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# 16 Nonmarket valuation and water resource management

*Richard T. Carson*

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## INTRODUCTION

Almost all water projects have a monetary cost and produce a vector of outputs. Benefit–cost analysis requires that all of these outputs be measured in monetary terms. It is hoped that most of these outputs, like reduction of flood risk, are desirable; but undesirable outcomes, like loss of habitat, can also occur. Some of these outputs, such as electricity, are readily valued in monetary terms by using their market price. Others, like supplying irrigation water, can refer to contractual prices or estimate their influence on profits by taking account of their marginal value in the production process. Still others, like recreational fishing and preservation of an endangered species, are not bought and sold in the marketplace and need to be valued using nonmarket valuation techniques (Champ et al., 2003; Freeman et al., 2014). This chapter looks at the use of these techniques in the context of water projects.

The notion of measuring and comparing the benefits and costs of a water project appears to have been first formalized in the 1902 US River and Harbor Act, which required a board of engineers to consider project benefits and costs. This Act distinguished between local/special and national/general benefits for the purpose of local cost sharing.<sup>1</sup> The US Flood Control Act of 1936 formalizes the need for a benefit–cost assessment with its requirement that a project’s ‘benefits to whomsoever they may accrue must exceed the costs’. Early formal analysis of water projects (e.g. Krutilla and Eckstein, 1958) looked at flood control, irrigation, hydroelectric and navigation benefits. Krutilla and Eckstein, at the end of their book (p. 265), note that they have not considered intangible benefits:

Values in addition to economy efficiency are at stake in water resources development; we have given them only passing consideration. Since water development has been an instrument for attaining certain social goals, water programs include numerous intangibles. Among these are the protection of human life in flood plains, the preservation of scenic areas because of their aesthetic appeal, the improvement of public health and welfare through provision of recreation facilities, the assurance of security from vagaries of water through irrigation agriculture – these, and many others.

This division between tangibles and intangibles was set out in the earlier unofficial 1950 ‘Green Book’ for evaluating water projects.<sup>2</sup>

The US Bureau of the Budget effectively required that, to be funded, a water project had to have a benefit–cost ratio greater than 1, based on tangible benefits (Budget Circular A-47, 1952). This effectively ruled out projects that were built largely to provide outdoor recreation. During the 1950s and 1960s, outdoor recreation grew at a very fast pace, and a major function of many proposed reservoirs was to provide for boating,

fishing and swimming. Congressional, state and local pressure to build such facilities was strong, and the US Senate (1957) held hearings specifically focused on the issue of including recreation in the evaluation of projects. Failure to count recreation in monetary terms was a major source of discontent with the Bureau of the Budget's rules for evaluating water projects.<sup>3</sup>

Dealing with outdoor recreation was vexing, because one obvious way to count recreation was to add up expenditures made by recreators; this method was supported by many water project sponsors, who often took it to the next level by adding in some measure of induced secondary benefits or by using a largely ad hoc per day value. Government economists knew these practices were wrong. In 1935, John Maurice Clark, a prominent economist at Columbia and then president of the American Economic Association, wrote a report to the National Planning Board that 'recommended that where public works provide an economic service, these values be measured in monetary terms whenever possible, and that reliance be placed on individual willingness to pay as a basic standard' (Hufschmidt, 2000, p. 42). What was needed was a way to determine maximum willingness to pay (WTP) for outdoor recreation. The US Forest Service had posed this question to a set of prominent researchers and received the sketch of a method by Harold Hotelling (1947) that involved the notion of an implicit demand curve in which the effective price was the travel cost to get to the recreation site. Hotelling's approach relied on a technical connection between the nonmarket good of interest, recreation and a marketed good, in this case the expenses on travel. The US Forest Service did not pursue Hotelling's approach further. Trice and Wood (1958) were the first to operationalize Hotelling's travel cost (TC) approach and did so for the State of California (1957), which needed an evaluation of a set of reservoirs on the Feather River. The other common approach for valuing outdoor recreation, contingent valuation (CV), was also proposed in 1947 by Ciriacy-Wantrup. It, too, saw its first application in 1958 by Audience Research Inc., which was contracted by the US National Park Service to look at the willingness to pay park entrance fees by residents of the Delaware River Basin.

The US Senate held hearings on water projects that produced US Senate (1962) Document 97, which put forth three objectives for water projects: (a) economic development, the efficiency criteria used in the Green Book and Budget Circular A-47; (b) preservation defined in terms of environmental stewardship, which explicitly included outdoor recreation, as well as fish and wildlife enhancements; and (c) well-being of people, which explicitly included the loss of life due to flooding and meeting the particular needs of groups facing hardships, which kept the door open to including secondary benefits. It was clear from this document that Congress wanted nonmarket goods in the form of outdoor recreation, preserving and enhancing environmental quality, and saving lives included in the analysis of water projects, and this is reflected in subsequent guidance documents on water projects as well as in major books dealing with water projects such as Maass et al. (1962).<sup>4</sup> The notion that provision of recreation could be a major objective of a water project on an equal footing with other purposes more readily measured in economic terms is enshrined in the 1965 Federal Water Projects Recreation Act. At about the same additional travel cost (e.g. Brown et al., 1964; Knetsch, 1964a; Merewitz, 1966), studies on water-based recreation started to appear, getting a major boost from Clawson (1959), Knetsch (1963) and the 1966 Clawson and Knetsch book, *Economics of Outdoor Recreation*.<sup>5</sup> Contingent valuation studies of outdoor recreation

that used a constructed market in the context of a survey started with Davis (1963a, 1963b) and the first comparison (Knetsch and Davis, 1966) of estimated values for water-based recreation show that the two approaches produced comparable estimates.

Jack Knetsch also had a hand in the third popular technique for nonmarket valuation, hedonic pricing (HP). He provided the first application (1964b) to look at the impacts of a water project that involved estimating the influence its proximity to the Tennessee Valley Authority (TVA) reservoirs had on property values. What was interesting here is that Knetsch's work was influenced by the work of Renshaw (1958a, 1958b), which saw the value of the outputs of water projects as being capitalized into the value of private land rather than being in the hedonic framework of Court (1939) and Griliches (1961), which took the form of solving an index number problem.<sup>6</sup> Knetsch's study was followed soon thereafter by Schutjer and Hallberg (1968), who looked at a water project in Pennsylvania, and David (1968), who looked at different characteristics of lakes in Wisconsin.

There are three other approaches to nonmarket valuation that should be mentioned here. The first is to have some standardized value, such as a unit day value for a particular type of recreation. While this approach often has great appeal to those needing to carry out benefit–cost assessments, it begs the question of where the unit day value comes from. It took some time for this issue to be sorted by moving away from ad hoc values to values that ultimately were derived from CV and TC studies (Duffield, 1989). The second approach can be thought of as a dose–response function in which, for instance, pollution adversely impacts a fishery. When this (negative) input to the production process impacts a recreational fishery, the impact is in terms of lost recreational fishing days rather than commercial catch, in which its impact is more readily valued (Stevens, 1966). If a unit day value for the type of recreation is available, then the estimate from the dose–response function can be used with it to value the lost days. A variant of this approach comes into play in many instances of risk reductions to human health or life, in which a dose–response approach is used to quantify the biological impact that is then valued using one of the nonmarket valuation approaches.<sup>7</sup> The third approach recognizes that on rare occasions an explicit political market, such as a referendum, is created that can supply the good by having the public vote on whether to provide it (Carson, Hanemann and Mitchell, 1987). Results from referenda are occasionally used to help benchmark CV (Vossler and Kerkvleit, 2003) and in a few instances such as open space initiatives (Kotchen and Powers, 2006; Nelson et al., 2007) enough referenda have been held to draw inferences about a class of goods that extends beyond a single political jurisdiction.

