     13  I          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.041      9  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.023      5  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 0.005      1  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
               I---------I---------I---------I---------I---------I---------I
              -3.89     -2.59     -1.30      0.380E-14 1.30      2.59      3.89
```

Figure 4-4: Histogram of standardized residuals for Zone Scheme 2 intervals are unreliable.

Two methods were used to detect the presence of heteroscedasticity: a graphical method and the Glejser test.[24] The plots of the squared residuals on the natural log of round-trip distance (Figures 4-5 and 4-6) were examined to determine whether a systematic relationship existed between the residuals and the explanatory variable. Heteroscedasticity does not appear to be present for Zone Scheme 2. For Zone Scheme 1, however, the plots suggest a mild correlation between the squared residuals and the natural log of round-trip distance.

To test further for the presence of heteroscedasticity, the Glejser test was performed on the model. The Glejser test proposes regressing the absolute value of the error term on various functional forms of the explanatory variable. Appendix B displays the results of the Glejser test. When the test was run, no heteroscedasticity was detected for Zone Scheme 1 whereas slight heteroscedasticity was detected for Zone Scheme 2. Appendix C shows the results when White's correction was applied to the models. As a practical matter,

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[24] See Gujarati (1988) for a discussion of the various methods of detecting heteroscedasticity.

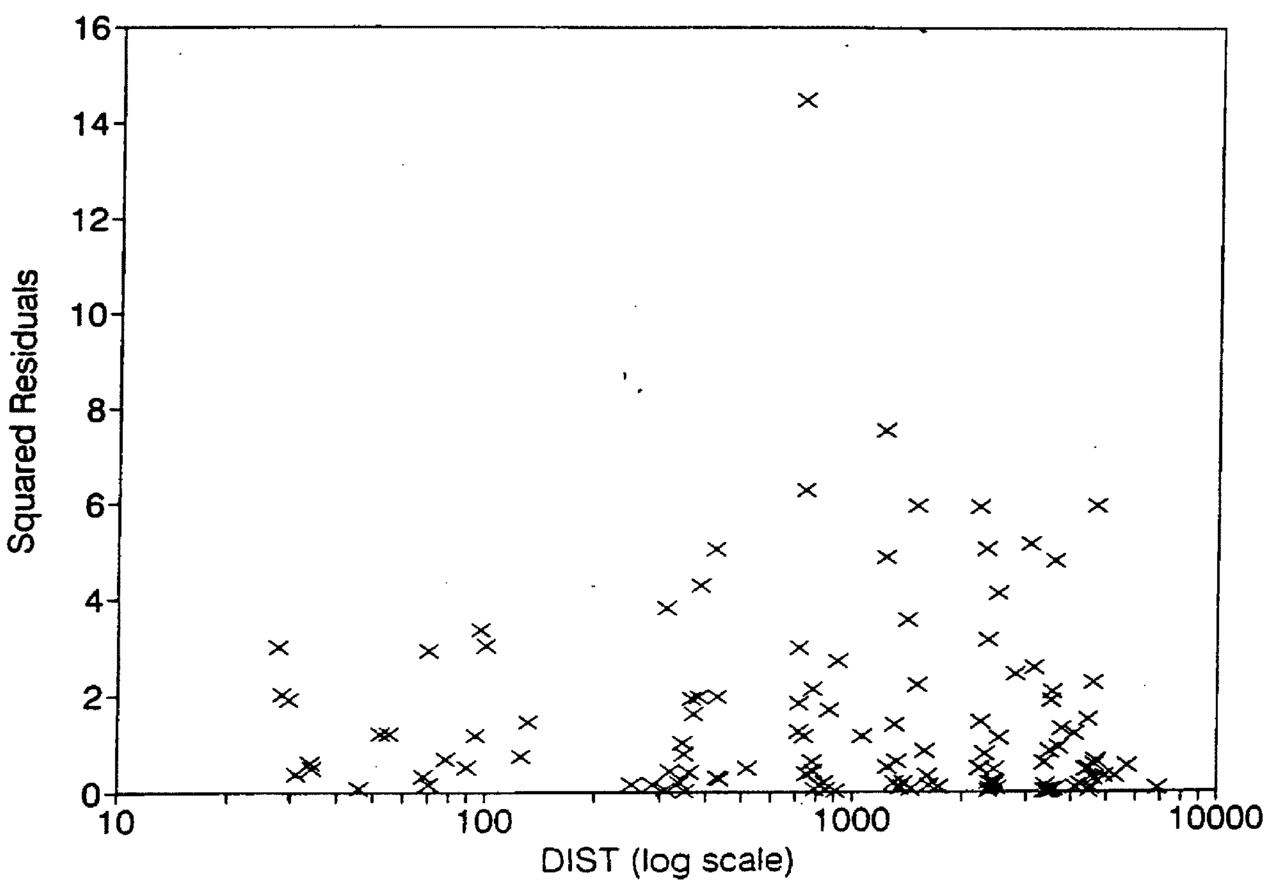

Figure 4-5: Plot of squared residuals on Natural Log of round-trip distance for Zone Scheme 1

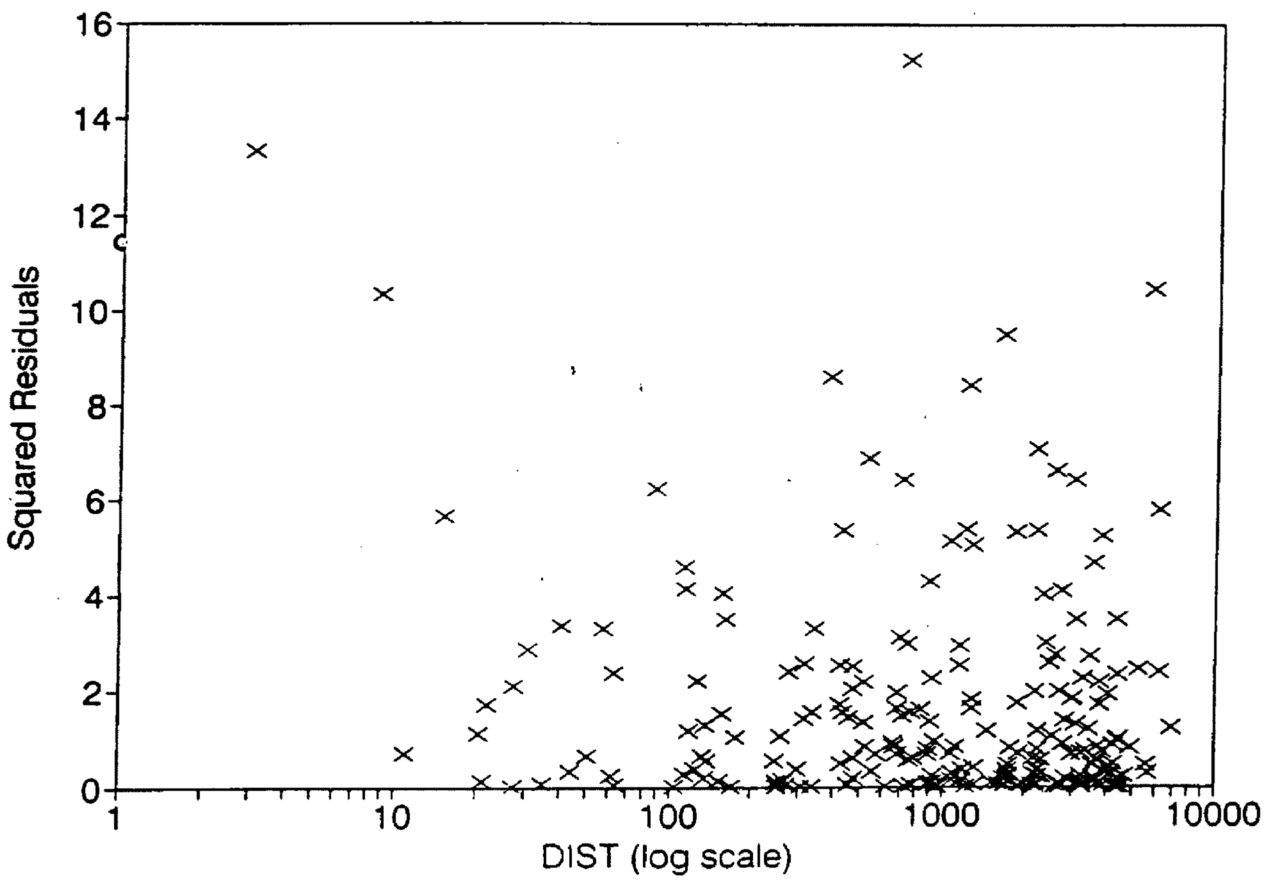

Figure 4-6: Plot of squared residuals on Natural Log of round-trip distance for Zone Scheme 2

the model, estimated for both zone schemes, does not appear to be seriously impaired by heteroscedasticity and statistical tests can be interpreted with confidence. It is important to note that the presence of heteroscedasticity does not produce biased estimated coefficients; therefore, estimates of trip prediction and consumers surplus are not affected.[25]

4.3 Model Prediction

An important characteristic to consider when evaluating a regional TCM is the ability of the model to predict visitation to the region. To calculate predicted visits, average round-trip distance for each origin-zone/destination-site pairing is substituted for the DIST variable in equations 2 and 3. The antilog of predicted per capita visits is then taken and multiplied by zonal population yielding predicted visits for each pairing.

