IMPACT OF FLUCTUATING RESERVOIR ELEVATION ON RECREATION USE AND VALUE

December 1999

U.S. Department of the Interior
Bureau of Reclamation

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. AGENCY USE ONLY ***(Leave Blank)***	**2. REPORT DATE** December 1999	**3. REPORT TYPE AND DATES COVERED** Final

4. TITLE AND SUBTITLE Impact of Fluctuating Reservoir Elevation on Recreation Use and Value	**5. FUNDING NUMBERS**
6. AUTHOR(S) Jonathan Platt and Dawn Munger	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Bureau of Reclamation Technical Service Center Economics Group (D-8270) Denver, CO 80225-007	**8. PERFORMING ORGANIZATION REPORT NUMBER** EC-1999-1*
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Bureau of Reclamation Policy Analysis Office Denver , CO 80225	**10. SPONSORING/MONITORING AGENCY REPORT NUMBER** DIBR

11. SUPPLEMENTARY NOTES

n/a

12a. DISTRIBUTION/AVAILABILITY STATEMENT Available from the National Technical Information Service, Operations Division, 5285 Port Royal Road. Springfield, Virginia 22161 (703) 487-4650	**12b. DISTRIBUTION CODE**

13. ABSTRACT ***(Maximum 200 words)***

This paper reviews a series of methods for evaluating the effect of changing reservoir water elevations on recreation use and value. The approaches covered range from simplistic to complicated. The choice of approach depends on several factors including: output requirements of the analysis, the level of accuracy required for the results, the adequacy of existing data, and constraints on time, budget, and technical expertise.

14. SUBJECT TERMS Reservoir Recreation, Reservoir Elevation	**15. NUMBER OF PAGES** ** pages
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT UL	**18. SECURITY CLASSIFICATION OF THIS PAGE** UL	**19. SECURITY CLASSIFICATION OF ABSTRACT** UL	**20. LIMITATION OF ABSTRACT** UL

Technical Memorandum Number EC-1999-1

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December 1999

ACKNOWLEDGMENTS

This research was conducted under fiscal year 1998-2000 Bureau of Reclamation manuals and standards funding. The authors would like to thank Earl Ekstrand and Steve Piper of the Bureau of Reclamation's Technical Service Center Economics Group for their helpful comments and guidance in peer reviewing this paper. We would also like to thank ??? for her/his?? assistance in preparing this document for publication.

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APPENDIX

1.0 INTRODUCTION

Effects on water based recreation are an integral factor in the assessment of many U. S. Bureau of Reclamation (Reclamation) activities. Given Reclamation's historic role as a dam building agency, recreation analyses of proposed reservoir sites were typically an important consideration in project evaluation. In more recent years, the agency's emphasis has adjusted to the movement away from dam construction and toward water management. Accordingly, the focus of most recreation analyses has also shifted from measuring the impacts of new sites to estimating changes at existing sites. Efficiently managing water stored behind Reclamation dams often implies changing historic reservoir operations. As a result, reservoir reoperation has become a common characteristic of many Reclamation studies including dam safety, flood control, water supply, water quality studies, etc. Given Reclamation's evolving role in the achievement of efficient water management across the West, economic analysis of changing reservoir operations has become critical to the decision making process.

Changing reservoir operations, meaning changes in the amount and/or timing of reservoir releases and storage, has implications for flatwater recreation through fluctuations in reservoir elevation or water level. Water level fluctuation affects recreation use and value in a variety of ways through changes in water depth and surface acreage. Changing water levels may positively or negatively affect any of the following factors: 1) safety, 2) water access, 3) water quality, 4) aesthetics, and 5) crowding. Safety can be impacted through exposing or inundating stumps, rocks and other obstructions. Water access varies as facilities become unusable both with increasing and decreasing water depth. In addition, shoreline access to the water may be affected by the magnitude of mud flats. Water quality, including changes in clarity, smell, and pollutant concentration, may influence expectations for safe water contact thereby affecting the desirability of water sports - swimming, fishing, boating, waterskiing, etc. Exposing or inundating reservoir "rings", mud flats, etc. can affect a wide range of activities through changes in aesthetics. Finally, changes in water levels and surface acres often result in recreation use being further concentrated or diffused.

This paper evaluates a range of approaches for estimating the impact of fluctuating reservoir water levels on recreation use and value. While reservoir water level fluctuations are generally hypothesized to affect both recreation use and associated economic value, the magnitude of the impact is often very site specific.

It is typically speculated that as water levels decline at a given reservoir, overall recreation use and value will also decline. The magnitude of the recreation reaction to a change in water levels at a particular reservoir depends on a number of factors including: 1) physical characteristics of the lake, 2) usable range of water access facilities, 3) current reservoir water levels, 4) availability of substitute sites, 5) tolerance of recreator populations to water level changes, 6) mix of recreation activities, etc. Physical characteristics of a lake, including lake contours and physical obstructions, can strongly influence recreation. Gradually sloping lakes can result in wide mud flats with relatively small water level changes. Mud flats are visually displeasing and hamper shoreline access to the water. Reservoirs where physical obstructions have not been removed obviously pose a considerable threat to boat based activities. Water access facilities, such as boat ramps and marinas, are most attractive when they provide flexibility across a wide range of water levels as a result of length (boat ramps) or mobility (marinas). Current water levels, reflecting a baseline or starting point for water level fluctuations, provide a frame of reference for evaluating impacts. For example, should water levels be very low and most of the recreation effect already incurred, further water level reductions may be minor. Conversely, should water levels be high enough to adequately support recreation and a proposed drawdown causes facilities to become unusable, the recreation effect could be significant. The availability of quality substitute sites in the region can also play a role in estimating potential water level impacts on recreation. Should other nearby sites exist which would be unaffected by a proposed drawdown plan, it is likely that recreators would move to those other sites. Recreator tolerance to the implications of reservoir drawdown would also be important. If a proposed drawdown falls within recent historical ranges, recreators may have adapted and be willing to accept a certain level of monthly fluctuation. Tolerance may also be a function of the number of substitute sites in the region. Finally, the mix of recreational activities at a given site may have an effect since certain types of recreators are less apt to be impacted water levels (e.g., land based activities) or better suited to deal with crowding issues.[1] As a result, changing water levels may or may not impact the level of recreation use and value. Having said this, it should be noted that virtually every study reviewed for this project showed a negative relationship between water levels and recreation use.

[1] Webster (1993) found that different types of water based receators reacted differently to water level fluctuations and varying levels of congestion/crowding. Jet skiers seemed to enjoy higher densities of recreators while non-motorized boats preferred solitude.

2.0 RECREATION DEMAND THEORY

The demand for recreation is based on consumer demand theory, where individuals purchase goods and services in quantities that maximize utility (satisfaction or enjoyment) given their level of available income. The utility obtained from consuming different quantities of recreation and other goods and services can be described using a utility function, where utility is a function of the quantities of various goods and services consumed. The consumption decision can be represented as:

$$Z = U(Q_r\,(Qual_r),\, Q_a)$$

subject to:

$$P_rQ_r + P_aQ_a = M$$

where Z is total utility, Q_r is the quantity of recreation, $Qual_r$ is the quality of the recreation experiences, Q_a is the quantity of all other goods and services, P_r is the price of recreation, P_a is the price of all other goods and services, and M is available income. Solving this optimization problem results in first order conditions which require the marginal utility of recreation and other goods to be equal at the quantities purchased:

$$U'_{Qr} = P_r\lambda$$
$$U'_{Qa} = P_a\lambda$$

where U'_{Qr} and U'_{Qa} are measures of the utility an individual receives from purchasing the last unit of the good, or marginal utility. The lambda(λ) represents the marginal utility of income. Therefore, price multiplied by lambda is the opportunity cost (purchases forgone) of purchasing the good. The first order conditions indicate that an individual will purchase each type of good until the marginal utility of the last unit purchased is equal to the marginal utility given up in terms of other purchases to purchase the good. The quantity of the different goods are purchased such that the utility associated with each purchase, at the margin, is equal to its price.

Of particular note for this paper is the $Qual_r$ term. In addition to the price of recreation, the quality of the recreation experience also influences the number of recreation trips taken (Q_r). The quality of the recreation experience can be affected by many factors, including reservoir water elevations. A positive relationship is generally hypothesized between reservoir water elevations and recreation use and value.

3.0 LITERATURE SEARCH

To obtain information on the range of analytical approaches for estimating impacts of fluctuating reservoir water levels on recreation, a literature search was conducted.