## A STYLIZED ZONAL TRAVEL COST MODEL

To see how travel cost analysis works, we start with Hotelling's original insight of drawing concentric circles around a recreation site like a lake (see Figure 16.1).<sup>8</sup> What is observed are the number of trips taken to the site (located at the intersection of the vertical and horizontal lines) from each of the bands (labeled 1 through 10) defined by the concentric circles. Because each trip reflects an economic choice made in a market context, this type of data is often referred to as revealed preference (RP) data. Before we can use these RP data, we need to know more about the market context in which the

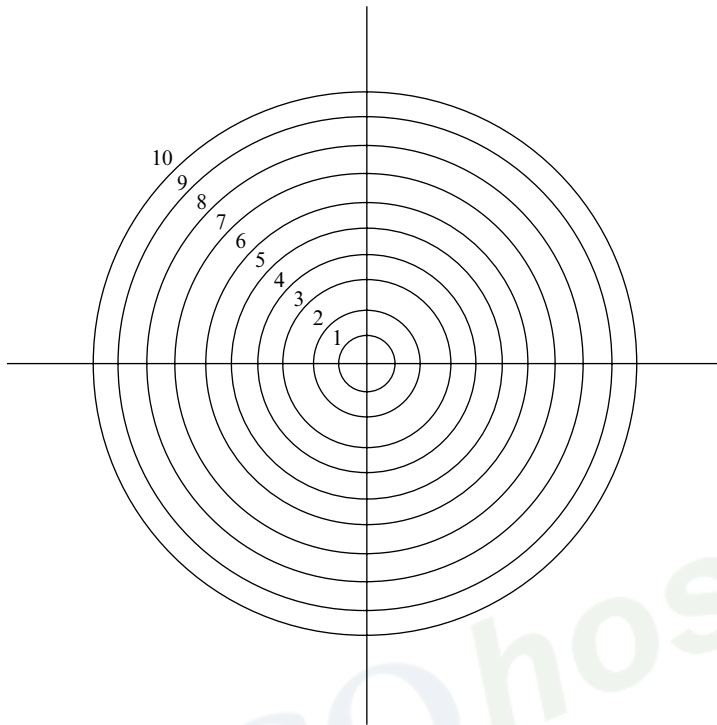


Figure 16.1 Concentric circles defining zones for trips and travel cost

choice of visiting the recreation site was made. Chief among such market features are the nature of the population in each of our ten bands, often referred to as zones, which generated the observed trips, and the cost to visit the site from each of those bands.

Now we will make six strong assumptions that will allow us to recover the Marshallian consumer surplus using a zonal travel cost model with aggregate data. These assumptions were the subject of considerable controversy in the early days of TC modeling, and modern approaches are largely designed around relaxing them. First, assume that the distributions of preferences in each of the ten bands are statistically equivalent. An implication of this assumption is that there are no selection effects, such that people with the highest values for the site are more likely to live near it. This assumption can be relaxed by assuming that there is no selection conditional on observables, which provides one rationale for using variables other than those related to cost as predictors. Another implication is that there is some random variation in the mixture of preferences in each zone, even though they are all drawn from the same overall meta-population.<sup>9</sup> Second, assume that the cost of getting to the site is proportionate to the Euclidian distance from it. With the advent of GIS capabilities, it is possible to use the distance as via the available road network. Third, assume that all of the people in a concentric circle must travel the same distance to get to the site. Obviously, this assumption cannot strictly hold, but it becomes a better approximation as the width of the bands defined by the concentric circles shrinks and a free-moving road network becomes dense. Fourth, assume that

there is a monetary metric that translates distance into cost. A popular conversion factor is the annual American Automobile Association's average operating cost for passenger vehicles. Relaxing this assumption in different directions and, in particular, with respect to allowing for a time cost has been a major focus of the modern travel cost literature. Fifth, assume that there are no costs associated with using the site that are not proportionate to the distance to the site. This assumption is easily relaxed by allowing for a constant expenditure for using the site, such as bait if a fishing site. It is violated, though, if visitors from distant bands have to pay for a place to spend the night while those living closer do not. Sixth, assume that the substitution possibilities for this recreation site of interest are the same in the entire space defined by the set of concentric circles. Relaxing this assumption requires accounting for the spatial structure of possible substitutes, and doing so is an important component of many travel cost models currently being estimated.

Let us now turn to defining the dependent variable. To be usefully defined, our trips need a time dimension, such as trips per week, month or year.<sup>10</sup> While we observe the number of trips from each zone, we still need the population generating the observed trips. If we divided trips from the zone by the zone's population and a small enough unit of time is used, the resulting variable will lie between zero and one, and will be bounded away from one. This variable can be thought of as the percentage of the population visiting the site. Since we do not observe individual trips, one person taking two trips is statistically indistinguishable from two people making one trip.

In the simplest case, we observe one cross-section of data comprising the number of trips taken from each of the ten zones during one time period, the population of each of the ten zones, the distance from the zone to the recreation site (assumed the same for all trips from that zone), and the cost per unit of distance to get to the zone. We generate data from the linear relationship:

$$PZ_i = 0.6 - 0.06 \cdot Cost_i + \epsilon_i \quad (16.1)$$

where  $PZ_i$  is the percentage of the population taking a trip and  $Cost_i$  is the cost of traveling from the zone to the site, which we have assumed here without loss of generality to be equal to the zone subscript. The error term  $\epsilon_i$  reflects random differences in the distribution of preferences across zones. This linear demand function defines a right triangle with consumer surplus being the area under it since we have no entrance fee at our recreation site. The (normalized) consumer surplus for this recreation site is 3, which comes from the product of the fraction visiting at zero cost (0.6) and cost (10) that would result in no visits to the site, all divided by 2. The lowest cost in which no visits would occur is known as the 'choke' price. The notion of a choke price embodies the typical theoretical construct used to identify travel cost models, weak complementarity. Under weak complementarity, a marketed good needs to be consumed in order that a consumer can enjoy the nonmarketed good. If the price of that marketed good becomes high enough, no consumption of the nonmarketed good will occur.

Figure 16.2 shows the ordinary least squares (OLS) estimate of our linear relationship. Note that we have intentionally changed the usual orientation of the  $x$  and  $y$  axes to emphasize that the exogenous variable is the cost of making a trip from each zone, and that exposing the zone's population to its trip cost generates the fraction of the zone's

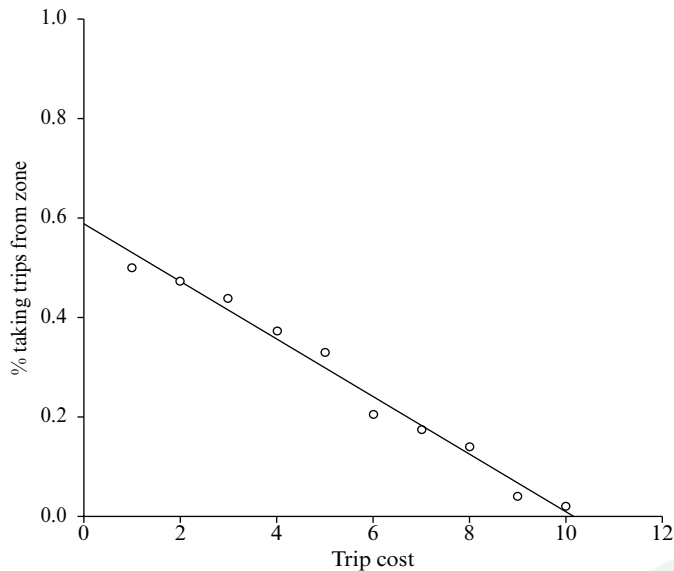


Figure 16.2 OLS fit to data generated from a linear zonal travel cost model

population observed to take a trip to the recreation site. A small amount of noise (0.2 times a standard normal) has been added. Of course we do an excellent job of fitting the linear demand function. In practice, the significance of the two parameter estimates depends on the size of the population in each zone. Modern practice would be to fit a logit or probit model using the generalized linear model approach (McCullagh and Nelder, 1989) in which the number of trips from zone  $i$  is taken as the number of successes and the binomial denominator is the size of the population in zone  $i$ . With data of this type, asymptotics can be done either by letting the number of zones become arbitrarily large or by letting the population in each zone become arbitrarily large. An alternative approach, and statistically equivalent way, with appropriate restrictions, of thinking about the data-generating process is to use the number of trips from each zone as the dependent variable in a count data model, with the zone's population serving as one of the predictor variables. The count data formulation also works when the number of trips for the time period is larger than the size of a zone's population.