Table 4-1 shows the actual visits and the predicted visits for Zone Scheme 1 (equation 2) and Zone Scheme 2 (equation 3) for the 19 waters. Overall, Zone Scheme 1

[25] Section 4.3 discusses the effect of a distance shift in mitigating heteroscedasticity. Appendix D presents the impacts of outliers on model estimation.

TABLE 4-1: VISIT PREDICTION BY ORIGIN ZONE FOR EACH ZONE SPECIFICATION

percent deviation from actual visits in brackets

ZONE SCHEME 1

	ACTUAL VISITS	PREDICTED VISITS	PREDICTED VISITS(+90)	PREDICTED VISITS(+10)
< 100 MILES	1,164	1,577 [+35]	693 [-40]	1,328 [+14]
100-299	238	175 [-26]	294 [+24]	195 [-18]
300-499	198	118 [-40]	175 [-12]	126 [-36]
500-999	287	200 [-30]	247 [-14]	206 [-28]
1000-1499	221	162 [-27]	155 [-30]	159 [-28]
1500-1999	99	78 [-21]	63 [-36]	74 [-25]
> 2000	82	44 [-46]	30 [-63]	41 [-50]
	2,289	2,354 [+2.8]	1,657 [-28]	2,129 [-7]

ZONE SCHEME 2

	ACTUAL VISITS	PREDICTED VISITS	PREDICTED VISITS(+90)	PREDICTED VISITS(+10)
< 50 MILES	818	3,876 [+374]	514 [-37]	1,705 [+108]
50-99	346	127 [-63]	203 [-41]	159 [-54]
100-199	147	96 [-35]	183 [+24]	116 [-21]
200-299	91	63 [-31]	112 [+23]	73 [-20]
300-399	147	93 [-37]	146 [-1]	102 [-31]
400-499	51	33 [-35]	47 [-8]	36 [-29]
500-749	192	178 [-7]	226 [+17]	184 [-4]
750-999	95	75 [-21]	79 [-17]	74 [-22]
1000-1249	173	112 [-35]	101 [-42]	106 [-39]
1250-1499	48	93 [+94]	77 [+60]	87 [+81]
1500-1749	53	65 [+23]	48 [-9]	59 [+11]
1750-1999	46	44 [-4]	29 [-37]	38 [-17]
2000-2499	69	61 [-12]	37 [-46]	53 [-23]
>2500	13	2 [-85]	1 [-92]	2 [-85]
	2,289	4,918 [+115]	1,803 [-21]	2,794 [+22]

predicts visits extremely accurately. Its prediction of 2,354 visits overpredicts actual visits of 2,289 by 2.8%. Zone Scheme 2 provides a less accurate estimate overpredicting visitation by 115% (4,918 visits). Each Zone Scheme displays high overprediction in the nearest zone (within 100 miles for Zone Scheme 1 and within 50 miles for Zone Scheme 2) and, with two exceptions, underpredicts for all the other zones. Duffield, Loomis and Brooks encountered the same problem in their 1987 study. In a subsequent technical paper, Duffield (1988) ascribed the problem of overprediction to inaccurate measurement of the distance variable for local fishing trips. As discussed in Chapter 3, anglers residing in the same zip code as that assigned to a river would record a distance traveled of zero miles for a fishing trip to the river. This error in the measurement of distance would understate the anglers' travel costs (in terms of distance traveled) and lead to an overprediction of visits to a site.

To correct this overprediction problem, Duffield suggested transforming the distance variable by introducing a fixed distance shift.[26] The distance found by Duffield to be

[26] Results of model estimation with the distance shifts are presented in Appendix E.

most successful in correcting for overprediction was 90 miles. In that study, inclusion of the shift in the model improved the fit, eliminated heteroscedasticity, reduced the prediction error from 83% to 4% and resulted in a previously insignificant variable becoming significant. While the main rationale for the shifted distance transformation was statistical, it can be justified on theoretical grounds as well. The distance shift can be interpreted as a fixed cost component representing the costs of planning and preparing for a trip. These costs would be approximately the same for a trip ranging from 10 to 400 round-trip miles--or approximately one day of travel. At $.27/mile, 90 miles corresponds to about $24. As Duffield points out, "the costs associated with trips of 10 miles versus 100 miles, for example, are not in a ratio of 1:10, but rather about 1:2."[27] Column 4 of table 4-1 shows the number of visits predicted by the model when the 90-mile distance shift is included. The shift eliminates the overprediction problem in the zones near the site and results in underprediction of 28% for Zone Scheme 1 and 21% for Zone Scheme 2. This represents a substantial improvement for Zone

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27 Duffield (1988), p. 6.

Scheme 2 (underprediction of 21% versus 115% overprediction without the shift) but does not improve the overall predictive power of the model under Zone Scheme 1 which already predicted trips quite accurately.

While statistically justified and intuitively appealing, selection of the appropriate distance shift is somewhat arbitrary. For the sake of comparison, a distance shift of 10 miles (suggested by Neher (1989)) was applied to the distance variable and the model reestimated. Predicted visitation with the 10-mile shift is reported in column 5 of Table 4-1. Overprediction for the origin zones closest to the sites is again reduced while visitation from the remaining zones tends to be slightly underpredicted. Overall, Zone Scheme 1 underpredicts by 7% and Zone Scheme 2 overpredicts by 22%. It must also be noted that the distance shift transformation resulted in higher adjusted R^2's and t-statistics and reduced heteroscedasticity (see Appendix B) for model estimation under each zone specification.

Table 4-2 presents actual and predicted visitation for each zone scheme aggregated by river. Because this is a regional model, visitation prediction for each site typically differs from actual site visitation. Some predictions differ

TABLE 4-2: VISIT PREDICTION BY RIVER

River	Actual Visits	Pred'd Visits Zone Scheme 1	Pred'd Visits Zone Scheme 2
Beaverhead	133	117	126
Big Hole	179	71	58
Bitterroot	64	96	98
Blackfoot	99	278	250
Boulder	50	42	115
Bighorn	161	55	70
Up.Clark Fk.	69	48	110
Md.Clark Fk.	112	295	1,340
Up.Flathead	53	202	167
Gallatin	216	223	134
Kootenai	93	105	1,512
Madison	441	48	51
Missouri	246	66	67
Rock Creek	89	137	101
Smith	34	121	163
Stillwater	93	48	81
Swan	27	87	72
Up.Yellowstone	24	94	102
Md.Yellowstone	106	221	302
TOTAL:	2,289	2,354	4,918

greatly. For example, the Madison, a site with a large number of visitors from distant locations, displays vast underprediction (441 actual visits versus 48 and 51 predicted visits). Conversely, visitation for sites with small numbers of predominantly local visitors, such as the Upper Flathead, is overpredicted (53 actual visits versus 202 and 167 predicted visits). These discrepancies can be explained in large part by the model's tendency to overpredict visits from nearby origins and underpredict visitation from more distant origins.