The intent of the literature search was twofold. First, to provide information on the range of approaches discussed in this paper, and second, to provide backup references for each approach for consultation by agency economists on theoretical or procedural questions.

The literature search was conducted in two parts, 1) keyword searches of several relevant databases (see Appendix A for a details) and 2) reviews of the references included in each collected study. Keyword searches using the Internet, Colorado Research Library System (CARL), Dialog Database, and Firstsearch Database provided a set of both published articles (journals, books, etc.) and unpublished articles (consulting firm reports, government agency reports, university working papers, etc.). Reviews of the references and bibliographies from these collected papers identified numerous additional studies for consideration. Each paper was briefly reviewed for applicability to the topic area. As part of the review process, several papers were discarded as inappropriate. The number of articles reviewed in detail totaled 36 (see the bibliography for citations for all 36 articles). Annotated bibliographies were developed for each of the papers subject to detailed review (see Appendix B).

4.0 RECREATION EVALUATION METHODS FOR RESERVOIR FLUCTUATION

As a result of the literature search, several different analytical methods were identified to address impacts on recreation from fluctuating reservoir water levels. Impacts to recreation fall into two categories: 1) impacts to recreation visitation and 2) impacts to recreation value. Approaches which measure change in visitation may not address valuation and vice versa. As a result, the approaches discussed below have been separated into visitation based approaches and valuation based approaches. The methods shown below are presented in order from least to most complex. Complexity is based on data, analytical, and time/budget requirements.

4.1 VISITATION BASED APPROACHES:

The purpose of the visitation based approaches is to measure changes in recreation use only. Recrreation use, also referred to as visitation, can be measured in various ways - trips or visits, days, hours, recreation visitor days, etc. Given the ultimate objective of this visitation information may involve valuation, the preferred use measure would be visits or trips. Should data only be available is some other format, information may be required to make the necessary conversion (e.g., days per trip, hours per day, etc.). To estimate changes in value, the visitation estimates derived from these models must be combined with information on recreational value obtained from another source using some form of benefits transfer.[2] Four approaches to visitation estimation are presented in this section: ratio method, facilities or resource access method, use estimating models, and delphi method.

4.1.1 *RATIO METHOD*:

The ratio method is the most simplistic approach to measure changes in recreation use and value. The approach estimates changes in recreation activity based on a ratio of reservoir water levels or surface acreage. Starting from a baseline level of recreation use and value, the ratio method assumes if water levels or surface acreage decline by a given percentage, recreation use and value would decline by the same percentage.

By assuming increasing (decreasing) water levels or surface acreages would result in increased (decreased) recreation use and value, the approach incorporates the basic logic assumed within the underlying recreation economic theory. However, by assuming recreation impacts are a continuous function of water levels or surface acreage, the approach ignores the potential for upper or lower recreation use thresholds associated with varying reservoir water levels. This

[2] For a discussion of benefits transfer approaches, see Platt 1996.

continuous relationship implies that recreation activity would increase without limit as water levels increase and decrease to zero as water levels approach zero. Such a relationship is highly unlikely, especially as water levels increase (decrease) beyond a certain levels.

Data Requirements:

- Baseline Recreation Use and Value Estimates
- Baseline Water Levels or Surface Acreage
- Alternative Water Levels or Surface Acreage

Advantages:

1. Analytically Simple
2. Limited Data Requirements
3. Minor Time and Budget Requirements

Disadvantages:

1. Typically Unrealistic
2. Inappropriate when Recreation to Water Level Relationship is Nonlinear

4.1.2 *FACILITIES OR RESOURCE ACCESS METHOD*:

The facilities or resource access approach attempts to measure changes in recreation use based on reservoir access exclusively. As reservoir elevations rise or fall, certain water based recreational facilities (e.g., boat ramps, marinas, swimming areas) may become inaccessible or undesirable. In its simplest form, the approach uses visitation by activity associated with each inaccessible facility to estimate changes in recreation use.

An extension of the approach attempts to deal with recreation substitution. As facilities become inaccessible/undesirable, recreators may consider a variety of substitution options: 1) use other facilities at the same reservoir (facility substitution), 2) recreate later in the season when facilities become usable (time substitution), 3) use another site (site substitution), or 4) pursue a different recreational activity at the same site (activity substitution). Using facility or resource excess capacity information by day type (i.e. weekend/holiday versus weekday)[3] at both the

[3] Wording convention: Two perspectives are presented in this section regarding the use of the term "day." Carrying capacity information is discussed on a "daily" basis since it would not vary by day type. Excess carrying capacity information (i.e. carrying capacity minus estimated visitation) is described using the term "day type" to reflect differences between weekends/holidays and weekdays. Weekends/holidays may experience lower excess carrying capacity as compared to weekdays due to higher levels of visitation.

focus sites and other regional sites, the analysis could theoretically address all of the above forms of substitution except activity substitution.

Given availability of visitation information by activity and facility, the approach seems to work best for reductions in reservoir access, particularly for sites with limited facilities. However, should unrestricted historical visitation information[4] be available by activity and facility, the approach would also work for improvements in access. Given the natural orientation of the approach toward reductions in access, the following discussion focuses on that scenario.

Analytical Procedure:

The access method can be used to evaluate changes in recreation use by activity, month, and day type (i.e. weekend/holiday or weekday). Data on recreation facilities, water elevations when facilities become unusable or undesirable, amount of recreation use by activity/month/day type, percent of use by activity by facility, facility and resource carrying capacities, etc. would all be used to develop the analysis. The procedure normally involves the following steps:

<u>Step 1</u>: Identify Potentially Affected Recreation Activities

Assuming one knows which reservoirs would be affected by the alternatives under consideration, the first step in the analysis would be to evaluate which recreational activities at each site may be impacted through reduced access to facilities should water levels drop. Should boat ramp access be presumed affected, most boat based activities (e.g. power boating, waterskiing, sailing, boat fishing, etc.) could be impacted. Other water based activities (e.g. swimming, shoreline fishing, etc.) could also be assumed affected, although the location of impact may be more diffused than in the boat ramp analyses.[5] Since this approach focuses on access, land based activities would not be addressed.

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[4] Unrestricted visitation estimates refer to use numbers which were unconstrained by facility unavailability.

[5] For swimming and shoreline fishing, assumptions would have to be made identifying at what point these activities would be impacted. Would one assume that shoreline fishing would cease once water levels dropped to the point where anglers would have to stand in the mud flats

Step 2: Site Specific Background Data on Potentially Affected Recreation Activities (Current Conditions)

Once the list of potentially affected recreation activities has been defined for each site, background visitation information for those activities should be gathered in a format suitable to the analysis. The following information allows for calculation of the current average use by site, recreation activity, facility, month, and day type (weekend/holiday or weekday).

For each site:

A. For each affected recreation activity, make a list of facilities available to access the water: boat ramps, marinas, swimming beaches, popular shoreline fishing areas, etc.

B. Gather historic visitation information by activity, month, and day type (5-10 year trend).

- Visitation information is best measured in terms of trips or visits. Should data only be available in some other format, steps would need to be taken for conversion into trips (i.e. gather data by activity on: days per trip, hours per trip).
- Estimating recreation visitation by activity is made difficult in the presence of multiple activity visits. The typically applied procedure for handling multiple activity visits is to characterize each visit by its primary activity. In this way, all visits can be identified with one primary activity.
- The decision is often made to only focus on the high use recreation season, where the majority of activity falls (typically May to September or October). While the access approach could be applied across the entire year, from the perspective of time substitution especially, care must be used in evaluating the length of the recreation season for each activity.
- To allow for estimation of visitation by activity and day type, information would have to be collected on the percent of visitation by activity which occurs on weekends/holidays versus weekdays for each month.

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to fish? Would swimming cease once the sandy beaches where separated from the water and swimmers would have to cross mud flats to reach water? These shoreline oriented activities may require knowledge of the contours of the lake before decisions could be made at what water levels these activities would be eliminated.

C. Estimate the percent of use by activity associated with each facility. For example, for power boating, allocate visitation between each of the boat ramps and marinas.[6] If the percentage varies across the year, indicate the percent by activity, facility, and month.

Step 3: Water Level Data:

Hydrologic modeling would provide the water level data (e.g. average monthly water level, end of month water level, water levels according to a weekly or daily schedule, etc.). The gathering of historic water level data would allow for comparisons with historic visitation data.