The major issue with our simple TC model, if our original set of six assumptions holds, is that the functional form linking the percentage taking trips in a zone to the zone's cost is unknown. For this reason there has been substantial experimentation with simple alternative functional forms and with Box-Cox transformations. The class of generalized additive models (Hastie and Tibshirani, 1990) offers an even more flexible framework while retaining most of the usual statistical tools used to evaluate model fit. However, what we really need to pin down are the two extreme points on the line depicted in Figure 16.2. Both of these points are likely to be poorly defined in any empirical dataset. There may be few, if any, people who face a zero price. More important, though, is the estimate of the choke price, which can have a large influence on any consumer surplus measure. Here the problem is that the number of trips from zones that

are further and further out is unlikely to drop to zero. The reason for this is that some people from far-away zones may be visiting a zone relatively close to the recreation site of interest for completely unrelated reasons and travel to the recreation site while on that visit (Smith and Kopp, 1980). The difficulty, of course, is that if only data on aggregate trips are available, it is impossible to separate these trips out and model them differently.

## FROM THE ZONAL TRAVEL COST MODEL TO COUNT DATA MODELS

Travel cost models have always been heavily influenced by data availability.<sup>11</sup> Early empirical studies often used automobile license plate information, because that was what was recorded at entrance gates to recreation sites. License plates, in many states, revealed the county of origin, and this could be used to obtain an estimate of distance to a recreation site, albeit with substantial measurement error. Over time, the easiest problem to fix with the zonal TC model has been the distance variable, and TC models are sometimes referred to as 'single site' rather than 'zonal'. Recording recreator home zip codes provides a much finer resolution of a visitor's origin, and programs have been developed to calculate the distance by road rather than having to use straight-line distances. The availability of population statistics for zip codes provided the needed denominator for trips. The availability of summary statistics for other demographic variables, such as income and the percentage of retired, allowed the unrealistic assumption that all zones had the same distribution of preferences to be weakened by substituting the assumption that, with observed demographic variables, areas had statistical equivalent preference distributions.

The conversion of distance to a monetary metric in terms of vehicle operating expense was seen early on (Knetsch, 1963) as a problem with TC models, because people face both a budget constraint and a time constraint (McConnell, 1975). The implication of not including the cost of travel time was to induce a clear downward bias in the estimate of consumer surplus (Cesario and Knetsch, 1970). It became popular to follow a recommendation made by Cesario (1976) to include time cost at 25 percent to 50 percent of the wage rate, which he based on reviewing estimates of the value of time in transportation studies. The fraction of the wage that should be used is still an active source of research. Fezzi et al. (2014) exploit a natural experiment whereby recreators could choose between two roads of roughly the same distance to get to a recreation site, but one of these roads had a toll and a faster travel time. Their result suggests on average 75 percent of the wage rate. Larson and Lew (2014) advance a novel approach, based on allowing the value of travel time to be a random fraction of the wage rate in a mixed logit model. Still, as Randall (1994) points out, a fundamental weakness of any variant of the TC approach is that it was the perception of the cost to use a site that should drive behavior, and variables highly correlated with that perception will produce similar predictions about recreational behavior, even though they may produce very different consumer surplus estimates.

The other major problem with the single-site TC model was the presence of competing recreation sites. Looking at Figure 16.1, it should be obvious that putting a competing site anywhere destroys the spatial structure of demand. In general, people living in the

same zone will not be the same distance from the original site and a competing site. Further, the problem gets worse as more competing recreation sites are considered. The early solution was simply to include the cost of competing sites as a regressor in the trip demand function. This worked reasonably well if there was only a small number of competing sites. Cicchetti et al. (1976) showed that greater efficiency could be obtained by estimating a system of seemingly unrelated regressions to look at outdoor recreation sites. Sutherland (1982) proposes the use of a four-stage model to look at a set of water-based recreation sites whereby trips were generated at origins, a model of site attractiveness, a gravity model to allocate trips at origins to destinations based on distance and attractiveness, and a demand/valuation model. As more factors were considered, it was clear that individual-level data were needed. Indeed, Sutherland's application had individual-level data that were aggregated upward as needed for particular purposes.

Burt and Brewer's (1971) paper is usually acknowledged as the first to use individual-level data to estimate a system of demand equations for recreation sites. Their interest was a standard one – adding new, ordinary, water-based recreation sites to a system of water-based sites, some of which were unusual. Their work was influential for exploring welfare implications, but it was clear that the modeling they proposed was difficult and relied heavily on maintained assumptions. However, once individual-level data were available, there were alternative approaches to the use of a system of demand equations. Depending on the nature of the individual-level data available, it was natural to think about two forms these data might take: (a) the number of trips taken to a site; and (b) the choice between competing sites.

Count data in the form of the number of trips were at first analyzed using OLS regression, which revealed a major difficulty. Many samples were obtained on site and most respondents had taken only one trip, which was the one they were taking when interviewed. The difficulty here is that on-site interviewing ensures a truncated distribution, since zero counts cannot be observed and incorporate a sample selection effect since those visiting the site more often are more likely to get interviewed. None of these issues is fatal, and appropriate econometric techniques have been developed for this type of data.<sup>12</sup> More generally, count data models can be seen as the logical successor of the single-site TC model.<sup>13</sup> It is straightforward to incorporate demographic variables as a major source of variation in terms of the number of trips taken as well as differences in cost to the site of interest and competing sites (Parsons, 2003). Quality measures can be incorporated as predictor variables if the count data are collected for multiple time periods. Englin et al. (1997) provide an approach that allows outcome success (e.g. fish catch) to be jointly determined with the number of trips. It is also possible (Creel and Loomis, 1992) to combine count data for sites with a model of the choice between sites.<sup>14</sup>

## RANDOM UTILITY MODELS

When interest focused on why one recreation site was chosen over another, the need for a choice model was obvious. The outdoor recreation literature here starts in the late 1970s with the work of Hanemann and others, who used the random utility model (McFadden, 1974) to look at choice behavior and, in the process, addressed key issues with respect to



underlying welfare measurement.<sup>15</sup> The basic random utility model (RUM) posits that the utility of choice alternative  $j$  for individual  $i$  is given by:

$$U_{ij} = V_{ij} + \varepsilon_{ij}, \quad (16.2)$$

where  $V_{ij}$  is the systematic component of utility observable by the econometrician in the sense that  $V_{ij}$  can be estimated as a function of observable characteristics,  $x_{j1}, \dots, x_{jk}$  of alternative  $j$  and  $\varepsilon_{ij}$  is a random component. The random component is not random from the perspective of the individual but from the perspective of the econometrician, who does not observe all of the factors influencing the individual's choice. Given  $j = 1, \dots, J$  choice alternatives, the individual is assumed to pick the alternative giving the largest utility. Usually  $V_{ij}$  is parameterized in a linear fashion as  $\sum_k \beta_k x_{jk}$ , although transformation of individual  $x_{jk}$  are common. Interaction terms between attributes of the good and characteristics of the individual are also common since an individual's characteristics are the same across all choices and, hence, cannot influence choice unless some form of heterogeneity in preferences is assumed. The distributional assumption for the error component in (16.2) is important and is what distinguishes different discrete choice models from each other. The assumption that error terms come from an extreme value Type I distribution,  $f(\varepsilon_{ij}) = \text{EXP}(\varepsilon_{ij}) \cdot \text{EXP}(-\varepsilon_{ij})$ , yields the standard conditional logit model whereby the probability that the  $j_{th}$  alternative is chosen by the  $i_{th}$  individual is given by:  $p_{ij} = V_{ij} / \sum_j V_{ij}$ .

The standard conditional logit model always predicts the observed shares for each alternative, but imposes a strong assumption known as independence of irrelevant alternatives (IIA) on the substitution pattern between alternatives. The IIA assumption requires the ratio of the probabilities that the two distinct alternatives are picked does not change as other alternatives are added to or taken away from the choice set. This is an implausible assumption for highly correlated alternatives and is sometimes known as the red bus–blue bus problem. Adding a blue bus traveling on the same route at close to same time is likely to draw more from individuals currently taking the red bus than it would from those driving to work. Many statistical models have been proposed to relax the IIA condition and allow for more flexible substitution patterns with the most popular ones, for applied research, being the nested logit model and the mixed logit (Hensher et al., 2005).