Comparison of the visits predicted under each zone scheme for each river reveals a considerable amount of variability in the predictive power of the two model specifications. For example, Zone Scheme 2 overpredicts visitation on the Kootenai by 1,525% while Zone Scheme 1 overpredicts by only 13%. The variability of the predictive power of the model under each zone scheme suggests that the zonal TCM is quite sensitive to the specification of zone size.[28]

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[28] Predicted visitation for specifications of the model which include dummy variables appear in Appendix F.

4.4 Benefit Estimation

As discussed in Chapter 2, ordinary consumer surplus is used as an estimate of the net benefits derived from fishing. Consumer surplus is represented graphically as the area under the Marshallian demand curve and above the price paid for the good. For a zonal TCM, consumer surplus can be calculated directly from the first-stage demand curve by taking the integral between the observed round-trip distance and a specified upper level of integration at which visitation is driven to zero for each origin-zone/destination pairing. The consumer surpluses for each origin-zone/destination pairing are then summed for each site.[24]

In the first stage demand curve, the distance variable serves as a proxy for the price of accessing the site. To calculate consumer surplus in monetary terms, the distance variable must be multiplied by the variable cost of travel. As discussed in Chapter 2, the variable cost of travel was determined to be \$.27 per mile.

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[24] The procedure for calculating consumer surplus relies on the method described in Duffield (1988).

To arrive at the formula for calculating consumer surplus, the antilog of Equation (1) is taken, yielding:

$$VISITS_{ij}/POP_i = e^{b0} D_{ij}^{b1} \quad (4)$$

where: b_0 = the predicted intercept[25]
b_1 = the estimated coefficient on round-trip distance.
D_{ij} = average observed round-trip distance from origin i to site j.

To obtain per capita consumer surplus at the origin-destination level:

$$CS = k_{tc} \int_{Dij}^{Duj} e^{b0} D_{ij}^{b1} \; dD_{ij} \quad (5)$$

$$= k_{tc} e^{b0}(b_1+1)^{-1}(D_{uj}^{b1+1} - D_{ij}^{b1+1}) \quad (6)$$

where: k_{tc} = the variable cost of travel.
D_{uj} = the upper level of integration for D.

Total consumer surplus at the origin-destination level (TS_{ij}) is calculated:

$$TS_{ij} = CS_{ij}POP_i \quad (7)$$

To obtain consumer surplus per trip, total consumer surplus is divided by the number of trips.

$$\text{CS per trip} = \Sigma TS_{ij}/\Sigma VISITS_{ij} \quad (8)$$

---

[25] Gujarati (1988) mentions that b_0 may be a biased estimate of the antilog of β_0. He points out, however, that in many model estimates, a biased estimate of the intercept is of minor concern.

Duffield (1988) analyzes the impact of selecting an upper level of integration--or a choke price--among various options. In order to allow comparisons with the results of Duffield *et al* (1987), the upper level of integration (D_{uj}) to be used is the sum of the maximum observed distance to a site and the current observed distance(D_{ij}) for each origin-zone/destination pairing. Results when the upper level of integration was the same for all sites in the study--the maximum distance for the nineteen river sample--are displayed in Appendix G.

Duffield (1988) also discusses the relative merits of choosing between actual and predicted trips to represent the intercept. To remain consistent with Duffield (1987), this study will use actual trips in estimating consumer surplus. The use of actual trips avoids the problems associated with the errors in trip prediction previously mentioned. Benefit estimates using predicted trips are reported in Appendix H.

Table 4-3 contains the estimated average consumer surplus per trip for each of the nineteen waters for each of the zone schemes. The results suggest that benefit estimation for the two schemes is rather insensitive to the specification of the origin zone. The average consumer surplus per trip for Zone Scheme 2 exceeds that for Zone Scheme 1 by 3.3%. An

TABLE 4-3: ESTIMATED AVE CONSUMER SURPLUS PER TRIP BY RIVER

River	C.S. per TRIP Zone Scheme 1	C.S. per TRIP Zone Scheme 2	C.S. per TRIP Duffield Study
Beaverhead	159	161	75
Big Hole	156	158	109
Bitterroot	48	49	44
Blackfoot	119	118	91
Boulder	159	160	89
Bighorn	117	119	86
Up.Clark Fk.	126	126	38
Md.Clark Fk.	69	72	49
Up.Flathead	119	121	39
Gallatin	201	206	90
Kootenai	89	91	44
Madison	267	265	155
Missouri	65	67	45
Rock Creek	181	181	109
Smith	90	92	56
Stillwater	91	91	54
Swan	167	177	47
Up.Yellowstone	106	107	151
Md.Yellowstone	43	31	39
AVE C.S. PER TRIP	121	126	75
(std dev)	57	56	36

examination of the consumer surplus estimates for each river reveals very little variability among the estimates under each zone scheme. The Blackfoot, Madison, and the Middle Yellowstone are the only rivers for which benefit estimates for Zone Scheme 1 exceed those for Zone Scheme 2 (by .8%, .8%, and 39%, respectively).

The similarity of the benefit estimates for the two zone schemes is not especially surprising. As Duffield observes, consumer surplus estimation is largely a function of trip-weighted average distance and the upper level of integration. These are the same for each zone scheme at a given site. The difference in benefit estimates between the two schemes is due to the more inelastic coefficient on distance for Zone Scheme 2. As displayed in Appendix H, benefit estimation using predicted trips yields quite different results.

To compare the two zone schemes further, the rivers were ranked in order of estimated consumer surplus for each zone scheme. Table 4-4 displays these rankings. The rankings appear to be quite consistent. The rankings for only four rivers (the Blackfoot, Bighorn, Smith, and Stillwater) differ by only one rank. To analyze the correlation of the rankings generated by the two zone schemes, Spearman's rank correlation

TABLE 4-4: RANKING OF RIVERS BY AVE CONSUMER SURPLUS PER TRIP

Zone Scheme 1			Zone Scheme 2			Duffield Study		
1	Madison	267	1	Madison	265	1	Madison	155
2	Gallatin	201	2	Gallatin	206	2	Up.Yellowstone	151
3	Rock Creek	181	3	Rock Creek	181	3	Big Hole	109
4	Swan	167	4	Swan	177	4	Rock Creek	109
5	Beaverhead	159	5	Beaverhead	161	5	Blackfoot	91
6	Boulder	159	6	Boulder	160	6	Gallatin	90
7	Big Hole	156	7	Big Hole	158	7	Boulder	89
8	Up.Clark Fk.	126	8	Up.Clark Fk.	121	8	Bighorn	86
9	Up.Flathead	119	9	Up.Flathead	121	9	Beaverhead	75
10	Blackfoot	119	10	Bighorn	119	10	Smith	56
11	Bighorn	117	11	Blackfoot	118	11	Stillwater	54
12	Up.Yellowstone	106	12	Up.Yellowstone	107	12	Md.Clark Fk.	49
13	Stillwater	91	13	Smith	92	13	Swan	47
14	Smith	90	14	Stillwater	91	14	Missouri	45
15	Kootenai	89	15	Kootenai	91	15	Kootenai	44
16	Md.Clark Fk.	69	16	Md.Clark Fk.	72	16	Bitterroot	44
17	Missouri	65	17	Missouri	67	17	Md.Yellowstone	39
18	Bitterroot	48	18	Bitterroot	49	18	Up.Flathead	39
19	Md.Yellowstone	43	19	Md.Yellowstone	31	19	Up.Clark Fk.	38

coefficient was calculated. This technique measures the degree of correlation between two rankings. A perfect positive correlation is represented by +1 while a perfect negative correlation, or exact inverse relationship, would be -1. The Spearman's rank correlation coefficient, or Spearman's rho, for Zone Schemes 1 and 2 is .996 which was found to be significantly different from zero. This suggests that the model produces consistent and highly correlated rankings of site values under the two zone schemes.