If water level is generated from the hydrologic model on a monthly basis, problems of interpretation may result. If actual operations create significant daily or weekly fluctuations in reservoir water level and the hydrologic model only generates monthly water level estimates, significant discrepancies can exist between actual and estimated conditions. Often assumptions are made to estimate average monthly water levels.

Step 4: Facility Water Level Thresholds:

For each water based facility (e.g. boat ramp, marina, swimming beach, etc.), determine at what water level use would no longer be possible or desirable, both on the high end and the low end. From the perspective of desirability, this threshold may be subjective and vary across recreators. Note that there may also be a position taken by the reservoir's managing body to close a facility at a particular water level.

While the simplistic version of this analysis reflects only short-term impacts given it's orientation toward current site facilities, a longer-term perspective could be achieved by considering facility mitigation options, including the construction of additional facilities. To evaluate impacts with mitigation, the water level based usability thresholds for current facilities would need to be adjusted and information included on the new facilities. Assuming resource

[6] The allocation of boating activity to each facility can be complicated if marina use is included within the boating visitation estimates. Perhaps the best way to handle the public boat ramp versus marina allocation would be to separate them. In this way, one could assume different substitution paths (e.g. assume public boat ramp use would substitute to other public ramps and then to other sites; whereas marina use would likely substitute to other marinas before transferring to other sites.). The best scenario involves visitation for boat ramp based boating and marina based boating being obtained from different sources (e.g., boat ramp counts versus marina operator's records) such that the estimates were already separated. A further complication with respect to marinas is the issue of private boats versus rental boats. Loss of private boat visitation from a marina may substitute to other marinas based on the availability of boat slips. Conversely, substitution of rental boat activity to another marina would require information on the type and utilization of rental boats). This substitution element can get complicated fast, certain simplifying assumptions would likely be required.

carrying capacity is non-constraining, new facilities would affect the analysis by adding excess facility capacity to the reservoir, thereby increasing the potential for facility substitution.

Step 5: Estimate of Recreation Visitation without Substitution

Compare the hydrologic water level data to the usability thresholds for each recreational facility to determine which facilities become unusable. Based the amount of recreation use by activity, month, day type, and facility, estimate the worst case scenario depicting recreation use losses by activity assuming no substitution.

Step 6: Facility/Resource Excess Carrying Capacity Data:

To allow for analysis of substitution between facilities at the same site, day type excess carrying capacity data would be necessary for each facility by activity and month. This represents the amount of additional recreation use by activity which could be absorbed in each month for each day type. Day type excess carrying capacity by activity and month represents daily carrying capacity minus day type visitation for that month for that facility. Day type visitation by activity and month may be unavailable and would therefore need to be estimated separately for weekends/holidays and weekdays based on the percentage of monthly visitation by activity allocated to weekends/holidays versus weekdays (where weekend/holiday and weekday percentages would presumably come from site managers or surveys).

Since excess carrying capacity by activity and month can be expected to vary by day type, the approach attempts to consider differences between weekends/holidays and weekdays. Using data on activity specific daily carrying capacities by facility, monthly visitation by activity, and activity specific visitation percentages by weekend/holiday and weekday, the analyst can estimate of excess facility and resource carrying capacity by activity, month, and day type.

It may also be useful to compare reduced resource carrying capacities (e.g. boating carrying capacity of the lake based on surface acreage) as reservoir water levels drop, to the sum of the facility carrying capacities by activity. It is possible that the sum of the capacity of the facilities exceeds the capacity of the lake resource, especially when the reservoir surface acreage is declining. If this is the case, daily resource carrying capacities would be applied in the analysis instead of facility carrying capacities.

Step 7: Estimate of Recreation Visitation Assuming Same Site Substitution (Facilities and Time Substitution)

As noted above, once appropriate data has been collected to estimate day type excess carrying capacity by activity and facility, water levels could be compared to facility water level threshold data to estimate which facilities would become unusable or undesirable. Referring back to the percentage of visitation for each activity using these facilities would allow estimation of visitation losses by month, day type, and activity before considering substitution. The analysis would then reduce these activity specific visitation losses by the amount of activity specific excess facility or resource based capacity available per day type at the site. The first substitution option is assumed to be to other facilities at the site during the same day. Should the visitation losses exceed the excess capacity of the other facilities or the reservoir as a whole, we would assume the other facilities or the overall reservoir would experience increased visitation up to their carrying capacities, before looking to other substitution options (e.g. time substitution or site substitution).

Another same site substitution option is for recreators to decide to visit later during the season assuming the facilities become usable. Time substitution assumes that recreators would have equal opportunity to visit later in the recreation season. The analysis follows the same logic as facilities substitution, the only difference being instead of looking at excess capacity of other facilities during the same day, facility/resource excess capacity is reviewed over the rest of the recreation season by day type. Time substitution is further complicated by the need to determine season lengths by activity (e.g., power boating during the winter months is obviously not an option). This form of substitution would imply that recreators would have information as to potential future water levels across the recreation season. While it is possible this information would be available to the general public, it is rather unlikely. While the capability of addressing time substitution is possible within the analysis, given these somewhat questionable assumptions, this form of substitution may not be emphasized in the analysis.

Step 8: Carrying Capacity Data for Substitute Sites

To consider potential substitution of recreation use to other regional sites, we would need to develop estimates of excess carrying capacity by activity, month, and day type for each of the substitute sites. Unless the potential substitute sites also experience water level fluctuations, implying some of the facilities at these other sites may be unusable, excess capacity estimates by day type would not have to be developed for each facility (e.g. the estimates could reflect resource based carrying capacities). The capacities could be based on reservoir size, parking lot capacities (if the lots are single activity), etc. From these daily resource capacities by activity, we would subtract current visitation by activity to estimate excess capacity by activity, month, and day type at each potential substitute site.

Step 9: Estimate of Recreation Visitation Assuming Alternative Site Substitution

Once excess carrying capacity by activity, month, day type, and substitute site has been estimated, remaining recreation losses at the focus site (after considering own site substitutions) by activity, month, and day type could be compared to the substitute site(s) excess capacity to determine if any recreation losses could be absorbed by the substitute sites. As with time substitution, site substitution is not necessarily a given, some people may not be willing to travel the extra distance to the substitute site. Assumptions would have to be made on the issue of willingness to substitute.

While use of carrying capacities is likely to be a useful procedure for estimating excess capacity for facility, time, and site substitutions, it should be noted that carrying capacity data is often unavailable. In such cases, historical peak visitation information or site manager observations may be used in lieu of carrying capacity data to try and deal with the various forms of potential substitution.

Data Needs: Typically, much of the information necessary for the analysis is not collected, and as a result, the analyst may need to tap the professional judgement of site management.

1) For each directly affected[7] site, gather data on:

a. Potentially affected recreation activities.
b. Water based facilities by activity.
c. Five to ten years of visitation data by primary recreation activity and month.
d. Percentage of visitation, by activity and month, which occurs on weekends/holidays versus weekdays.
e. Percent of visitation by facility for each activity.
f. Water level data (monthly, weekly, daily).
g. High and low water level thresholds for each facility.
h. Daily facility and resource based carrying capacity data by activity.

2) For each substitute site, gather data on:

a. Daily resource carrying capacity data by activity.
b. Visitation data by activity, month, and day type (weekends/holidays versus weekdays).

Advantages/Disadvantages:

Advantages:

- Given this method involves a non-modeling approach, it may be less complex than modeling approaches. However, even with this approach, the data requirements can be daunting.
- Can be developed without gathering data from the general public.
- The extended approach attempts to address various possible forms of substitution. Substitution effects are frequently dismissed or ignored within recreation analyses.

Disadvantages:

- The analysis is oriented toward addressing impacts to water based activities (boating fishing swimming, etc.). Activities which are influenced by water through aesthetics, but do not require actual access to water, are not addressed (e.g. land based activities: picnicking, camping, hiking).
- Since the approach is based upon utilization of existing facilities, it has a current orientation

[7] Directly affected sites reflect those where water levels fluctuate as a result of the alternatives under consideration.

unless information about future facilities is available.
- While survey based data collections are not required, much of the information for the analysis will probably need to be based on the professional judgement of recreation managers at each site. As a result, the approach is fairly subjective.
- The approach measures changes in visitation only, valuation is not addressed.