As an example of a large travel cost RUM, we consider Carson, Hanemann and Wegge's (1987, 2009) model of recreational fishing in Alaska. The underlying data come from a diary survey of all trips taken by a sample of those holding recreational fishing licenses during a 22-week period. Trips are characterized by location (29 sites) and type of fish (13 groups). Most of the 29 sites are specific rivers or lakes, although, for completeness, distant sites are aggregated by region. The fish groups are for the most part individual species like silver salmon, although some less common freshwater lake fish have been combined. The last of the 13 fish groups is a 'no target' category. Not all fish species are available at all sites, and there is time series variation with temperature and an index of fishing quality.

The nested logit model allows for the prediction of a chain of probabilities (see Figure 16.3). It will be more instructive to start at the bottom rather than the top of this figure. At the bottom is a set of standard conditional logit models, for example, the choice

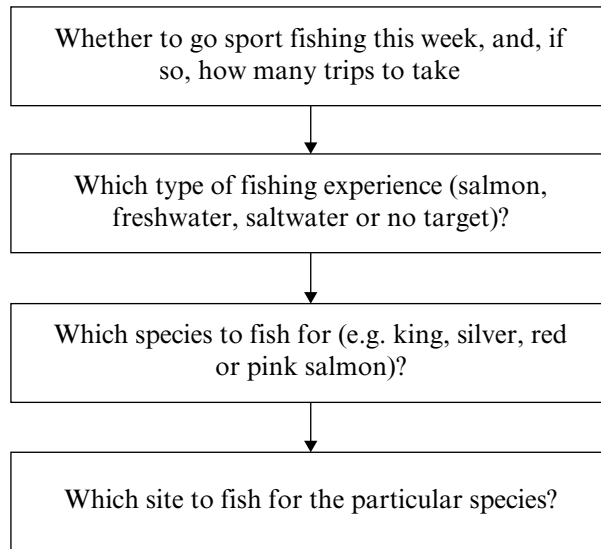


Figure 16.3 *Conceptual structure of nested logit model of Alaskan sport fishing*

of what site to fish for king salmon, conditional on the observed trip being a king salmon fishing trip. The expected utility of a particular site choice  $j$  was estimated to be:  $-0.9468 \cdot \ln(\text{TRAVEL COST}_{ij}) + 0.9589 \cdot \text{SITE RATING}_{jt} + 0.5376 \cdot \ln(\text{HARVEST}_{j,t-1}) + 2.1272 \cdot \text{CABIN}_{ij} + 0.1764 \cdot \text{CROWD}_{f_{ijt}}$ , where the  $i$  subscript has been suppressed if there is no variation in the variable at the individual level. Interesting features of this equation are that travel cost is ‘individualized’ using information on the recreator’s vehicle, that there are two site quality variables, an indicator of the recreator’s investment in the site through building an (often primitive) cabin, and that there is an interaction,  $\text{CROWD}_{f_{ijt}}$ , between the recreator’s preference for crowds and the level of crowding at site  $j$  at time  $t$ . Of the two site quality variables, one,  $\text{SITE RATING}$ , is from a publicly released report that widely followed the rate of how good fishing for a particular species at site  $j$  is currently. The other is an estimate of the harvest of the target species in the previous year. Similar models are estimated for each of the freshwater and saltwater species, and these form the bottom branches of the nested logit model shown in Figure 16.4.

At the next level of the nested logit model, the recreator chooses which species of salmon to fish for from the salmon macro group (king, red, silver, pink).<sup>16</sup> The estimated conditional logit model here takes on a particularly simple linear form with eight predictor variables: a constant for each salmon species (with the pink salmon constant normalized to zero) and four inclusive values (the natural log of the sum of the exponentiated estimates of the expected utility at each site where the particular species was available). The inclusive values are what link the branches of the nested logit model and allow correlation between the alternatives in a lower branch.<sup>17</sup> Note that the inclusive values are time varying, because (a) the number of sites where a particular salmon species is available varies by week, and (b) the utility of fishing for a particular species at particular sites varies due to the weekly site quality rating and the weekly level of crowding at the site.

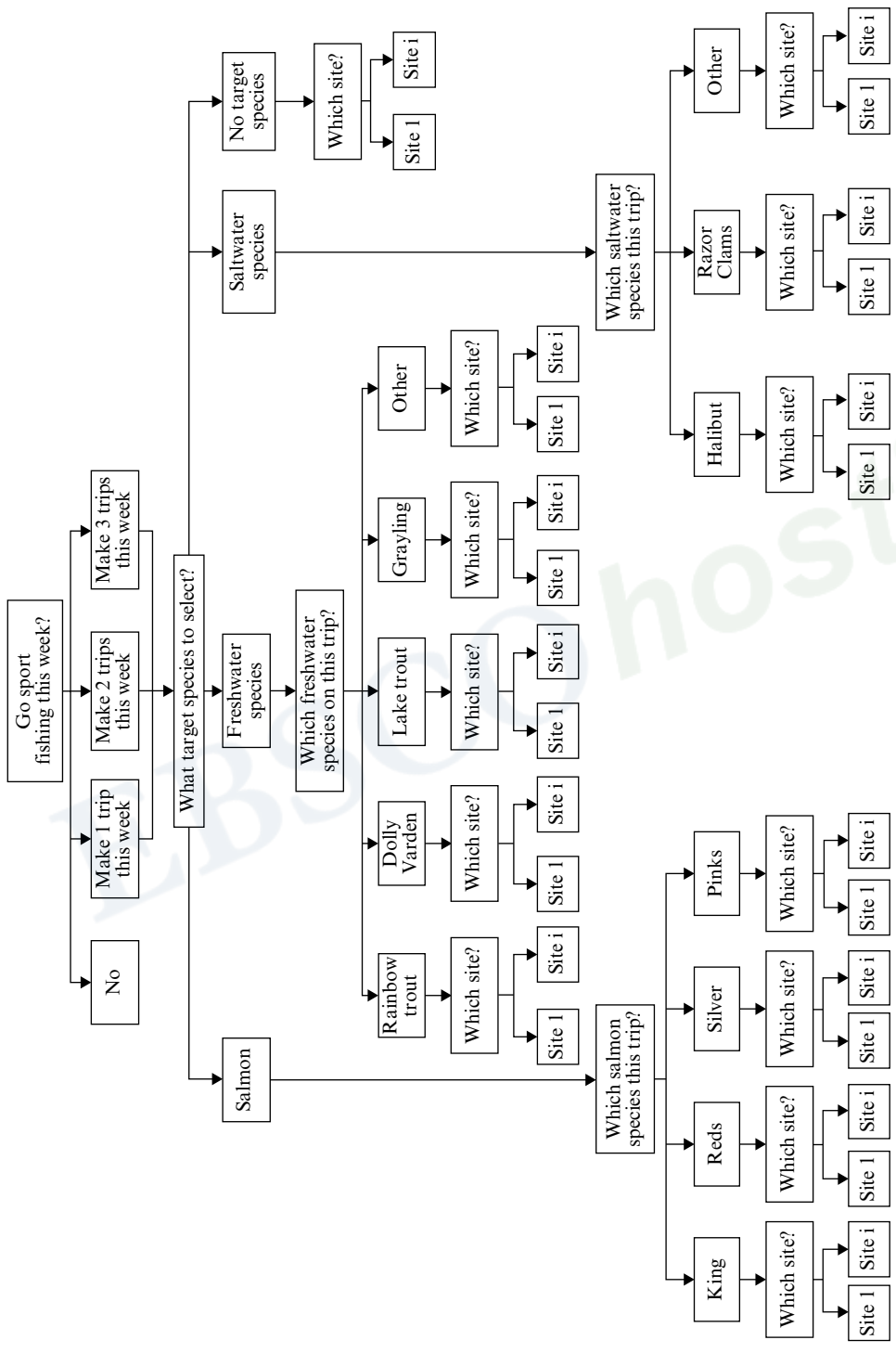


Figure 16.4 Hierarchical representation of nested logit model of recreation fishing in Alaska