A less formal method of examining the rankings is to see how they correspond to the conventional wisdom regarding the waters' reputations among anglers. As expected the Madison, the Gallatin, Rock Creek, and the Big Hole can be found among the highest valued rivers in the sample. One would also expect to find the Upper Yellowstone, the Bighorn, and the Missouri in this group. Yet, of the nineteen waters, the Upper Yellowstone ranks 12 under Zone Schemes 1 and 2, the Bighorn ranks 11 under Zone Scheme 1 and 10 under Zone Scheme 2, and the Missouri ranks 17 under Zone Schemes 1 and 2. Another noteworthy ranking includes the Swan ranked 4 under each scheme.

To explain these unexpected rankings it is important to recall that consumer surplus per trip is a function of trip-weighted average distance and the maximum distance traveled to a site which corresponds to the price which drives visitation to zero on the demand curve. The low number of observed site visits to the Upper Yellowstone (24) make reliable estimation problematic. In addition to drawing large numbers of local anglers from Billings and Helena, the Bighorn and Missouri Rivers have relatively low maximum observed travel distances (4,107 and 4,981 miles, respectively). These factors combine to produce benefit estimates which are lower than expected. On the other hand, the Swan, with 6,913 miles, had one of the higher maximum distances reported in the sample. The Swan also had one of the smallest sample sizes in the survey. It is not likely that repeated samples would yield such high measures of distance traveled for the Swan. The result of repeated samples would be a more plausible ranking for the Swan.

4.5 Comparison with Duffield Study

As discussed previously, the study by Duffield *et al* (1987) used different model and zonal specifications to estimate the net benefits for fishing in Montana. The model included variables for trout catch, demographic characteristics of angler origin, site quality and substitute fishing sites. The zone scheme approximated concentric circles relying on arrangements of individual counties, county clusters and states. The study did not have the advantage of using ZIPFIP to measure the distance traveled for each angler. The distance traveled for each angler was taken as the hand-measured origin-zone/destination distance assigned to the zone pertaining to each angler.

When the model was estimated for the 19 waters subsample, the Adjusted R^2 was .758. The coefficient for the natural log of round-trip distance of -1.894 (t-statistic of -31.46) describes a more inelastic first-stage demand curve than those generated in this study. The intercept for the model was estimated as -5.031 (t-statistic of -3.84). As discussed in Section 4-3, the model was heteroscedastic and overpredicted visits by 83%. These problems were mitigated by the addition of a shift factor to the distance variable. The superior fit of the model estimated in this study (Adjusted R^2's of .8706 and .847) is very likely due to the more accurate measurement of the distance variable made possible by the use of ZIPFIP.

The average consumer surplus per trip for the Duffield study, reported in column 4 in Table 4-3, is $74. This value is less than those reported for Zone Schemes 1 and 2 ($121 and $126) but within one standard deviation of each of those estimates. The benefit estimates for each river, however, vary considerably from those calculated for Zone Schemes 1 and 2. The rankings of the rivers by average consumer surplus per trip are presented in Table 4-4. The most notable discrepancies are the Upper Yellowstone (ranked 1 in the Duffield Study and 12 in Zone Schemes 1 and 2) and the Upper Clark Fork (ranked 19 in the Duffield Study and 8 in Zone Schemes 1 and 2). The Spearman's rho calculated to compare the rankings generated by Zone Scheme 1 and the Duffield Study was .509 which was significantly different from zero at the 5% level. The Spearman's rho comparing Zone Scheme 2 and the Duffield Study was .504 which was significantly different from zero at the 5% level. The Spearman's rho indicates a moderate degree of correlation between the rankings of each zone scheme and the ranking of the Duffield estimates. While, on the regional level, the models yield similar results, they exhibit considerable variability among site benefit estimates.

CHAPTER 5

CONCLUSION

This chapter briefly summarizes the results reported in the study and suggests areas for further research.

5.1 Summary

The purpose of this study was to examine the sensitivity of a bivariate regional travel cost model to variations in the specification of origin zones. It was expected that the specification of zonal schemes--like other aspects of model specification--would affect benefit estimation. To test this hypothesis, data on visitation by fishermen were used to estimate the net benefits of fishing for nineteen Montana fishing streams. The results of OLS model estimation using two zonal schemes were compared along with results reported by Duffield *et al* (1987). The model was found to be quite sensitive to the specification of origin zone.

OLS estimation for the two zone schemes appeared to produce somewhat similar results. The adjusted-R^2's for the two zone schemes were .8706 and .8470 and the estimated coefficients for the log of the distance variable were -2.15 and -2.03. Heteroscedasticity was not found to be a serious problem for either zone scheme. The reported R^2's exceed those reported in other studies using the same data set (Duffield *et al* (1987), Neher (1989), and Holliman (1993)). Additionally, the problem of heteroscedasticity encountered in those studies is largely absent in this study. This can be attributed to the more accurate measurement of travel distance made possible by the use of the ZIPFIP program.

The two zone schemes produced quite different results in predicting visits to the region. Zone Scheme 1 overpredicted visits to the region by 2.8% and Zone Scheme 2 overpredicted visits by 115%. Predicted visitation for individual rivers varied considerably for each zone scheme. Much of the error in predicting trips is due to each zone scheme's overprediction of trips for the nearest zone. A fixed distance shift was found to mitigate much of the overprediction problem.

Estimation of consumer surplus per trip for each river revealed that the benefit estimation is rather insensitive to the specification of origin zone. The average consumer surplus per trip for Zone Scheme 2 exceeded that for Zone Scheme 1 by 3.3%. An examination of the consumer surplus estimates for each river reveals very little variability among the estimates under each zone scheme. When predicted trips were used in benefit estimation, however, the results were quite sensitive to the specification of origin zone.

The primary conclusion to be drawn from this effort is that the specification of origin zones is an important consideration in the construction of a travel cost model. Decisions regarding zonal specification will affect model estimation. A secondary conclusion pertains to the importance of accurately estimating distance. The use of ZIPFIP in estimating travel distance produced an improved fit and reduced heteroscedasticity when compared to previous studies.

5.2 Suggestions for Further Research

Subsequent research efforts might address several limitations of this study.

The problem of overprediction of visitation from nearby sites was a trait of both model specifications. The two fixed distance shifts (10- and 90- miles) lessened this problem. Additional investigation might seek to determine the optimal distance shift which produces the best estimates and improves the predictive power of the model.

The problem of overprediction might also be solved by establishing more specific destination sites. The use of a single zip code to identify a destination site which may stretch for over one hundred miles introduces the potential for inaccuracies in the measurement of distance. More detailed questions on angler surveys could supply such information.

As mentioned in Chapter 2, a bivariate model invites the problems associated with omitted variable bias. The inclusion of non-price variables very likely would improve the good fit of the model and provide less biased estimates of consumer surplus. The problems of including variables in a model for sites which attract visitors from great distances are discussed in Chapter 2.

Possibly the dearth of sensitivity analyses examining the effect of zonal schemes on TCM estimation is due to the processing effort required to produce the data sets. With the ever-increasing power of computers, the task of processing data to compare numerous zoning schemes becomes increasingly feasible. One tool that may be particularly useful in organizing the spatial data essential for TCM estimation is the rapidly developing Geographic Information Systems (GIS) software. Subsequent research efforts may employ GIS to compare numerous zonal specifications.

APPENDIX A
DATA TABLES

The following tables contain the data for visitation, round-trip travel distance, and population for each origin zone/river pairing for zone schemes one and two.