4.1.3 *STATISTICAL USE ESTIMATING MODELS (UEM)*:

Use estimating models use regression techniques to estimate statistical relationships between visitation and a wide range of explanatory variables. The type of use estimating model to pursue is often predicated upon the type of data available. Hydrologic data on water level fluctuation is often provided on a monthly basis ideally implying the use of a monthly oriented UEM. Unfortunately, visitation information may not be available on a monthly basis, typically annual visitation is all that is available. In this case, all is not lost - annual UEMs, while perhaps less detailed in their use of data, are still a viable option.

Both monthly and annually oriented UEMs can be estimated using either total visitation data or visitation data separated by recreational activity. Given it is possible that only certain activities would be directly impacted by water level fluctuations (e.g., water based activities such as boating, waterskiing, fishing, swimming, etc.), the more appropriate model definition could require targeting in on only those impacted activities. Using total visitation instead of visitation for only the impacted activities may result in problems at the model estimation stage. Should information on non-impacted activities be included in the modeling, statistically significant relationships with the water level variables may be missed.

A problem with attempting an activity specific model is that monthly or annual visitation may not be broken down by activity. Breaking down visitation by activity is at best problematic given the likelihood of multiple activity trips. Typically, visitation by activity estimates categorize trips based on their primary activity, while not perfect, this concept is normally adequate.

While water based recreation activities may be the most obvious of the potentially impacted recreation activities stemming from a change in reservoir water level, one should not dismiss possible impacts to land based activities. Certain land based activities may have no relationship whatsoever with reservoir water levels while others may. Many land based activities may benefit from the scenic qualities associated with the reservoir, as water levels drop and unsightly mud flats or reservoir rings develop, land based activities could also be adversely affected. Modeling the impact upon land based activities could be accomplished within the context of a total visitation model (includes both water and land based activities) or a separate land based activity model in addition to the water based activity model.

4.1.3.1: **Annual Visitation Model**:

Bowker, et al. (1994) developed annual UEMs for Shasta and Trinity Lakes in northern California. While monthly water level data was available, their modeling options were somewhat limited by the existence of only annual visitation data. As illustrated below, the authors applied a start of the recreation season water level variable (May or June) in conjunction with a seasonal drawdown variable (May/June minus September water levels) to predict the influence of water levels on annual visitation.

Total Annual Visitation_{jt} or Annual Visitation by Activity_{ajt} = f (Water Level_{jt}, Drawdown_{jt}, Year_{t})

Activity: a = 1,...,l
Site: j = 1,...,m
Year: t = 1,...,o

where:

Dependent Variable: Total annual visitation at site *j* in year *t* or Total annual visitation at site *j* in year *t* in activity *a*

Explanatory Variables:

Water Level_{jt} = Beginning of Recreation Season Average Monthly Water Levels (May or June) at site *j* in year *t*. Considered to be somewhat of a measure of natural conditions.

Drawdown_{jt} = Amount of Drawdown Between Beginning of Season Water Levels and September Water Levels at site *j* in year *t*

Year_{t} = Annual Time Variable

Data Needs:

- total visitation or total visitation by activity
- beginning and end of season water levels

Advantages/Disadvantages:

Advantages:
- simplicity
- minor data needs
- could use time series data

Disadvantages:
- fails to consider month by month water levels
- no valuation
- limited to measuring changes within historical range of water level and visitation

4.1.3.2: **Monthly Visitation Model**:

Data permitting, estimation of a monthly UEM may be preferable since it would take into consideration visitation and water level fluctuation not only across years, but across months within each year. An early monthly UEM estimated the influence of fluctuating water levels at Lake Texoma on the Oklahoma/Texas border (Badger, 1972).

Monthly Visitation_{jmt} =f(Month_m, Year_t, Water Level_{jmt}, Water Quality_{jmt}, Weather_{jmt}, Socio_{mt}, ...)
or Monthly Visitation
by Activity_{ajmt}

Activity: a = 1,...,l
Month: m = 1,...,p
Year: t = 1,...,o
Site: j =1,...,m

where:

Dependent Variable: Total visitation at site *j*, in month *m*, and year *t* or Total visitation in activity *a*, at site *j*, in month *m*, and year *t*

Explanatory Variables:

Month_m =	Variable identifying individual months or groupings of months
Year_t =	Variable identifying individual years
Water Level_{jmt} =	Monthly Water Levels (Average, End of Month, Monthly Range) by site and year
Water Quality_{jmt} =	Monthly Average Water Quality by site and year
Weather_{jmt} =	Monthly Average Temperature, Total Monthly Precipitation, etc. by site and year
School_{mt} =	Binary Variable indicating whether school is in cession by month and year
Socio_{mt} =	Population, Income and similar variables for market area, by month and year

Data Needs:
- monthly visitation, by activity if available
- monthly water levels
- monthly water quality
- monthly weather conditions
- socioeconomic/demographic variables (population, income, education, age, etc.)

Advantages/Disadvantages:

Advantages:	- more comprehensive than annual model - addresses water level changes for each month
Disadvantages:	- more involved in terms of data and complexity compared to the annual model - no valuation - limited to measuring changes within historical ranges of water level and visitation

4.1.3.3: **Contingent Behavior Data and Use Estimating Models**:

The annual and monthly visitation UEMs are estimated based on existing historical visitation and water level data. These approaches work well until one attempts to evaluate an alternative where water level fluctuation is beyond the historical range. Using a model to project effects beyond the range of the underlying data is normally inadvisable. An option to expand the range of data used within these models is to conduct contingent behavior surveys. Contingent behavior questions involve setting up a scenario and asking recreators how they would react in terms of their visitation behavior. An advantage of contingent behavior questions is that respondents may find it easier to indicate how they would react to a hypothetical change in terms of visitation as opposed to value (e.g., some respondents have difficulty in assigning dollar values in contingent valuation scenarios). To try and address some of the criticism regarding the hypothetical nature of both the contingent behavoir and contingent valuation approaches, researchers have begun asking follow-up questions to gauge how certain individuals are about their responses.

If an alternative involves a change in reservoir water elevations outside the range of historically available data, a survey could be conducted with questions asking recreators how they would react if such conditions actually occurred. Typically, as part of the discussion of the scenario, computer enhanced pictures or drawings of the site under the proposed conditions are provided to the respondent to aid in visualizing the situation.[8] As with any survey, proper care must go into describing the proposal, the baseline, and any important underlying assumptions. Contingent behavior results are often combined with the historic actual data when attempting to estimate a model (see discussion of the Callaway et. al, 1995 model under the individual travel cost model section).

Alternatively, contingent behavior data are sometimes used either as the sole data source in attempting to develop a model, or directly as an estimate of visitation after applying the appropriate expansion factors to estimate total site visitation. The direct application of the

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[8] In a couple of reservoir drawdown studies, Ben-Zvi and Associates (1989 and 1990) used floating markers placed out in the lake to indicate water levels.

contingent behavior data was used to estimate changes in recreation visitation in a study of reservoir water level changes proposed for four western North Carolina reservoirs (Cordell and Bergstrom, 1993). A survey was sent to a sample of current site recreators to determine their reactions, in terms of both willingness-to-pay and visitation, to maintaining reservoirs at full pool later into the recreation season. The respondents were provided with artist renderings of several developed and undeveloped scenes around each reservoir under each water level scenario. They were the asked if and how their visitation patterns might change under each scenario. This data was combined with information obtained from a panel of local recreation experts (see Delphi section) to estimate changes in visitation and number of recreators. An early contingent behavior study (Badger, 1972) asked boaters at Lake Texoma in Oklahoma what water level they considered to be dangerous and whether they would adjust their visitation should such water levels be reached. Nearly 50 percent of the respondents indicated that they would either reduce or stop boating at a specified water level (apparently there was some disagreement between respondents as to the water level where boating became dangerous).

Data Needs:
- For the stand alone approach, no pre-survey data would be required other than a sample of recreators should a mail survey be conducted.
- For the modeling based approaches, all data would be obtained either from the survey or existing sources and would depend on the modeling approach be attempted.

Advantages/Disadvantages:

Advantages:
- Unhampered by historical data. The survey provides flexibility in the range of data collected.
- Recreator's respond to questions about visitation behavior as opposed to willingness-to-pay
- Results can be combined with other estimation approaches

Disadvantages:
- Requires a survey of recreators which can be time consuming, costly, and demanding of technical expertise
- Relies on hypothetical visitation behavior, not verifiable until after the fact
- Contingent behavior questions evaluate change in recreation use only

4.1.4 *DELPHI TECHNIQUES*:

Delphi techniques are broadly defined as any approach which makes use of the subjective judgement of recreation professionals or similarly knowledgeable persons. Rigorous delphi applications often use strict query procedures where several rounds of questions are asked and respondents see and react to the responses of others. While the rigorously applied approaches are seldom used for recreation issues, the idea of taping the knowledge base of recreation experts is not new to recreation studies.