At the next level, the recreator's choice between a salmon, freshwater, saltwater or no target trip is modeled as a function of four constants (with the one or no target normalized to zero), income (with no target normalized to zero), an indicator that the recreator said that site choice was more important than the target fish species, and the inclusive value from the lower branch. There is also a set of three indicators for owning a boat (specific to saltwater branch), favoring catch-and-release fishery (specific to freshwater branch) and fishing for trophy catch (specific to salmon branch). This level of the nested logit model has the inclusive values from the different branches, differing by the quality of fishing in the lower branches. These differences predict switching between branches. Having higher income is consistent with the recreator being more likely to choose saltwater fishing and, to a lesser extent, salmon fishing over freshwater or no target fishing. Those with a site focus tend to be either no target or freshwater fishing. The boat owner, catch-and-release, and trophy indicators are all highly significant and predict higher probabilities of choosing their associated branch. The top nested logit level predicts the number of trips taken in a particular week.<sup>18</sup> Here temperature is the major determinant – expected fishing trips in a week fall considerably when the temperature drops below 40 °F. They go up the greater the access the recreator has to leisure time, if the recreator has a boat, cabin or recreational vehicle, and the higher the recreator's self-assessed skill level is. The number of trips in a week tends to go down if the recreator, on average, takes long trips. Trips spike during the week of 4 July when it seems as if everyone in Alaska is fishing. The model fit allows for the possibility that the inclusive values representing the utility of fishing opportunities have different parameters before and after 4 July, with the estimates suggesting that coefficients are larger for the first half of the season than for the second half.

This model of recreational fishing can answer a wide array of policy questions. Carson et al. (2009) examine one change that helps illustrate the richness of a large travel cost RUM model. Let us assume that government biologists monitoring a king salmon run on a particular river determine that it needs to be closed for fishing in order to ensure that enough king salmon make it upstream to spawn. The first reaction of those who would fish that river is to think about where else they can go king salmon fishing, and the model predicts the shift in site choices conditional on fishing for king salmon. Sometimes the newly projected recreational fishing pressure on other king salmon sites will cause government biologists to want to close down other sites to ensure adequate spawning. Closing one or more king salmon site(s) will cause some shift to other species of salmon, and the lower overall quality of salmon fishing will shift some trips to saltwater and other types of fishing. Finally, the overall lower quality of fishing opportunity passed up to the top of the nested logit value through an inclusive value will result in some people to fish fewer days and others not fishing at all. The welfare loss in terms of consumer surplus for this chain of actions can be estimated and, if coupled with a model of expenditures on recreational fishing, the overall loss in revenue to the commercial sector associated with closing a king salmon run on a particular river can also be estimated.

The major alternative to the nested logit model is the random parameters logit model or, as it is typically now referred to, the mixed logit model. It allows the parameters of the utility function to vary across individuals by assuming that these parameters are drawn from a specified distribution(s), where the standard conditional logit model assumes the model parameters are fixed (Hensher et al., 2005). The choices are correlated because

individual unobserved variation in the taste parameters is used to evaluate the different alternatives. Train (1998), in a highly cited paper, estimates a mixed logit model of recreational fishing on different Montana rivers.

The switch to the RUM framework was also accompanied by taking the broader perspective that what was being estimated was a household production function. The other household production function approach often used with water resources is averting behavior (AB).<sup>19</sup> It can be used with either aggregate consumption or individual choice data. Like TC analysis, AB can also have a time component. Harrington et al. (1989), for instance, find one of the major actions undertaken by residents of Luzerne County, Pennsylvania, in response to an outbreak of giardia, a water-borne biological disease, is to haul water in from clean sources. AB represents a lower bound on the value of a resource because the averting actions are typically an imperfect remedy. In an early empirical study of averting behavior, Smith and Desvousges (1986a) look at the use of filtration systems and bottled water in several Massachusetts towns in response to fears of toxic contamination. Turning to rural households in Pennsylvania, Abdalla et al. (1992) examine household expenditures in response to contaminated groundwater wells in rural Pennsylvania. In a recent paper, Graff-Zivin et al. (2011) look at how a major grocery store chain's sales of bottled water in California and Nevada change at the zip code level in response to drinking water quality violations reported to customers.

There is also a small number of AB studies in developing countries. Pattanayak et al. (2005), for instance, look at expenditures on various ways to help cope with an unreliable water supply in Nepal.<sup>20</sup> More generally, the issue of water demand in many low-income developing countries is amenable to the use of travel cost analysis. Obtaining water is a major household task and one typically undertaken by women, who carry water from an external source to their home. The choice of which external water source to use is influenced by how long it takes to walk there and by perceptions of contamination/quality issues. The household production function approach can be used to place a monetary value on the time spent obtaining water and how time is a tradeoff for reducing the risk associated with using a particular water source (Nauges and Whittington, 2010; Kremer et al., 2011).

## CONTINGENT VALUATION

The logic underlying the TC models is that there is a choke price for every individual that represents the cost at which they would switch from taking the recreation trip. This quantity is the individual's WTP to visit the site, given the other costs (e.g. travel cost) of using the site. Many early CV studies put this question directly to individuals (Mitchell and Carson, 1989a). McConnell (1977) is a good example. Recreators on Rhode Island beaches were asked a bidding game question about their willingness to pay a specific amount that iterated up or down by \$0.50 until a yes response changed to a no (or no to a yes). McConnell then empirically shows that this amount is a function of two measures of the quality of the beach recreation day (temperature and congestion), the number of beach trips and income, as well as showing that the congestion effect differs across the beaches examined in an intuitive way related to their characteristics. Putting a monetary value on different types of water-based recreation has continued to be a mainstay CV

application (Carson, 2011). There are studies looking at different types of fishing and boating, diving on coral reefs, waterfowl hunting, river rafting and instream water flows, urban water parks and whale watching.

One reason for the popularity of CV is that it can be used to value a good that does not yet exist and is considerably different than existing goods. Take, for example, the situation in which people can currently go fishing on a river but the river is difficult to reach, and another situation in which a road to the river is built, along with a boat launch ramp, toilets and parking. The question survey respondents might now be asked is whether they prefer the unimproved site with a zero entrance (or parking) fee versus the improved site for a specified fee.<sup>21</sup> It is also possible to use CV to look at how attendance changes both in terms of numbers of visitors and in terms of their demographic characteristics (Teasley et al., 1994). In a CV study of visitors to Lake Nakuru National Park in Kenya, Navrud and Mungatana (1994) find foreign visitors to be much less price elastic than Kenyan visitors, a result that has helped contribute to setting differential entrance fees at major African national parks.

The 1960s saw increasing concern over water pollution in the USA, culminating in the passage of the 1972 Clean Water Act. Economists would be asked to value the benefits of improving water quality. Gramlich (1977) looked at the Boston area public's WTP to improve the Charles River to swimmable quality water (something that has only just recently been achieved); Oster (1977) looked at cleaning up the Merrimack River; and Greenley et al. (1981) asked respondents to consider situations involving long-lived heavy metal contamination in the South Platte River Basin. However, it was the CV studies of the benefits of improving national water quality estimated using national representative samples (Mitchell and Carson, 1981; Mitchell and Carson, 1986a; Carson and Mitchell, 1993) that played a major role in US water policy by providing both estimates of the value of achieving the goals of the US Clean Water Act (US EPA, 1994) and providing a source for benefit-transfer exercises used to value regulations intended to improve water quality (Griffiths et al., 2012). These studies pioneered the use of the payment card to help avoid starting point bias, which sometimes occurred using the bidding game elicitation format. They also presented respondents with an easy-to-understand water quality ladder (Figure 16.5) that described water levels in terms of human uses and, in turn, was linked to underlying physical parameters. Both innovations are now frequently used. WTP for three different water quality improvements were obtained. These estimates were then stacked on top of each other in a regression model that explained differences in WTP as a function of the water quality change, an indicator for engaging in water-based recreation and an indicator of environmental preferences. This 'valuation function' allowed different water quality improvements and, coupled with other questions in the survey on allocation across geographic areas, provided a way of downscaling the estimates.<sup>22</sup> Later studies in the USA (Viscusi et al., 2008) and in the UK (Metcalf et al., 2012) have moved to describing water quality changes in terms of ecosystem services as well as recreation use suitability. Furthermore, they have improved spatial resolution by moving to a discrete choice experiment (DCE) framework asking a sequence of questions that collects more information from each respondent (Louviere et al., 2000; Carson and Czajkowski, 2014).<sup>23</sup>