TABLE A-1: NUMBER OF VISITS FOR EACH ORIGIN ZONE/RIVER PAIRING
(predicted visits in parentheses)

River Num	Zones 1	2	3	4	5	6	7
1	42(84)	20(5)	31(5)	20(8)	12(8)	3(4)	5(3)
2	78(34)	20(5)	22(6)	23(11)	21(9)	9(4)	6(3)
3	56(38)	1(8)	1(5)	4(36)	0	1(5)	1(3)
4	60(230)	9(13)	7(6)	12(8)	4(6)	3(4)	4(2)
5	27(12)	5(6)	2(4)	4(6)	7(9)	4(4)	1(2)
6	86(15)	13(7)	11(3)	39(12)	6(12)	5(5)	1(1)
7	46(14)	7(4)	2(4)	6(8)	2(15)	0	6(3)
8	62(254)	32(8)	9(6)	4(12)	1(5)	1(4)	3(3)
9	30(167)	7(8)	4(4)	3(5)	4(8)	4(4)	1(2)
10	87(190)	14(6)	20(5)	34(8)	34(10)	16(4)	11(2)
11	56(73)	16(10)	7(6)	3(4)	8(6)	1(3)	2(4)
12	93(15)	43(5)	61(5)	94(8)	89(9)	32(4)	29(3)
13	200(36)	11(4)	9(3)	6(8)	12(8)	4(4)	4(3)
14	35(104)	9(5)	8(4)	19(9)	7(7)	6(4)	5(3)
15	20(60)	7(4)	1(3)	3(47)	0	3(8)	0
16	70(24)	4(2)	2(3)	6(1)	6(12)	4(4)	1(2)
17	12(25)	6(42)	0	3(4)	5(14)	0	1(1)
18	11(19)	8(12)	1(45)	0	1(11)	2(4)	1(3)
19	93(173)	6(21)	0	4(7)	2(12)	1(10)	0

TABLE A-2: AVERAGE ROUND-TRIP DISTANCE FOR EACH ORIGIN ZONE/RIVER PAIRING
(- indicates no visits from origin zone)

River	Zones						
Num	1	2	3	4	5	6	7
1	34	426	714	1,577	2,369	3,500	4,220
2	79	377	715	1,328	2,295	3,475	4,681
3	71	382	912	1,227	-	3,124	4,428
4	29	285	797	1,300	2,444	3,603	5,271
5	126	311	785	1,724	2,482	3,498	4,897
6	100	318	866	1,305	2,435	3,383	4,107
7	132	436	777	1,355	2,486	-	4,613
8	28	362	815	1,065	2,787	3,490	4,468
9	27	351	901	1,387	2,220	3,350	5,698
10	34	347	778	1,499	2,249	3,532	4,597
11	46	338	848	1,450	2,390	3,764	4,399
12	97	420	740	1,489	2,297	3,571	4,615
13	70	343	738	1,346	2,450	3,487	4,485
14	52	427	752	1,251	2,370	3,373	4,613
15	55	358	714	1,219	-	3,673	-
16	95	516	845	1,411	2,240	3,428	4,462
17	90	309	-	1,623	2,512	-	6,913
18	68	250	715	-	2,195	3,354	4,047
19	31	370	-	1,614	2,339	3,047	-

TABLE A-3: POPULATION FOR EACH ORIGIN ZONE/RIVER PAIRING (000's)

River	Zones						
Num	1	2	3	4	5	6	7
1	74	993	3,354	26,942	63,953	65,862	92,483
2	186	762	3,472	24,428	64,802	66,089	93,616
3	164	1,263	5,363	22,555	48,567	71,955	104,040
4	150	1,129	4,461	17,167	54,756	73,278	102,873
5	169	623	2,888	22,499	82,072	77,813	67,667
6	135	730	2,763	26,621	100,297	87,186	35,801
7	226	895	3,205	19,101	62,536	72,249	95,289
8	150	1,129	5,233	16,675	54,316	72,395	103,922
9	92	1,080	4,154	11,741	55,667	72,007	109,095
10	167	749	3,397	23,105	73,511	71,673	81,139
11	122	1,268	5,227	9,968	50,139	68,359	118,519
12	125	890	3,290	24,285	70,613	69,500	84,977
13	151	511	2,031	18,752	70,209	69,364	92,579
14	229	1,063	2,945	18,896	55,187	73,544	101,923
15	149	513	1,860	19,223	70,383	69,571	92,001
16	192	613	2,656	2,401	84,906	78,867	62,245
17	175	1,018	3,246	15,052	56,250	74,762	103,091
18	75	750	3,255	24,225	77,504	72,843	75,168
19	124	579	2,589	24,784	91,997	81,776	51,820

TABLE A-4: NUMBER OF VISITS FOR EACH ORIGIN ZONE/RIVER PAIRING

River	Zones													
Num	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	34	8	10	10	29	2	11	9	8	4	2	1	5	0
2	67	11	9	11	18	4	21	2	19	2	6	3	6	0
3	35	21	1	0	0	1	3	1	0	0	1	0	1	0
4	56	4	8	1	3	4	8	4	3	1	1	2	2	2
5	6	21	4	1	2	0	1	3	3	4	2	2	1	0
6	13	73	10	3	3	8	29	10	3	3	3	2	1	0
7	10	36	3	4	1	1	3	3	1	1	0	0	4	2
8	51	11	20	12	5	4	4	0	0	1	1	0	3	0
9	30	0	6	1	1	3	2	1	3	1	3	1	0	1
10	83	4	12	2	15	5	22	12	31	3	8	8	9	2
11	38	18	11	5	3	4	2	1	6	2	0	1	2	0
12	73	20	25	18	52	9	59	35	74	15	15	17	23	6
13	154	46	7	4	7	2	4	2	7	5	1	3	4	0
14	32	3	2	7	5	3	14	5	5	2	4	2	4	1
15	16	4	4	3	1	0	3	0	0	0	1	2	0	0
16	17	53	0	4	1	1	4	2	5	1	3	1	1	0
17	7	5	4	2	0	0	1	2	2	3	0	0	0	1
18	10	1	8	0	1	0	0	0	1	0	1	1	1	0
19	86	7	3	3	0	0	1	3	2	0	1	0	0	0

TABLE A-5: AVERAGE ROUND-TRIP DISTANCE FOR EACH ORIGIN ZONE/RIVER PAIRING
(0 indicates no visitors from origin zone)

River	Zones													
Num	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	11	133	336	516	699	937	1,315	1,896	2,229	2,648	3,274	3,952	4,220	0
2	63	177	259	473	688	836	1,287	1,758	2,236	2,853	3,376	3,674	4,681	0
3	50	106	382	0	0	912	1,089	1,642	0	0	3,124	0	4,428	0
4	22	134	264	454	627	925	1,091	1,720	2,263	2,984	3,098	3,855	4,268	6,275
5	15	157	269	476	785	0	1,217	1,892	2,233	2,668	3,249	3,747	4,897	0
6	21	114	278	454	768	903	1,152	1,747	2,319	2,551	3,253	3,578	4,107	0
7	41	157	248	578	664	890	1,188	1,522	2,404	2,567	0	0	4,294	5,250
8	9	118	316	438	687	975	1,065	0	0	2,787	3,490	0	4,468	0
9	27	0	338	429	737	956	1,085	1,991	2,125	2,506	3,277	3,566	0	5,698
10	27	170	313	553	740	891	1,290	1,883	2,204	2,713	3,258	3,806	4,243	6,189
11	3	136	253	526	782	899	1,309	1,733	2,243	2,830	0	3,764	4,399	0
12	89	128	339	532	713	893	1,282	1,836	2,212	2,718	3,292	3,817	4,331	5,744
13	57	113	296	426	683	927	1,179	1,679	2,258	2,720	3,039	3,636	4,485	0
14	44	138	247	479	669	891	1,121	1,615	2,227	2,727	3,209	3,701	4,366	5,600
15	31	153	306	427	714	0	1,219	0	0	0	3,465	3,777	0	0
16	35	114	0	516	759	931	1,225	1,784	2,168	2,601	3,273	3,894	4,462	0
17	64	126	249	429	0	0	1,456	1,707	2,173	2,737	0	0	0	6,913
18	62	134	250	0	715	0	0	0	2,195	0	3,006	3,701	4,047	0
19	20	159	266	473	0	0	1,163	1,764	2,339	0	3,047	0	0	0

TABLE A-6: POPULATION FOR EACH ORIGIN ZONE/RIVER PAIRING
(000's)

River	Zones													