A panel of knowledgeable locals was used to help develop estimates of the potential change in number of recreators associated with reservoir management scenarios maintaining water levels later into the recreation season at four western North Carolina reservoirs (Cordel and Bergstrom, 1993). A survey was used to elicit valuation responses to apply to the recreator estimates for calculating total annual value for each scenario at each reservoir. The delphi panels responses were averaged with contingent behavior responses also obtained from the survey. Of particular interest to the authors was how the panel reacted to questions about the possibility of the scenarios attracting new recreators to the sites. This aspect was beyond the scope of the survey's contingent behavior questions of current site users.

Data Needs: - Like virtually any survey based approach, pre-survey data requirements are typically minor (may require sample population for mail surveys). Necessary data is dependent on the issues being addressed and would be collected from the survey itself.

Advantages/Disadvantages:

Advantages:
- very flexible in data obtained
- relatively inexpensive, fast approach to gathering data
- based on professional judgement

Disadvantages:
- subjective
- responses become questionable beyond range of observed behavior
- not verifiable until after the fact

4.2 VALUATION BASED APPROACHES:

Contrary to the visitation based approaches, valuation approaches are primarily concerned with estimating changes in recreation value. Recreation value is measured in terms of consumer surplus or recreators willingness-to-pay over and above what they actually pay. Three general methods/models are presented: 1) contingent valuation, 2) travel cost, and 3) hedonic price.

In addition to model selection based on economic theory and data availability, selection of the appropriate functional form and statistical/econometric technique can have important implications for empirical results. Typical functional forms, or assumed curve shapes, used in recreation demand studies include linear, semi-log (log-lin and lin-log), and double log. All these forms result in downward sloping curves such that visitation declines as travel costs increase. Other factors to consider include the prediction of negative trips (potential problem with the linear form), an allowance for diminishing returns (total benefits increase at a decreasing rate as site quality characteristics increase, semi-log forms may fail to provide this characteristic), and allowance for average benefits per trip to either remain constant or increase as site quality increases. Total benefits functions, applied in contingent valuation studies, often use a polynomial/quadratic functional form. Econometric approaches are often selected based upon the nature of the underlying data. In addition to the standard ordinary and weighted least squares regression techniques, maximum likelihood limited dependent variable approaches take into account the unique characteristics of the model's dependent variable - yes/no or 0/1 variables (logit/probit), non-negative (tobit, Cragg), integer (count data). Heckman approaches allow for sequential linked statistical estimation across a range of regressions. Seemingly unrelated regressions have been used for multiple equation models. Finally, nonlinear regressions are sometimes applied when the other forms are seen as too restrictive. Typically, the decision as to functional form and econometric approach takes place after selection of the overall method (UEM, CVM, TCM, etc.).

4.2.1 *CONTINGENT VALUATION METHOD (CVM) MODELING*:

4.2.1.1: **Single Alternative Modeling Approach**:

One approach to measuring economic values for a range of management scenarios is to develop separate models for each scenario. The problem with this approach is that the model cannot be applied to estimate values for scenarios other than those specified.

Bowker, et al. 1994 estimated six equations for three management scenarios under both drought and non-drought conditions at Shasta and Trinity Lakes in northern California. Drought conditions were defined as average water levels at or below 50 feet down from top of pool in May for Shasta Lake and in June for Trinity Lake. The logic was that management options vary under drought and non-drought conditions, therefore recreator reaction in terms of both visitation and willingness-to-pay may also vary considerably under drought and non-drought conditions. The equations were estimated using a Tobit procedure to account for the censored nature of the WTP data (significant percentage of zero bids). The value per day estimates derived from these models were combined with visitation estimates derived from use estimating models.

Annual Household WTP_{ij} = f (Site $Quality_{ij}$, $Income_i$, $Substitutes_i$, $Nonlocal_i$, $Payment_i$, $Lake_j$)

Household: $i = 1,...,n$
Site: $j = 1,...,m$

where:

Dependent Variable: Annual willingness-to-pay (WTP) for household *i* to site *j*

Explanatory Variables:

$Quality_{ij}$ = Likert scale recreation quality index for $household_i$ to $site_j$
$Income_i$ = $Household_i$ annual gross income

$Substitute_i$ =	Binary variable indicating existence of substitute recreation possibilities for $household_i$
$Nonlocal_i$ =	Binary variable indicating if residency of $houshold_i$ is with a 60 mile radius of the site
Payment =	Binary variable representing the payment vehicle (vehicle pass or recreation expenses)
$Lake_j$ =	Binary variable representing the lake (Shasta or Trinity)

Data Needs:
- Annual WTP for each household from the contingent valuation survey
- Recreators site quality perception
- Household income
- Location of residence
- Household's substitute sites

Advantages/Disadvantages:

Advantages:
- survey requirement implies flexibility, can ask a wide range of questions (not constrained by available data)
- fairly simple modeling

Disadvantages:
- Requires survey and associated time, cost, and technical requirements
- Doesn't address visitation or number of recreator households
- Hypothetical responses, not verifiable until after the fact
- Not adaptable to other management actions

4.2.1.2 **Multiple Alternative Modeling Approach**:

While Bowker et al., (1994) estimated different models for each alternative under consideration, it would seem that another option would be to include all the contingent valuation responses for all alternatives into one model and estimate a statistical relationship based on characteristics across the alternatives (e.g., water levels, number of usable boat ramps, etc.). The advantage of this approach is that impacts could be estimated for any alternative within the range of the underlying data. As compared to the alternative specific approach, this approach provides for greater flexibility in model application, particularly with regard to potential future analyses.

A study of the recreation effect of holding water levels at near full pool several months later into the recreation season at four western North Carolina reservoirs utilized a single model to address four different alternatives (Cordell and Bergstrom, 1993). The logit dichotomous choice contingent valuation model pooled responses across alternatives and reservoirs to estimate annual willingness-to-pay (WTP) per recreator at each reservoir for each alternative. The average annual WTP estimate per recreator was combined with recreator estimates developed using contingent behavior and Delphi panel data.

The valuation model used the results of dichotomous (yes/no) choice questions where respondents were presented with both an improved water level scenario and a given WTP bid amount assumed to represent an annual recreation pass per recreator for that site and scenario. The range of bid amounts was developed from pretest surveys. The mail survey depicted the alternatives using artists renditions of several locations (developed and undeveloped recreation areas, boat ramp) at each reservoir under each water level scenario. The semi-log logit model was estimated as follows...

Yes/No response to scenario_{ijs} = f(Bid Amount_{ijs}, Recreation Budget_i, Experience_i, Sex_i, Reservoir_j, and Alternative_s)

Individual: i = 1,...,n
Site: j = 1,...,m
Alternative: s = 1,...,q

where:

Dependent Variable: Willingness-to-pay the proposed amount for individual *i* at site j for alternative/scenario *s*

Explanatory Variables:

Bid Amount_{ijs}	= randomly selected amount that individual_i would have to pay annually to obtain the corresponding water level $\text{alternative/scenario}_s$ at site_j
Recreation Budget_i	= percent of individual's household income spent on recreation
Experience_i	= years of participation at the reservoir divided by age
Sex_i	= 0 = female, 1 = male
Reservoir_j	= set of dummy variables to represent each reservoir_j
Alternative_k	= set of dummy variables to represent each $\text{alternative/scenario}_s$ (while Cordell and Bergstrom specified this variable reflect each alternative, one could theoretically use water levels/surface acres in lieu of this variable to make the model more flexible)

Two early examples of the use of contingent valuation with respect to fluctuating reservoir water elevations focused on high mountain reservoirs in Colorado (Walsh et. al, 1980 and Walsh, 1980). These studies used standard open-ended willingness-to-pay questions to determine how low reservoirs could drop before recreators would stop visiting. These studies also looked at the influence of congestion on reservoir recreation benefits, where congestion was measured by the number of people encountered within a given distance of the recreator. Generally speaking, the authors note that failure to take congestion into account will result in overstated recreation benefits. It was interesting to note that the congestion effect proved to be a function of the level of development at the reservoir - as one would expect, recreators at undeveloped reservoirs had a much lower tolerance for congestion as compared to recreators at developed reservoirs. The authors note that there exists a breakeven point where the gain in benefits accruing to additional site users begin to be outweighed by the loss of benefits to existing site users as a result of the congestion effect.