CV flexibility has resulted in it being used to value most nonmarket aspects of water resources that policymakers have been interested in. We mention six here, as they have

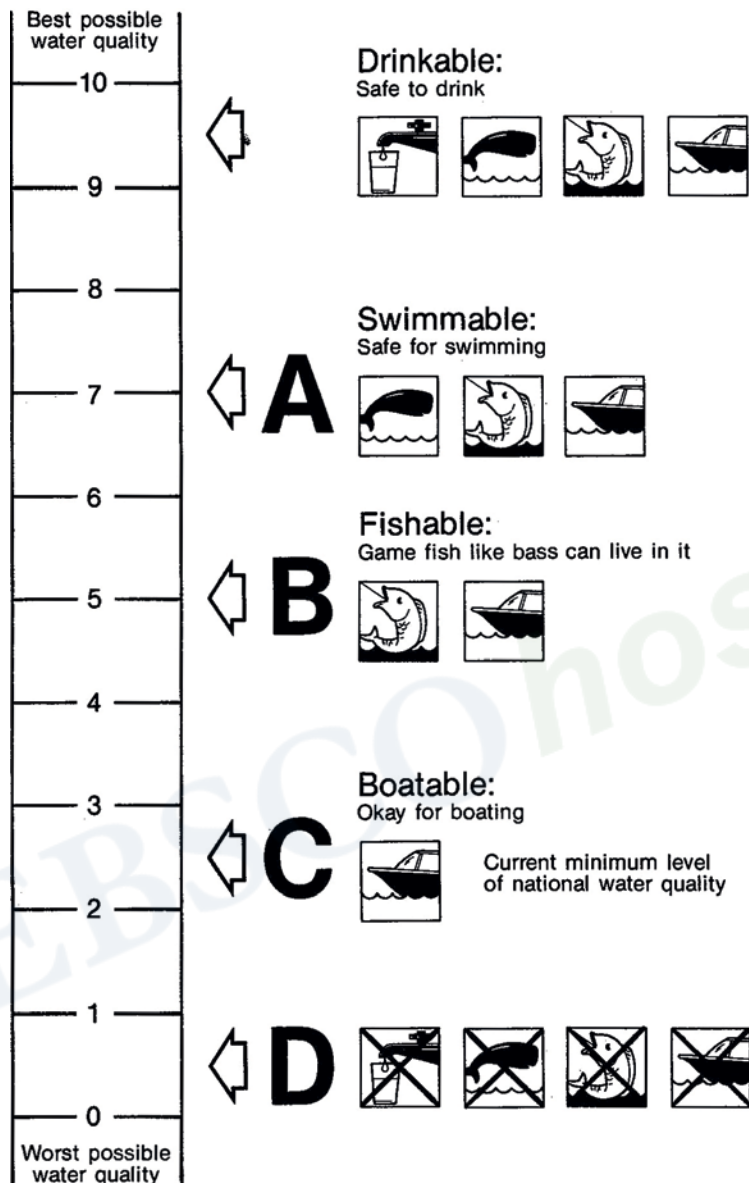


Figure 16.5 Illustrative water quality ladder

been the subject of a considerable amount of work that has played into various policy debates. The first is to look at the valuation of different aspects of instream flow, an important issue in many arid areas (Daubert and Young, 1981; Loomis 1987; Boyle et al., 1993; Berrens et al., 1996).<sup>24</sup> The second is the (potential) contamination of groundwater aquifers (Mitchell and Carson, 1989b; Bergstrom et al., 2001). Here, CV can be used to value the existence value of uncontaminated aquifers, the option value

of either an uncontaminated aquifer or cleaning up a contaminated one, and direct use value in the presence of other alternatives. The third is valuing the reduction of carcinogenic and microbial risks present in the drinking water supply (Carson and Mitchell, 1986b; Adamowicz et al., 2011). Here, CV can be used to estimate the value of a statistical life or the value of a statistical illness.<sup>25</sup> The fourth is the reliability of municipal water systems in which the ability of CV (Carson and Mitchell, 1987) to determine how much households were willing to pay in the form of higher water bills to avoid water rationing has altered how water economists think about how water systems should be managed. Howe and Smith (1993) and Griffin and Mjelde (2000) further explore the issue of water reliability from the perspective of household WTP to avoid different types of shortages. This issue is looming larger in the face of population growth and climate change. A fifth common application is to value specific types of ecosystems, such as coral reefs and wetlands, and uses of those ecosystems.<sup>26</sup>

The last CV application area we considered involves household WTP to prevent oil spills in which the Carson et al. (1992) study involving the *Exxon Valdez* oil spill focused attention on the use of CV to measure the harm to the public's passive use of a distant resource.<sup>27</sup> We briefly describe the more recent study (Carson et al., 2004) on preventing oil spills along California's central coast between San Francisco and Los Angeles. The issue is smaller spills typically associated with barges that spill oil at the shoreline (Carson et al. 2004). Survey respondents are shown maps that identify the area (and distinguish it from the supertanker routes from Alaska) and are shown pictures of different types of shoreline. The nature of the ecosystem being protected is described in words as well as being summarized in a graphic (see Figure 16.6). The likely injury without a prevention plan is described and a prevention plan presented. A random sample of California households is drawn and respondents are interviewed in person. They are randomly assigned to one of five tax prices. The main data from the study are the percentage of the sample willing to pay each of the randomly assigned amounts: \$5 (69 percent), \$25 (57 percent), \$65 (49 percent), \$120 (40 percent) and \$220 (29 percent). From these data, summary statistics describing the distribution of household WTP can be calculated. In conjunction with other information collected in the survey, a discrete choice model predicting who favors the proposed prevention plan as a function of the tax price, income and other household characteristics can be estimated.

## HEDONIC PRICING

Relative to the large number of CV and TC studies that have been undertaken to value various aspects of water resources, there has been a much smaller number of hedonic pricing (HP) studies focused on water issues.<sup>28</sup> After early applications, like Knetsch (1964b) and David (1968), those undertaking hedonic applications tended to think more formally about housing being a bundle of attributes in the sense of Lancaster (1971). Rosen's (1974) formal theoretical framework for hedonic pricing also began to be used.<sup>29</sup> Brown and Pollakowski (1977) looked at distance from the shoreline of multiple lakes in Seattle and showed that it was possible to get an estimate of how much of the value of open space along the shore was incorporated in nearby houses. They note that hedonic pricing is not able to capture utility that might accrue for people who did not live in