Num	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	9	65	342	649	2,618	720	11,163	15,752	34,726	29,097	34,290	31,248	82,007	92,069
2	57	129	225	536	2,568	859	10,693	13,505	36,126	28,478	32,765	33,020	83,701	10,693
3	39	250	736	889	1,272	4,086	5,733	16,820	29,738	18,817	34,272	37,617	81,183	22,766
4	97	48	399	730	1,100	3,361	6,040	11,115	31,533	22,955	34,113	38,996	83,409	19,379
5	14	155	252	371	873	2,014	16,657	14,020	40,662	41,016	38,893	38,903	61,222	6,445
6	8	127	172	548	551	2,209	7,561	19,029	38,210	61,295	30,264	56,825	34,892	909
7	104	122	262	634	1,234	1,956	8,520	10,527	36,892	25,606	37,024	35,028	82,035	13,187
8	97	53	425	703	1,122	4,078	5,297	11,355	31,571	22,498	32,821	39,529	82,519	21,284
9	61	30	687	390	639	3,515	5,993	5,744	20,107	35,507	32,820	39,128	87,129	21,649
10	65	102	378	371	1,587	1,775	10,483	12,598	41,023	32,331	41,548	30,080	73,156	7,953
11	12	110	674	592	2,375	2,640	4,676	5,291	18,937	31,171	27,594	40,591	89,694	28,675
12	48	76	493	395	2,259	985	11,239	13,042	40,045	30,545	40,943	28,423	75,896	9,022
13	81	70	354	157	868	1,163	9,162	9,587	24,511	45,596	40,740	28,555	82,211	10,307
14	107	121	267	795	974	1,964	7,784	11,108	32,680	22,223	34,538	38,735	83,512	18,314
15	82	67	356	157	759	1,101	9,105	10,079	24,087	46,104	40,727	28,709	81,791	10,140
16	16	169	254	360	1,325	1,297	6,643	17,354	44,145	40,164	38,149	40,547	57,094	5,099
17	23	151	259	759	592	2,639	6,947	8,086	22,811	33,405	33,765	40,877	84,670	18,369
18	62	12	354	381	1,611	1,633	9,532	14,629	43,276	34,101	39,743	32,990	68,329	6,834
19	96	28	157	422	758	1,827	7,328	17,446	37,875	53,825	36,707	44,997	50,514	1,270

TABLE A-7: NUMBER OF PREDICTED VISITS FOR EACH ORIGIN ZONE/RIVER PAIRING

River	Zones													
Num	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	78	4	3	2	5	1	6	4	6	4	3	2	9	0
2	14	4	3	2	5	1	6	4	6	3	3	2	4	0
3	15	22	19	0	0	5	4	22	0	0	6	0	5	0
4	206	3	5	3	3	4	5	3	5	2	3	2	4	0
5	64	6	3	2	4	0	10	4	8	5	3	2	2	0
6	19	10	2	2	1	2	5	6	6	8	3	4	2	0
7	63	5	4	2	3	2	5	4	6	13	0	0	4	0
8	1360	4	4	3	2	4	39	0	0	3	5	0	5	0
9	125	0	6	2	1	4	5	1	4	5	3	9	0	1
10	89	3	4	1	3	2	6	3	8	4	3	2	4	0
11	1460	6	10	2	4	3	2	2	3	6	0	3	5	0
12	6	5	4	1	4	1	6	3	7	4	3	2	4	0
13	25	4	4	1	2	1	6	3	4	5	4	2	4	0
14	56	6	4	3	2	2	6	4	6	3	3	2	4	1
15	89	3	4	1	3	0	55	0	0	0	3	7	0	0
16	13	32	0	1	2	1	4	5	8	5	3	2	3	0
17	6	9	4	20	0	0	3	2	4	23	0	0	0	0
18	16	1	11	0	50	0	0	0	14	0	4	2	4	0
19	240	1	2	13	0	0	5	5	15	0	13	0	0	0

APPENDIX B
GLEJSER TEST FOR HETEROSCEDASTICITY

The Glejser test (Glejser (1969)) examines the relationship between the error term and the independent variable by regressing the absolute value of the error term on various functional forms of the independent variable. A correlation between the two terms suggests the presence of heteroscedasticity. Such a correlation is indicated by a t-statistic which is significantly different from zero. The specifications of the independent variable include:

a: $\ln(DIST_{ij})$
b: the inverse of $\ln(DIST_{ij})$
c: the square root of $\ln(DIST_{ij})$
d: the inverse of the square root of $\ln(DIST_{ij})$

Results of the regressions follow on the next page:

Zone Scheme 1:

Spec.	Adj R^2	t-stat
a	.0036	-1.203
b	-.0012	.9241
c	-.0023	-1.132
d	-.0002	.9906

with 90-mile shift:

Spec.	Adj R^2	t-stat
a	.0067	.4275
b	-.0034	-.7652
c	-.0060	.5117
d	-.0044	-.6813

with 10-mile shift:

Spec.	Adj R^2	t-stat
a	-.0042	-.6991
b	-.0073	.3348
c	-.0052	-.6072
d	-.0067	.4231

Zone Scheme 2:

Spec.	Adj R^2	t-stat
a	.0110	-1.848
b	.0497	3.519
c	.0167	-2.166
d	.0369	3.058

with 90-mile shift:

Spec.	Adj R^2	t-stat
a	.0015	1.149
b	.0012	-1.125
c	.0014	1.143
d	.0013	-1.131

with 10-mile shift:

Spec.	Adj R^2	t-stat
a	-.0046	-.0508
b	-.0042	.3108
c	-.0046	-1.035
d	-.0044	.2341

APPENDIX C
RESULTS OF WHITE'S CORRECTION

White's Correction (White (1980)) produces an estimate of the variance of the least squares estimator which allows appropriate inferences regarding the model estimators (see Greene(1990) pp. 403-4). The results of White's Correction on the two zone schemes follow:

Zone Scheme 1:

	Constant	$\ln(DIST_{ij})$
Coefficient	7.6946	-2.1473
OLS se	.5209	.0746
t-ratio	14.771	-28.787
White's se	.4861	.0685
White's t-ratio	15.831	-31.364

Zone Scheme 2:

	Constant	$\ln(DIST_{ij})$
Coefficient	7.0372	-2.0317
OLS se	.4046	.0585
t-ratio	17.395	-34.751
White's se	.5238	.0744
White's t-ratio	13.436	-27.325

APPENDIX D
OUTLIERS

Because OLS estimation relies upon the square of the deviation for each data point, data points which deviate greatly from the true regression line have a substantial impact on model estimation. These data points--or outliers--may be the result of measurement error or may be unrepresentative of the population. One way of examining the sensitivity of the model to the presence of potential outliers is to estimate the model after omitting observations which are three or four standard deviations from the mean. The results after omitting such observations follow:

<u>Zone Scheme 1:</u>

omitting observations greater than three standard deviations from the mean:

$$\ln(VISITS_{ij}/POP_i) = 7.5608 - 2.1297 \ln(DIST_{ij})$$