Data Needs:
- Individual's yes/no responses to the contingent scenarios
- Household recreation budgets
- Individual's years of experience at the site, sex, age, other socioeconomic and demographic variables
- Reservoir water levels/surface acres should the model be so defined

Advantages/Disadvantages:

Advantages:
- Survey provides flexibility in data collected
- Model adaptable to a range of water level/surface acre scenarios
- Reasonably simple modeling

Disadvantages:
- Requires survey and associated time, cost, and technical requirements
- Doesn't address visitation or number of recreator households
- Hypothetical responses, not verifiable until after the fact

4.2.2 *TRAVEL COST METHOD (TCM) MODELING*:

The travel cost method models recreation visitation as a function of travel costs and other explanatory variables. The basic premise with the approach is that travel costs act as price for accessing the site. As travel costs increase the farther away one lives from the site, visitation decreases, all else being equal. This price and quantity information allows for construction of a site demand curve. The area under the site demand curve and above cost represents net willingness-to-pay (i.e., consumer surplus), the typical measure used to represent recreation benefits. As a result, these approaches provide estimates of both visitation and value.

4.2.2.1: **Aggregate TCM Models**

The aggregate TCM models use information aggregrated across zones as opposed to individual recreators. Zones can be characterized as a specific zip code or county, grouping of counties, or a concentric ring about the site. These approaches are typically less data intensive as compared to the individual TCM approach (presented below) given all information is collected in aggregate by zone. Given the aggregated orientation, the only recreator contact required would be on-site recreator surveys to determine county/zip code of residence. The rest of the zonal data is normally available from existing sources.

4.2.2.1.1 Zonal TCM Model:

The zonal TCM model estimates total site visitation as a function of site specific quality variables such as water levels/surface area, water quality, recreation facilities, fish catch rates, weather, etc. and general user population variables such as travel distances, population, and socioeconomic characteristics (e.g., average income, education, race, age). User population information is broken down by zone as opposed to by individual recreator. Finally, distance and site quality characteristics for other sites in the neighborhood of the study site are typically included to account for the interrelationship between sites.

The travel cost model is developed in two stages: 1) estimate the per capita demand curve (discussed above), and 2) calculate the site demand curve from the per capita curve. To derive the second stage site demand curve, the coefficients from the per capita curve are used to estimate each zone's demand for trips to the focus site under increasing distances. Visitation to the site across all zones based on current travel costs reflects current demand. This current demand represents one point on the site demand curve. The rest of the curve is mapped out by calculating visitation by zone as prices/travel costs are increased until visitation from all zones go to zero (choke price).

Given zonal TCM data requirements are based on aggregated information for each zone, they are somewhat less intensive as compared to the data requirements of the individual TCM. The most detailed data need for this model is to have site visitation separated by zone. Entrance stations often provide a useful location for not only gathering visitation estimates but also for querying people as to their county or zip code of residence.

$\text{Trips/Population}_{ijt} = f\,(\text{Price}_{ijt}, \text{Site Quality}_{jt}, \text{Substitutes}_{ijt}, \text{Socioeconomics}_{it}, \text{Time}_{t})$

Zone: $i = 1,...,n$
Site: $j = 1,...,m$
Time: $t = 1,...,o$

where:

Dependent Variable = Number of trips or trips per capita to site j by zone i each time period t

Explanatory Variables:

Price_{ijt} = Out-of-pocket costs of travel and time costs of travel from zone i to site j in time period t, often includes entrance fees

Site Quality_{jt} = Site characteristics, possibly including fish catch rates, water quality, water quantity and flow, recreational facilities, weather, etc. for site j in time period t (variation created by pooling sites or gathering time series data).

$Substitutes_{ijt}$ =	Site quality characteristics and distance to other sites in the region (site, zone, and time period specific). Typically focuses on site substitution, other forms of substitution are sometimes modeled (e.g., fish species substitution).
$Socioeconomics_{it}$ =	Population characteristics such as income, racial breakdown, and age for zone *i* in time period *t*
$Time_t$ =	Time period trend variable (months, years)

Instead of requiring two separate models as in the individual choice model, the zonal TCM simultaneously includes both probability of participation and frequency of participation components by including population in the model. While the single equation characteristic of the zonal TCM is often regarded as an advantage, the probability of participation and frequency of participation terms can be estimated separately using a Heckman approach (for an example, see Loomis et .al, 1995). Trips per capita from zone *i* to site *j* can be expressed as follows:

$$\frac{Trips_{ij}}{Population_{i}} = \frac{Trips_{ij}}{Recreators_{ij}} \vee \frac{Recreators_{ij}}{Population_{i}}$$

$$\left(\textit{Trips per Capita}\right) = \left(\textit{Frequency of Visitation}\right) \vee \left(\textit{Probability of Participation}\right)$$

Although traditionally this model uses cross-sectional aggregated data, it can also be estimated with time series data. Time series data have the advantage of potentially providing variation in the site quality variable without pooling data across sites. While zonal TCM's are often constructed for single sites only, multiple site or regional models are also common. As the name implies, multi-site and regional models attempt to estimate visitation and value for a series of sites. Multi-site models typically estimate separate equations for each site whereas regional models generally combine data across sites to estimate a single pooled model. Loomis and Cooper (1990) warn that site quality coefficients within a pooled site model may vary significantly from those based on a single site time series model. Loomis and Cooper preferred the single site time series model and strongly suggested using lagged quality variables to test for habit forming behavior.

A multiple site model was used to calculate of total recreation benefits at four Pecos River New Mexico reservoirs (Ward, 1989). A simultaneous system of single site equations was estimated using seemingly unrelated regression techniques. Cross price terms, reflecting the travel costs to each of the other three sites, were used to measure substitution between sites. An all or nothing procedure was used to estimate the total value of the water in each reservoir. The total recreation value per acre-foot of water proved to be considerably higher than the agricultural value of the water. Given data was collected via a household survey conducted at a single point in time, no variation in site quality factors (e.g., water levels, water quality, etc.) was available by site. As a result, site quality factors could not be incorporated into the models.

Another recent application of the zonal TCM was developed for three U.S. Army Corps of Engineers districts (Ward et. al, 1996). This extensive effort developed regional models for each district using data from 23 different reservoirs. The pooled site zonal travel cost models developed were very comprehensive in addressing the full gamut of potential explanatory variables as suggested by economic theory. The travel cost variables reflect not only the variable costs associated with driving to each site, but also valued the travel time. The estimates of distance and time traveled where obtained from PCMiler, a program which uses actual road distances as opposed to "as the crow flies" distances. A wide range of site quality variables include recreation facilities, fishing quality, water quality, water levels and variability, and weather. Demographic variables include population, racial breadowns, age breakdowns, and income levels. Finally, a site substitution index was developed for each county by summing "distance-deflated" surface acres (surface acres/distance) for all lakes and reservoirs with 250 miles of each county.

In addition to the pooled site regional models developed for each Corps district, the authors also developed an overall "national" model by pooling the data across all the reservoirs. The objective of this overall model was to try and estimate changes in visitation and value at sites not included in the underlying data (use and benefits transfer) by taking advantage of the full range of available data across all 23 reservoirs. The authors performed various tests and came up two primary conclusions: 1) model derived benefits estimates appeared to be more accurate/transferred better than model derived use estimates, and 2) both benefits and use estimates appear to be more accurate when the model can be calibrated with actual accurate visitation data from the target site. The authors suggest running the model to predict visitation over a period of time where visitation is known. Comparing predicted visitation with actual visitation provides information for calibrating the model to the known level of visitation, this calibration step needs to be performed before attempting any visitation or benefit forecasting with the model. Obviously, the model performs the poorest for sites where visitation information is either nonexistent or of questionable accuracy, a situation which unfortunately occurs far to often at Reclamation sites. The authors also note that while the actual estimates derived from the model may not be acceptable from the perspective of accuracy, that for alternative comparison purposes, the differential in results between alternatives is likely to be accurate (i.e., any inherent error would be consistently seen across all alternatives). Finally, the authors also espouced the advantages of combined hydrologic, biologic, and economic models such as the RIOFISH model discussed below. The strength of the research stems not only from the modeling, but also in the development of an interactive program. The program allows non-technical personnel to run a wide range of what-if scenarios, based upon factors both within and outside the control of reservoir managers, at virtually any site for which the necessary data is available.