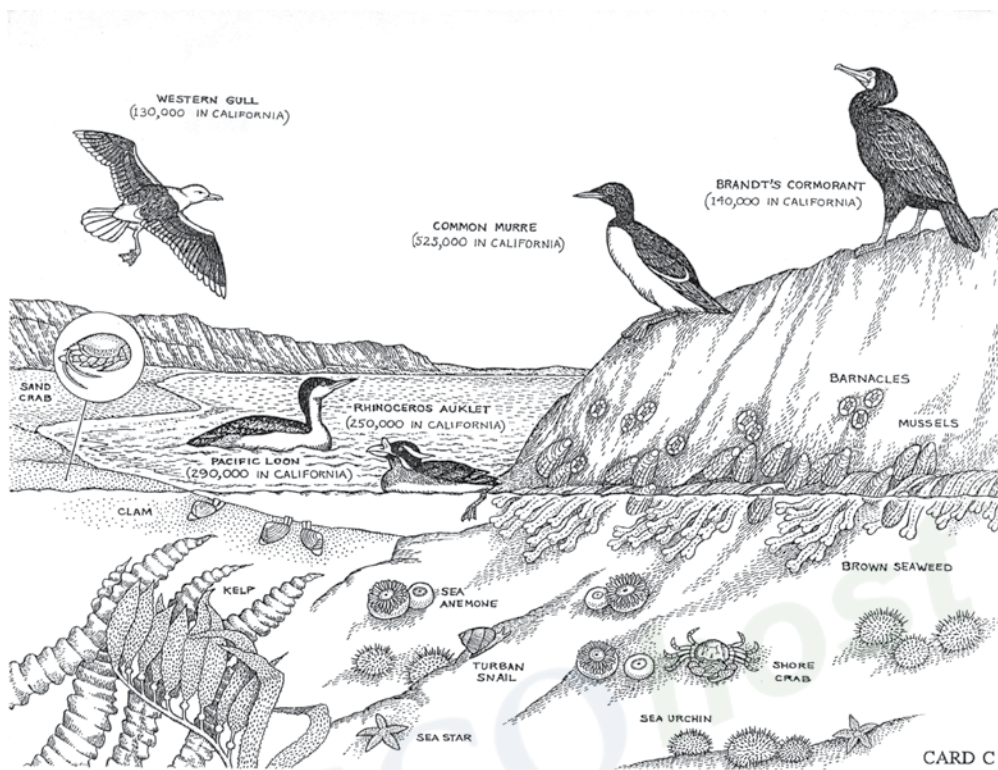


Figure 16.6 Central California coastal ecosystem

neighborhoods near the shore. Epp and Al-Ani (1979) look at acidic pollution in homes in rural areas of Pennsylvania along waterways and show that housing prices fall as PH levels fall, and that there is an interaction between falling PH levels and increasing population, suggesting greater demand for higher water quality in areas that were growing.

Rosen (1974) posited a two-stage model. The first observed market prices for goods to implicit prices for their attributes.<sup>30</sup> The second looks at consumer demand for the attribute. The first stage of a standard hedonic pricing model takes the form:

$$g(\text{price}) = f(x_1, x_2, \dots, x_k) + \epsilon \tag{16.3}$$

where all of the variables are understood to have a subscript  $i = 1, 2, \dots, n$ . Originally, the most common functional forms for  $g(\bullet)$  and  $f(\bullet)$  were the standard linear and log-linear representations. Following Cropper et al.'s (1988) Monte Carlo simulation of the ability of different functional forms to recover implicit price, use of a Box-Cox transformation has become a standard feature of empirical work. There has also been some interest in semi-parametric (Mason and Quigley, 1996) or non-parametric approaches (Stock, 1991) used to estimate the first stage of the hedonic pricing equation. Issues that arise in the estimation of  $f(\bullet)$  include: (a) what predictor variables to include; (b) the functional form of included predictors; (c) whether interactions between predictor variables

are included; (d) a high degree of multicollinearity between environmental predictors; (e) too little variability in some of the predictors; (f) some combinations of predictor variables are not present in the observed data; (g) the possibility that some of the predictor variables are endogenous; and (h) the possibility that the housing market is not in equilibrium. In addition, the hedonic pricing function should be driven by the distribution of perceptions involving property attributes and even the objective measures of the main environmental attributes of interest can involve substantial measurement error, due to the need to extrapolate data spatially from a relatively small number of monitors. Boyle et al. (1999), who look at the role that water clarity of freshwater lakes plays on property values in Maine, and Leggett and Bockstael (2000), who look at the influence of water pollution in the Chesapeake Bay on housing prices, are two of the most commonly cited water-based hedonic pricing studies. Muller (2009) looks at a range of specification issues that are likely to be important considerations in the empirical estimation of hedonic pricing function involving water-related attributes.

The second-stage hedonic equation has always been problematic because it has to sort out demand from supply. Most empirical work assumes that the changes of interest are marginal enough that the implicit prices from the first stage are reasonable to use. Another assumption often made to help justify this practice is to assume that the number of homes available in an area is essentially fixed over the period of interest. An instrumental variables solution has also been suggested, since the problem is disentangling demand from supply, yet convincing instruments rarely emerge. In earlier times, following Rosen (1974), identification came from assuming a non-linear functional form, but this has generally proven unsatisfactory, as has the earlier strategy of identification by being able to observe HP equilibria in multiple markets. A related issue arises from the fact that the value of an environmental amenity can be reflected in both the housing market and in the wage market.<sup>31</sup> For instance, an ocean view is likely to be reflected only in the house price, but general proximity to the ocean can be reflected in both housing prices and wages.

In recent work, Bin et al. (2009) use HP to ask whether mandatory riparian buffer strips, often favored by conservation programs, influence property prices. They found that, while riparian properties command premiums, riparian buffers do not, suggesting that there are no private benefits associated with this requirement.<sup>32</sup> Bin and Landry (2013) look at the time path of how flood risks get capitalized into home prices as a function of extreme events like hurricanes. Gopalakrishnan and Klaiber (2014) look at housing prices in Pennsylvania in areas where there is extensive fracking and show that homes near fracking operations that are on municipal water systems do not appear to suffer losses (if they are not on heavily trafficked roads), while homes whose water source is groundwater wells do suffer a loss in value. Abbott and Klaiber (2013) use an innovative matching strategy that estimates the value of a club good, recreation lakes belonging to homeowner associations (HOA) in two adjacent Phoenix area communities where the two HOAs face different prices for water due to contractual history. Their approach bypasses some of the main HP specification issues and provides estimates of how the lakes are differentially capitalized into home prices, depending on proximity to the lake and the price of water that the HOA faced.

## CONCLUDING REMARKS

Water is a multifaceted resource. It has played an important role in the process of economic development since before recorded history. In modern times, the requirement to carry out benefit–cost analyses of water projects provides the impetus to value water-based outdoor recreational activities in monetary terms. This need directly gave rise to the travel cost/household production function approach and played an important role in the development of contingent valuation and hedonic pricing. The next challenge facing economists was to place a monetary value on changes in water quality, which was the focus of major environmental initiatives in the USA and other countries. Using RP data, economists were able to show that water quality influenced recreation behavior as well as housing prices. CV scenarios offering tradeoffs involving higher levels of water quality and higher costs posed to households provided estimates of the economic value the public placed on specific water quality improvements. Since these successes, nonmarket valuation techniques have been used to place a monetary value on an ever-increasing array of resources influenced by water policy, ranging from impacts on endangered species to the reliability of municipal water supplies. The largest growth in application of nonmarket valuation techniques has been in developing countries that are facing many of the same environmental infrastructure issues that the USA faced earlier.

## NOTES

1. See Hufschmidt (2000), Pearce (2002), Young (2005), Birol et al. (2006), Hanemann (2006), Boland et al. (2009), Banzhaf (2010), Olmstead (2010), Griffin (2012) and Ward (2012) for extended discussions of the development of benefit–cost analysis and policy analysis in the context of water resources.
2. Ciriacy-Wantrup (1952, p. 85), in the first environmental and natural resources textbook, called the use of the word intangible ‘unfortunate’ and recommended using the term ‘extramarket’ instead. He argued that tradeoffs between extramarket and market goods can be obtained objectively, where this can be done through observation of ‘behavior in situations of choosing, either actually or hypothetically (in questionnaires, for example)’. What Ciriacy-Wantrup saw as being needed was the ability (through observation of behavior, interrogation and introspection) of agents being able ‘to compare changes in their state of well-being connected with *ex ante* changes in the combination of extramarket and marketed goods’ and that it was this objective evaluation that made determination of the optimal level of a public good such as conservation operational.
3. Other major concerns that have continued to the present include: the discount rate to be used; the period to be used for the economic analysis; whether secondary benefits (induced local economic activity including jobs) should be counted; and cost-sharing rules.
4. After Senate Document 97, the task of formulating guidelines for the valuation of water projects fell to the US Water Resources Council, an ad hoc successor to the Federal Inter-Agency River Basin Committee, which was responsible for the Green Book. The US Water Resources Council was established by President Kennedy in 1962 and issued a series of influential guidance documents through 1983 (US Water Resources Council, 1983), after which it was disbanded by President Reagan. Hufschmidt (2000) examines the Water Resource Council’s formation and actions.
5. Castle (2000) provides a short account of the early Committee on the Economics of Water Resources Development established by the chairs of the agricultural economics departments in the western US states through the Western Agricultural Economics Council. Castle notes that the Committee, which included Ciriacy-Wantrup, played a key role in the development of his belief in the need to find ‘ways of valuing market and non-market water uses on a comparable basis’ in order to ‘discover ways to expand the scope of economic analysis’. This group served as the precursor to the USDA-sponsored W-133 project and later W-2133 project that have played an important role in the development of nonmarket valuation techniques and their application to water-related issues.
6. Renshaw (1958a) clearly takes a Ricardian approach, albeit without mentioning Ricardo, and in this

sense is the logical predecessor of Mendelsohn et al's (1994) seminal work on the impact of climate change on US agriculture, as Schlenker et al. (2007) point out. Renshaw (1958b) takes the view that multiple regression can do the same job that property appraisers do, by developing a model that predicts property values as a function of observable attributes that is accurate enough to be useful.