(t)	14.353	-23.308
(se)	.5267	.0752

Adj. R^2: .8677 N: 123

omitting observations greater than four standard deviations from the mean:

$$\ln(VISITS_{ij}/POP_i) = 7.5608 - 2.1297 \ln(DIST_{ij})$$

(t)	14.353	-23.308
(se)	.5267	.0752

Adj. R^2: .8677 N: 123

Zone Scheme 2:

omitting observations greater than three standard deviations from the mean:

$$\ln(VISITS_{ij}/POP_i) = 6.7952 - 2.0025 \ln(DIST_{ij})$$

(t)	16.018	-32.953
(se)	.4242	.0608

Adj. R^2: .8372 N: 212

omitting observations greater than four standard deviations from the mean:

$$\ln(VISITS_{ij}/POP_i) = 7.0198 - 2.0296 \ln(DIST_{ij})$$

(t)	16.934	-33.995
(se)	.4145	.0597

Adj. R^2: .8424 N: 217

Smith and Kopp (1980) expressed concerns about the spatial extent of the market with regard to the validity of fundamental assumptions of the TCM. To investigate the sensitivity of the model to the imposition of a spatial constraint, the model was estimated with travel distance limited to a one thousand mile radius. One thousand miles approximates the maximum distance of two days of driving. The results of model estimation follow:

Zone Scheme 1:

$$\ln(VISITS_{ij}/POP_i) = 6.8438 - 1.9781 \ln(DIST_{ij})$$

(t)	10.008	-17.516
(se)	.6839	.1129

Adj. R^2: .8094 N: 73

Zone Scheme 2:

$$\ln(VISITS_{ij}/POP_i) = 6.2093 - 1.8601 \ln(DIST_{ij})$$

(t)	12.660	-23.048
(se)	.4905	.0807

Adj. R^2: .7971 N: 136

APPENDIX E
MODEL ESTIMATION WITH DISTANCE SHIFTS

Regression results for the model when a distance shift is included follow:

Zone Scheme 1:

90-mile shift:

$$\ln(VISITS_{ij}/POP_i) = 12.171 - 2.7161 \ln(DIST_{ij} + 90)$$

(t)	18.460	-29.422
(se)	.6593	.0923

Adj'd R^2: .8755 N = 124

10-mile shift:

$$\ln(VISITS_{ij}/POP_i) = 8.4042 - 2.2396 \ln(DIST_{ij} + 10)$$

(t)	15.697	-29.310
(se)	.5354	.0764

Adj'd R^2: .8746 N = 124

Zone Scheme 2:

90-mile shift:

$$\ln(VISITS_{ij}/POP_i) = 12.211 - 2.7009 \ln(DIST_{ij} + 90)$$

(t)	23.540	-36.910
(se)	.5187	.0731

Adj'd R^2: .862 N = 219

10-mile shift:

$$\ln(VISITS_{ij}/POP_i) = 8.1501 - 2.1814 \ln(DIST_{ij} + 10)$$

(t)	19.728	-36.678
(se)	.4131	.0595

Adj'd R^2: .8601 N = 219

APPENDIX F
MODEL ESTIMATION WITH DUMMY VARIABLES

An alternative model specification which includes dummy variables for each river was estimated. The results of model estimation follow:

<u>Zone Scheme 1:</u>

$$\ln(VISITS_{ij}/POP_i) = 8.5275 - 2.1856 \ln(DIST_{ij}) + DUM_j$$

(t)	18.199	-42.627
(se)	.4686	.0513

Adj R^2 = .9395 $\qquad$ n = 124

River number one was excluded from the set of river dummies. Results regarding the river dummies for Zone Scheme 1 are summarized on the following page:

River Num	Coeff.	t-stat	se	pred'd visits	actual visits	pred'd visits eq. 2
1	--	--	--	226	133	117
2	.4255	.9660	.4405	199	179	71
3	-1.967	-4.290	.4582	25	64	96
4	-.7543	-1.713	.4405	251	99	278
5	-.7385	-1.676	.4406	36	50	42
6	-.0129	-.0292	.4405	97	161	55
7	-.6758	-1.474	.4585	44	69	48
8	-1.115	-2.531	.4405	191	112	295
9	-1.119	-2.540	.4405	128	53	202
10	.4579	1.0396	.4405	700	216	223
11	-.7658	-1.739	.4405	94	93	105
12	1.7055	3.8713	.4406	476	441	48
13	.0407	.0926	.4405	127	246	66
14	-.3357	-.7621	.4405	188	89	137
15	-1.644	-3.404	.4831	43	34	121
16	-.3146	-.7140	.4406	64	93	48
17	-1.433	-2.970	.4825	38	27	87
18	-2.078	-4.533	.4585	21	24	94
19	-1.881	-3.896	.4828	66	106	221
TOTAL				3,014	2,289	2,354

Zone Scheme 2:

$$\ln(VISITS_{ij}/POP_i) = 6.8254 - 2.0207 \ln(DIST_{ij}) + DUM_j$$

(t)	13.091	-31.848
(se)	.5214	.0634

Adj R^2 = .8937 n = 219

River number one was excluded from the set of river dummies.

Results regarding the river dummies for Zone Scheme 2 are summarized below:

River Num	Coeff.	t-stat	se	pred'd visits	actual visits	pred'd visits eq. 3
1	--	--	--	109	133	126
2	1.1879	2.8749	.4132	169	179	58
3	-1.044	-2.100	.4971	31	64	98
4	-.0038	-.0091	.4160	215	99	250
5	-.5453	-1.245	.4379	57	50	115
6	.9635	2.3171	.4158	163	161	70
7	-.2714	-.6554	.4141	75	69	110
8	.0479	.1016	.4720	1,279	112	1,340
9	-.3223	-.7440	.4332	104	53	167
10	1.0900	2.6341	.4139	342	216	134
11	-.0194	-.0462	.4191	1,250	93	1,512
12	2.3554	5.7137	.4122	478	441	51
13	.9990	2.4119	.4142	160	246	67
14	.2492	.6009	.4147	115	89	101
15	-.5228	-1.041	.5023	86	34	163
16	.0705	.1623	.4345	77	93	81
17	-.5400	-1.168	.4622	38	27	72
18	-1.242	-2.294	.5414	26	24	102
19	-.4821	-1.038	.4643	157	106	302
TOTAL				4,931	2,289	4,918

APPENDIX G
CONSTANT UPPER LEVEL OF INTEGRATION

The constant upper level of integration--or choke price--for each zone scheme was 7,143 miles. Benefit estimates using this upper level of integration are displayed in Table G-1. Site rankings are displayed in Table G-2. For Zone Scheme 1, the Spearman's rank correlation coefficient between rankings reported in Table G-2 and those reported in Chapter 4 is .974. For Zone Scheme 2, the Spearman's rank correlation coefficient between rankings reported in Table G-2 and those reported in Chapter 4 is .979. The correlation coefficient for the rankings for Zone Schemes 1 and 2 and the rankings by Duffield are .591 for each scheme.