Water level fluctuations are typically modeled using either monthly (average or end of month) or yearly (average) water levels[9] or surface area estimates. Variation in monthly, weekly, or daily

[9] Number of feet above mean sea level (MSL)

water levels/surface acres are also commonly applied in annual models. Surface acres must be estimated from a depth-to-contour maps or using formulas estimated as a function of actual water levels, regardless, the conversion to surface acres many not be straightforward. Surface acreage is often preferred because it is more of a visual measure, many researchers claim that recreators react better to a visual stimulus as opposed to water level figures. Ward et. al, 1996 note that in the context of a pooled site regional model, using only water level data can be troublesome in that a full 1500 acre reservoir would generate as much visitation as a half full 3000 acre reservoir, all else being equal. The half-full reservoir would likely be much less appealing due to large mud flats, unsightly rings, facility unavailability, etc. The authors therefore suggest to use percent full and level of recreation pool in lieu of water level/surface area. The level of recreation pool provides an indicator of the size of the reservoir and percent full (actual water level divided by recreation pool) provides a relative water level measure. Pooling data across reservoirs provided the necessary variation in these variables for modeling.

The RIOFISH model (Cole, et al. 1995), provides an example of an integrated, statewide zonal travel cost model where hydrologic and biologic site quality characteristics are combined with economic factors to simulate systematic changes in sportfishing use and benefits. The model estimates angler reaction to variations in site management at 132 river and reservoir sites across the state of New Mexico. This model is perhaps one of the most complete efforts in integrating hydrologic, biologic, and economic factors into one package. As a result, the zonal travel cost fishing model accounts for such factors as: access, water levels/surface acreage, fish catch/keep rates, weather, water quality, etc. The model has a well defined user interface so that fishery and water managers can evaluate the implications of their planned actions on sportfishing activity and economic value across the state.

While more recent zonal travel cost models have evolved to the use of counties or even zip codes to represent zones, presumably to allow for more refined travel cost estimates and demographic data, early models often used concentric rings around the study site (10 miles, 25 miles, 50 miles, etc.). Somewhat more recent use of the concentric zone approach (Ben-Zvi & Associates, 1989 and 1990) have relied upon on-site surveys to gather the necessary travel cost, site quality, and demographic data.

Data Needs:

- Visitation data by zone (source: site management)
- Zonal travel cost data (sources: 1) calculated using Zip Fip/PC Miler for distance by zone and U. S. Department of Transportation for variable cost per mile, or 2) asked via a survey)
- Site Quality (sources: catch rates from site management/state fisheries agencies, water quality from site management/Reclamation water quality specialist/national databases, water level/instream flow from site management/Reclamation hydrologist, weather information from site management/national databases)
- Zonal socioeconomics data (source: U. S. Census Bureau): population, income, education, age, sex, etc.

Advantages/Disadvantages:

Advantages:

C Single equation
C Accounts for both participation and frequency decisions
C Typically, estimated using less complex OLS or WLS procedures
C Less data intensive than individual model
C Data are often available from visitor records without use of a survey
C Uses actual, observed visitation behavior
C Estimates both visitation and value

Disadvantages:

C Individual characteristics lost in zonal aggregates
C Weighting may be necessary with zones of unequal populations
C Greater probability of multicollinearity in grouped data
C Questionable handling of multiple site and purpose trips
C Cannot handle urban sites (lack of variation in travel cost)

4.2.2.1.2: Gravity TCM Model:

Gravity models, or models which allocate a given level of activity across locations, have been used by geographers and transportation analysts for years. Gravity models have also been used by recreation planners/economists to distribute regional recreation use across sites. While this approach has been somewhat less popular with economists since it doesn't use visitation-origin data and therefore may be less accurate in predicting recreation use at individual sites, the approach ultimately gets to the same place. Economists typically work with the visitation-origin data to predict visitation and value at a given site. Multiple sites can be included in the models and visitation and value summed across sites to reflect an entire region. Gravity models work in the opposite direction, where total visitation for an entire region is first estimated (trip generation submodel), followed by use of the gravity concept where the total visitation is then allocated across sites based on relative attractiveness (trip distribution submodel). The aggregate gravity model concept is similar in many ways to the random utility allocation models presented under the individual TCM model.

A gravity based TCM model of California rivers and reservoirs has been evolving since the late 1980's (Wade et. al, 1988). The authors developed a series of models to predict visitation by activity by zone and allocate zonal visitation across the 87 river and reservoir sites within the dataset. A household participation submodel is combined with a household frequency of visitation submodel to estimate average visitation by activity and household for each zone. Multiplying this by the number of households in each zone provides the estimate of total visitation by activity and zone. Both of the these models were estimated using certain demographic and regional site quality variables. The TCM gravity model allocates visitation by activity and zone across the various sites using information on travel costs and site quality across all relevant sites, plus information on zonal demographic characteristics. Actions by site managers (e.g., changing reservoir water levels) can influence site visitation through the attractiveness terms within the allocation model. Another example of the gravity model concept can be found in Kanaan and Day (1973).

Trip Generation Model: (Wade et. al, 1988)

1. Probability of Participation Submodel:

Participation (yes/no)$_{ia}$ = f (Education$_i$, Gender$_i$, Household Size$_i$, Income$_i$, Rural vs Urban$_i$, Recreation Opportunities$_{ai}$)

Activity:	a = 1,...,l
Zone:	i = 1,...,n
Site:	j = 1,...,m

where:

Dependent Variable: Whether each household in the sample participates in activity *a*

Explanatory Variables:

Education$_i$ =	Head of household education level
Gender$_i$ =	" " gender
Household Size$_i$ =	Number of household members
Household Income$_i$ =	Combined income across household members
Rural vs Urban$_i$ =	Residence in a rural or urban setting
Recreation Opportunities$_{ai}$ =	Index of household *i*'s regional freshwater recreation opportunities for activity *a*

2. Frequency of Visitation Submodel:

Visitation$_{ai}$ = f (Education$_i$, Gender$_i$, Household Size$_i$, Income$_i$, Rural vs Urban$_i$, Recreation Opportunities$_{ai}$)

Activity:	a = 1,...,l
Zone:	i = 1,...,n
Site:	j = 1,...,m

Dependent Variable: Total visitation in activity *a* across all sites for household *i*, given household *i* participates in activity *a*

Explanatory Variables: Same as for Probability of Participation Submodel
Trip Distribution (Gravity) Model: (Wade et. al, 1988)

$$\text{Visitation}_{aij} / \Sigma\, \text{Visitation}_{aij} = f\,(\text{Travel Costs}_{ij}, \text{Site Quality}_{aj}, \text{Socio/Demo}_{i}, \text{Recreation Opportunities}_{ai})$$

Activity	$a = 1,...,l$
Zone	$i = 1,...,n$
Site	$j = 1,...,m$

Dependent Variable: The percentage or share of zone *i*'s visitation in activity *a* at site *j*

Explanatory Variables:

Travel Costs_{ij} =	Average travel, time, and entrance fee costs per member of the recreation party
Site Quality_{aj} =	Site *j* characteristics related to activity *a* (e.g., facilities, fish abundance, size of lake, etc.)
Socio/Demo_{i} =	Socioeconomic/demographic characteristics of each zone (e.g., population, age, income, education, sex, race, etc.)
Recreation $\text{Opportunities}_{ai}$ =	Site substitution index for activity *a* and zone *i*

Data Needs:

- Household visitation by activity preferences by zone (household survey data)
- Zonal travel cost data (sources: Zip Fip/PC Miler for distance by zone, U. S. Department of Transportation for variable cost per mile)
- Site Quality (sources: catch rates from site management/state fisheries agencies, water quality from site management/Reclamation water quality specialist/national databases, water level/instream flow from site management/Reclamation hydrologist, weather information from site management/national databases)
- Zonal socioeconomics data (source: U. S. Census Bureau): population, income

Advantages:

- Accounts for both participation and frequency decisions
- Estimated using OLS/WLS procedures (except for participation model)
- Less data intensive than individual model (doesn't require visitation-origin data), more data intensive than zonal TCM
- Some of the data would be available from existing sources (site management, U.S. Bureau of Census, etc.)
- While the typical gravity model deals with only visitation, the Wade et. al, 1988 approach allows to valuation estimation

Disadvantages:

- Individual characteristics lost in zonal aggregates
- Cannot handle urban sites (lack of variation in travel cost)
- Not based on observed origin-destination data
- May be less accurate than site specific TCM model developed with visitation-origin data

4.2.2.2: **Individual TCM Model**:

The individual TCM uses information specific to each individual in the dataset to estimate visitation for the average recreator. This approach is substantially more data intensive as compared to the aggregate zonal approach given that all information must be on an individual recreator basis. Given the individual orientation, on-site and general population surveys are often conducted to gather the necessary data on both recreators and nonrecreators.