7. There is a large literature (e.g. Viscusi and Aldy, 2003) on estimating the value of a statistical life using different nonmarket valuation techniques that is not examined here.
8. Parsons (2003), Phaneuf and Smith (2005), and Bockstael and McConnell (2007) provide overviews of the key issues involved in doing travel cost studies. Haab and McConnell (2002) provide useful guidance on many of the econometric issues faced in nonmarket valuation exercises.
9. A stronger assumption, that all people in all zones had the same preferences, was made in some early work on travel cost but clearly is not needed to rule out the selection effect. Assuming identical distributions of preferences across all zones would leave us without a random component. A random component can be introduced by allowing different people in a particular zone to have unobserved cost deviations from the zonal average to get to the recreation site. Weber et al. (2012) look at issues involved with estimating a zonal travel cost model when quality can vary over time using instream flows at a Sonoran Desert recreation site.
10. This time dimension potentially allows for covariates that vary by time such as the unemployment rate to explain the difference in trip behavior if the available data take the form of a time series or a panel data set rather than the usual cross-sectional data that are most commonly used in travel cost analysis. There is another time dimension, the hours spent on site recreating, that is not addressed here but can be important in some circumstances.
11. Ward and Loomis (1986) provide an overview of a range of issues, many of them statistical in nature, as travel cost models moved from very simple zonal models with relatively little informational content to models that tried to control for site attributes, competing sites, differential access to sites and heterogeneous preferences.
12. The econometrics formulation of truncated count data models for use in recreation demand models is developed in Shaw (1988), Creel and Loomis (1990), and Grogger and Carson (1991). Complete count data can be obtained from random samples of the public or specialized samples such as fishing license holders by asking for a retrospective accounting of trips taken or by asking a sample to keep a diary account of the activity of interest.
13. There are other technical issues, such as how to model heterogeneity in the error component, that are likely to be important in practice with count data. In particular, the Poisson count data model's assumption of equality between the conditional mean and variance is likely to be violated in many empirical datasets.
14. Further, as Hellerstein and Mendelsohn (1993) show, count data representing the number of trips to a site can be seen as arising from an underlying repeated discrete choice model.
15. Hanemann's dissertation (1978) is the starting point, with Hanemann (1982, 1984) laying out the theoretical foundation. Much of this line of work is summarized in Bockstael et al. (1987).
16. A separate site choice model is estimated for no target recreational fishers, which does not involve a separate macro species group level.
17. The hierarchical structure of the nested logit model should not be taken as an indication that all recreators necessarily make decisions in this fashion. The hierarchical structure can help to conceptualize the set of decisions being made, but it should be seen mainly as a device that helps to facilitate estimation.
18. The choice alternatives are zero trips (where the coefficients on all predictors are normalized to zero), one trip, two trips, or three or more trips.
19. Sometimes these variants of a household production function are largely indistinguishable. For example, Montgomery and Needelman (1997) estimate a discrete choice TC model of fishing behavior in New York focused on whether people avoid lakes that the state has publicized as having toxic contamination and use that model to estimate the benefits of cleaning up those lakes.
20. They find averting expenses to be less than WTP for a completely reliable water supply, which is the expected theoretical relationship since the various coping actions undertaken do not make the water supply completely reliable. Interestingly, the cost of the coping actions undertaken was substantially higher than payments to the water utility, suggesting sizable welfare losses from the existing water system.
21. The usual assumption that is (implicitly) made is that the number of trips taken under the alternative to the status quo would be the same as under the current status quo. This need not be the case and, from a theoretical perspective, even the sign of any possible change in the number of trips is indeterminate. Some studies ask for an estimate of the likely number of trips that would be taken under the new alternative, which is known as an estimate of contingent behavior. Such studies also collect RP data on the number of past recreational trips. This allows the estimation of a model that combines the RP data with the contingent behavior data (Englin and Cameron, 1996).
22. An example of how to do this was carried out by predicting the Smith and Desvousges (1986b) CV

estimates for the Monongahela River that had used the Mitchell and Carson (1981) survey instrument as its starting point.

23. The early examples of using the DCE approach more than a single-price attribute in the environmental literature are Carson et al. (1990) and Adamowicz et al. (1994). As an aside here, it is worth noting that CV, as well as TC and HP, can be used in the context of a GIS mapping of benefit estimation when the appropriate valuation function has been estimated using the original data and the covariates used in that valuation function are available at the spatial resolution being used in the GIS system (Bateman et al., 2003; Geoghegan et al. 1997). Ge et al. (2013) prove a meta-analysis on the value of clean water that utilizes CV, HP and TC estimates.
24. It is also possible to use travel cost analysis to value instream flows as they influence recreation demand. See Ward (1987) for an early example.
25. Adamowicz et al. (2011) consider several different SP elicitation formats in their study. Carson and Louviere (2011) provide a common nomenclature for these different elicitation formats; all have been seen as variants of DCEs. The use of explicitly varied attributes (in addition to cost) allows Adamowicz et al. (2011) to efficiently value different types of drinking water risks.
26. There are now a sufficient number of nonmarket valuation studies that meta-analyses can be performed that look at the influence of the characteristics of the resource being valued and particular nonmarket valuation techniques used. Brander et al. (2007) provide a meta-analysis of valuation work on coral reef while Woodward and Wui (2001) provide a meta-analysis of valuation work on wetlands.
27. This use of CV has been the subject of a contentious debate and the subject of a NOAA-sponsored Blue Ribbon panel chaired by Kenneth Arrow and Robert Solow (Arrow et al., 1993). For recent commentaries on this debate, see the recent *Journal of Economic Perspective* symposium papers by Kling, Phaneuf and Zhao (2012), Carson (2012) and Hausman (2012).
28. There have, however, been a substantial number of hedonic housing price studies done looking at air pollution, crime, noise, proximity to hazardous waste sites, proximity to open space and school quality.
29. This is not to say that these earlier papers did not value environmental attributes; indeed David (1968) appears to be the first paper to include an indicator of water quality in a housing price regression equation.
30. Palmquist (2005) provides a comprehensive overview of the theoretical underpinnings of the hedonic pricing model. This is still an active area of research (e.g. Heckman et al., 2010) though as identification of the second stage of a hedonic pricing model is tenuous at best. Much recent work has gone in the direction of seeing sorting and matching as helping to define the underlying process (e.g. Kuminoff et al., 2013).
31. See the well-known Blomquist et al. (1988) paper. Albouy (2012) represents current thinking on modeling quality-of-life indicators and indicates a need to account for factors influencing productivity. One implication of this work, noted by Randall (1994) in his critique of the travel cost model, is that the choice of residential location is potentially endogenous; for example, people who like to go to the beach tend to live close to it. Hand et al. (2008) look at this issue in the context of housing prices and wages in Arizona and New Mexico, and find that households pay less for housing but receive lower wages in metropolitan areas with more surface water, with the net effect being a positive implicit price for surface water.
32. Contingent valuation has been used to look at the incentives needed to get property owners to voluntarily provide protection to riparian habitat (e.g. Kline et al., 2000).

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