TABLE G-1: ESTIMATED AVE CONSUMER SURPLUS PER TRIP BY RIVER WITH CONSTANT UPPER LEVEL OF INTEGRATION

River	C.S. per TRIP Zone Scheme 1	C.S. per TRIP Zone Scheme 2	C.S. per TRIP Duffield Study
Beaverhead	163	173	75
Big Hole	155	164	109
Bitterroot	49	52	44
Blackfoot	99	103	91
Boulder	158	166	89
Bighorn	127	135	86
Up.Clark Fk.	108	114	38
Md.Clark Fk.	69	74	49
Up.Flathead	114	120	39
Gallatin	187	196	90
Kootenai	92	97	44
Madison	240	251	155
Missouri	64	68	45
Rock Creek	170	179	109
Smith	92	97	56
Stillwater	93	99	54
Swan	138	146	47
Up.Yellowstone	106	112	151
Md.Yellowstone	35	37	39
AVE C.S. PER TRIP	119	125	75
(std dev)	50	52	36

TABLE G-2: RANKING OF RIVERS BY AVE CONSUMER SURPLUS PER TRIP WITH CONSTANT UPPER LEVEL OF INTEGRATION

Zone Scheme 1			Zone Scheme 2			Duffield Study		
1	Madison	240	1	Madison	251	1	Madison	155
2	Gallatin	187	2	Gallatin	196	2	Up.Yellowstone	151
3	Rock Creek	170	3	Rock Creek	179	3	Big Hole	109
4	Beaverhead	163	4	Beaverhead	173	4	Rock Creek	109
5	Boulder	158	5	Boulder	166	5	Blackfoot	91
6	Big Hole	155	6	Big Hole	164	6	Gallatin	90
7	Swan	138	7	Swan	146	7	Boulder	89
8	Bighorn	127	8	Bighorn	135	8	Bighorn	86
9	Up.Flathead	114	9	Up.Flathead	120	9	Beaverhead	75
10	Up.Clark Fk.	108	10	Up.Clark Fk.	114	10	Smith	56
11	Up.Yellowstone	106	11	Up.Yellowstone	112	11	Stillwater	54
12	Blackfoot	99	12	Blackfoot	103	12	Md.Clark Fk.	49
13	Stillwater	93	13	Stillwater	99	13	Swan	47
14	Smith	92	14	Smith	97	14	Missouri	45
15	Kootenai	92	15	Kootenai	97	15	Kootenai	44
16	Md.Clark Fk.	69	16	Md.Clark Fk.	74	16	Bitterroot	44
17	Missouri	64	17	Missouri	68	17	Md.Yellowstone	39
18	Bitterroot	49	18	Bitterroot	52	18	Up.Flathead	39
19	Md.Yellowstone	35	19	Md.Yellowstone	37	19	Up.Clark Fk.	38

APPENDIX H
BENEFIT ESTIMATES USING PREDICTED VISITS

Table H-1 contains the estimated average consumer surplus per trip for each of the 19 waters for each of the zone schemes using predicted site visits. The results suggest that the model is quite sensitive to the specification of the origin zone. The average consumer surplus per trip for Zone Scheme 2 exceeds that for Zone Scheme 1 by 32%. An examination of the consumer surplus estimates for each river reveals considerable variability among the estimates under each zone scheme. The consumer surplus estimates under Zone Scheme 2 for four rivers--the Upper Flathead, Gallatin, Rock Creek and Swan--are at least twice the size of the estimates under Zone Scheme 1. The estimates under Zone Scheme 1 for four waters--the Boulder, Middle and Upper Clark Fork and Kootenai--exceed the estimates under Zone Scheme 2 by 50, 31, 120 and 811 percent, respectively.

To compare the two zone schemes further, the rivers were ranked in order of estimated consumer surplus for each zone scheme. Table H-2 displays these rankings. The rankings

TABLE H-1: ESTIMATED AVE CONSUMER SURPLUS PER TRIP BY RIVER (PREDICTED TRIPS)

River	C.S. per TRIP Zone Scheme 1	C.S. per TRIP Zone Scheme 2	C.S. per TRIP Duffield Study
Beaverhead	83	133	75
Big Hole	138	240	109
Bitterroot	125	186	44
Blackfoot	36	63	91
Boulder	206	135	89
Bighorn	186	211	86
Up.Clark Fk.	195	149	38
Md.Clark Fk.	33	15	49
Up.Flathead	43	91	39
Gallatin	49	122	90
Kootenai	82	9	44
Madison	199	311	155
Missouri	135	206	45
Rock Creek	73	145	109
Smith	105	126	56
Stillwater	169	180	54
Swan	109	260	47
Up.Yellowstone	123	190	151
Md.Yellowstone	52	53	39
AVE C.S. PER TRIP	113	149	75
(std dev)	57	79	36

TABLE H-2: RANKING OF RIVERS BY AVE CONSUMER SURPLUS PER TRIP (PREDICTED TRIPS)

Zone Scheme 1			Zone Scheme 2			Duffield Study		
1	Boulder	206	1	Madison	311	1	Madison	155
2	Madison	199	2	Swan	260	2	Up.Yellowstone	151
3	Up.Clark Fk.	195	3	Big Hole	240	3	Big Hole	109
4	Bighorn	186	4	Bighorn	211	4	Rock Creek	109
5	Stillwater	169	5	Missouri	206	5	Blackfoot	91
6	Big Hole	138	6	Up.Yellowstone	190	6	Gallatin	90
7	Missouri	135	7	Bitterroot	186	7	Boulder	89
8	Bitterroot	125	8	Stillwater	180	8	Bighorn	86
9	Up.Yellowstone	123	9	Up.Clark Fk.	149	9	Beaverhead	75
10	Swan	109	10	Rock Creek	145	10	Smith	56
11	Smith	105	11	Boulder	135	11	Stillwater	54
12	Beaverhead	83	12	Beaverhead	133	12	Md.Clark Fk.	49
13	Kootenai	82	13	Smith	126	13	Swan	47
14	Rock Creek	73	14	Gallatin	122	14	Missouri	45
15	Md.Yellowstone	52	15	Up.Flathead	91	15	Kootenai	44
16	Gallatin	49	16	Blackfoot	63	16	Bitterroot	44
17	Up.Flathead	43	17	Md.Yellowstone	53	17	Md.Yellowstone	39
18	Blackfoot	36	18	Md.Clark Fk.	15	18	Up.Flathead	39
19	Md.Clark Fk.	33	19	Kootenai	9	19	Up.Clark Fk.	38

appear to be fairly consistent. The rankings for each river generally differ by no more than 2 or 3. Exceptions are the Boulder (ranking 1 for Zone Scheme 1 and 11 for Zone Scheme 2), the Upper Clark Fork (3 and 9) and the Swan (10 and 2). To analyze the correlation of the rankings generated by the two zone schemes, Spearman's rank correlation coefficient was calculated. The Spearman's rank correlation coefficient, or Spearman's rho, for Zone Schemes 1 and 2 is .73 which was found to be significantly different from zero. This suggests that the model produces somewhat consistent, though imperfectly correlated, rankings of site values under the two zone schemes.

A less formal method of examining the rankings is to see how they correspond to the conventional wisdom regarding the waters' reputations among anglers. As expected the Madison, Big Hole, Bighorn and Upper Yellowstone can be found among the highest valued rivers in the sample. One would also expect to find Rock Creek and the Gallatin in this group. Yet, of the 19 waters, Rock Creek ranks 14 under Zone Scheme 1 and 10 under Zone Scheme 2 and the Gallatin ranks 16 under Zone Scheme 1 and 14 under Zone Scheme 2. Other noteworthy rankings include the Upper Clark Fork ranked 3 under Zone

Scheme 1 and the Swan ranked 2 under Zone Scheme 2.

To explain these unexpected rankings it is important to recall that consumer surplus per trip is a function of predicted trips, the maximum distance traveled to a site and the average distance traveled for each origin zone/destination pairing. Section 4-3 contained a discussion of the discrepancies between predicted and actual visitation at the site level. Because the number of trips is in the denominator of the consumer surplus per trip formula, these discrepancies affect benefit estimation for specific sites. Visitation for Rock Creek, for example, is overpredicted resulting in a lower consumer surplus ranking than expected. Maximum distance traveled (which corresponds to the price which drives visitation to zero on the demand curve) and average distance traveled (which corresponds to the current price) are important factors in determining consumer surplus estimates. The Swan, with 6,913 miles, had one of the higher maximum distances reported in the sample. The Swan also had one of the smallest sample sizes in the survey. It is not likely that repeated samples would yield such high measures of distance traveled for the Swan. The result of repeated samples would be a more plausible ranking for the Swan.

The average consumer surplus per trip for the Duffield study, reported in column 4 in Table H-1, is $74. This value is less than those reported for Zone Schemes 1 and 2 ($113 and $149) but within one standard deviation of each of those estimates. The benefit estimates for each river, however, vary considerably from those calculated for Zone Schemes 1 and 2. The rankings of the rivers by average consumer surplus per trip are presented in Table H-2. The most notable discrepancies are Rock Creek (ranked 4 in the Duffield Study and 14 and 10 in Zone Schemes 1 and 2) and the Upper Clark Fork (ranked 19 in the Duffield Study and 3 and 9 in Zone Schemes 1 and 2). The Spearman's rho calculated to compare the rankings generated by Zone Scheme 1 and the Duffield Study was .15 which was not significantly different from zero at the 5% level. The Spearman's rho comparing Zone Scheme 2 and the Duffield Study was .35 which was significantly different from zero at the 5% level but indicates a small degree of correlation between the two rankings. While, on the regional level, the models yield similar results, they exhibit considerable variability among site benefit estimates.

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