The individual TCM is often estimated assuming a sequential recreator decision process. The first step typically involves the decision of whether or not to even participate in a given recreational activity. The second step is a conditional one, given one has decided to participate in a given activity, what sites will be used? Finally, given one's site selections, how many trips will be taken to each site? Assuming this decision structure, individual TCMs are estimated via a series of equations reflecting each decision step.

The decisions to participate in a recreation activity and at a particular site are modeled by estimating the average individual's probability of participation. The decision to participate or to use a particular site is a yes/no decision. Statistical modeling using this discrete yes/no type data creates problems for standard ordinary least squares (OLS) procedures. Fortunately, econometric software with canned discrete choice/limited dependent variable logit and probit estimation procedures are readily available.

4.2.2.2.1: Multi-stage, Linked Model:

Callaway, et al. (1995) provides a recent, fairly thorough example of an individual travel cost model designed to address reservoir water level fluctuations in the Columbia River Basin. Some of the unique characteristics of the Callaway et al. work are as follows: 1) the incorporation of a survey response model to address nonresponse biases, 2) the linking of the sequential submodels using latent variables (Inverse Mills Ratios), 3) the monthly orientation of the model to address monthly water level fluctuation, and 4) the use of pooled actual and contingent behavior data.

Stage 1 Model: **Probability of Responding to the Survey** (Nonresponse Bias):

One of the unique elements of the Callaway, et al. (1995) study was the manner in which nonresponse bias was addressed. Traditionally, adjustments for nonresponse biases in mail surveys have used information from follow-up telephone surveys of a random sample of nonrespondents. These follow-up surveys normally gather data regarding certain demographic variables. Unfortunately, this approach is often costly and has met within limited success. Instead of using this follow-up survey approach, Callaway, et al. attempted to model potential nonresponse bias. Basically, for each of the four survey regions, two models for estimating the probability of returning the survey and adequately completing 1) the actual behavior portion of the survey and 2) the contingent behavior portion of the survey were developed as a function of distances to sites, sample strata, and zip code level socioeconomic data. Given the use of data from different samples may introduce bias, and the following sample data were included as explanatory variables: 1) on-site sample of recreators, 2) general population sample weighed toward counties adjacent to the sites, 3) sample of known recreators from a previous contact, a rigorous approach to handling nonresponse bias was deemed necessary. Since actual socioeconomic data was available only for the respondents, for purposes of consistency, zip code average socioeconomic data was used to characterize both respondents and nonrespondents. To the extent that an individual's actual socioeconomic characteristics vary from the zip code averages, this approach would introduce a certain amount of accuracy bias. As a result, this submodel tends to move away from the individual nature of the overall model.

The models describing the probability of responding to and adequately completing the survey were estimated using probit procedures. Inverse Mills Ratios (IMR's) were calculated for each individual observation. IMR's represent the probabilities associated with providing actual and contingent recreation behavior information. The IMR's were included as explanatory variables in the subsequent site participation model. The inclusion of the IMR's in the site participation model provides a statistical correction for any systematic response bias. As will be discussed later, IMR's from the estimated site probability of participation model were also used in the subsequent frequency of visitation model. Through the use of these IMR's, the three sequential modeling steps were directly linked.

Probability of Returning a Survey Submodel:

$\text{Respondent}_i = f(\text{Socio}_i, \text{Price}_{ij}, \text{Strata}_i, \text{etc.})$

Individual: $i = 1,...n$
Site: $j = 1,...m$

where:

Dependent Variable: Binary dependent variable (1/0, yes/no) based on each individual *i*'s completion of the actual and contingent behavior sections of the survey

Explanatory Variables:

Socio_i = Zip code level averages for each individual *i* from the 1990 Census (e.g., percent urban, percent high school graduate, percent employed in agricultural or forestry industries)

Price_{ij} = Distance to each site *j* in the region for each individual *i*

Strata_i = Survey sample strata characteristics for each individual *i*

Stage 2 Model: **Probability of Participation in Activity A**:

The following discussion reflects somewhat of a generic presentation of a probability of participation model on the grounds that management activities could potentially affect an individual's decision to recreate and therefore the number of recreators by activity within a region. The work by Callaway, et al. (1995), did not model this step in the decision process since it did not appear to be a significant factor for their study. The basic objective of the Callaway, et al. work was to estimate the recreational effects of fluctuating reservoir water levels and instream flows . Based on the results of the surveys, it became apparent that fluctuating reservoir water levels and instream flows had very little influence on individual decisions to participate in a given recreational activity. As a result, modeling the number of recreators within the regions was seen as unimportant to the study. Should changes in reservoir water levels and instream flows have had a significant impact on the number of recreators within the region, a probability of participation model by activity would have been necessary. Where appropriate, probability of participation models are used to estimate participation probabilities by activity which are applied to estimates of a region's general population to calculate number of recreators by activity.

Probability of Participation in Activity A Submodel:

$\text{Participant}_{ia} = f\,(\text{Socio}_i, \text{Site Quality}_j, \text{Price}_j, \text{etc.})$

Activity a = 1,...,l
Individual i = 1,...,n
Site: j = 1,...,m

where:

Dependent Variable: Binary dependent variable (1/0, yes/no) based on each individual *i*'s participation in activity *a*

Explanatory Variables:

Socio_i = Age, Income, etc. of individual *i*

Site Quality_j = Quality of Site *j* (e.g., water level, water quality of closest site or average across sites in the region)

Price_j = Price/Travel Cost or Distance to Site *j* (closest site or average across sites in the region)

Since the objective of the probability of participation model is to explain why people decide to participate in a given activity, it is necessary to conduct general population surveys to include information within the dataset on both individuals who do participate and individuals who do not participate in the activity.

Stage 3 Model: **Probability of Participation in Activity A at Site J**:

Based on actual water conditions in the Columbia River Basin in 1993, Callaway et al., (1995) constructed models for estimating participation by activity, site, and month using separate models for each site. Data from a sample of Columbia River recreators was used to estimate models explaining the individual recreator's probability of participation in each activity, at each site, during each summer month. The focus of the analysis was primarily on the summer months where water level targets at each site had been identified within the alternatives. As a result, the models were specified to estimate effects for each of the summer months (May, June, July, and August) as well as for the remainder of the year. Applying the estimated probabilities of participation for each activity, site, and month to an estimate of the number of recreators in the Pacific Northwest allows for estimation of the number of recreators in each activity, at each site, during each time period. As noted above, because the number of recreators was considered unaffected by reservoir water levels and instream flows, re-estimation of the number of recreators in the region was deemed unnecessary.

Despite using a sample of recreators only, defined as individuals who had visited at least one of the Columbia River sites, the percentage of zero visit observations was quite large. This is due to the fact that recreators typically only visit one or two sites, implying zero visitation at all others. As a result, the overall visitation model had to address individual observations with both zero and positive visitation at each site. To handle this situation, the model was separated into two parts - a probability of participation model to estimate the probability of visiting each site, and a frequency of visitation model to estimate level of visitation for those visiting the site. The discrete/continuous nature of these two models preclude the use of standard ordinary least squares (OLS) procedures. The probability of participation model for each site, as described in this section, uses a discrete probit model to estimate the probability an individual recreator would visit a site. The second stage of the model represents the continuous choice of how many trips to take assuming one has chosen to visit the site. This later model needs to take into consideration the truncation in the sample data (i.e., all site users take at least one trip). An advantage of separating the visitation modeling into two stages includes the fact that different variables can be used in each modeling stage. An alternative formulation could have combined both steps into one model using a zero bounded tobit estimator, however the option to use different variables would not have been possible.

Note that the monthly orientation of the model was necessary to address monthly fluctuation in visitation as a result of monthly water level and instream flow targets associated with the alternatives under consideration. Use of monthly data, particularly monthly water level and instream flow data, created some problems in model estimation due to multicollinearity in water levels between sites. Multicollinearity occurs when explanatory variable data tends to move in tandem, in so doing, collinear variables basically explain the same facet of the variation in the dependent variable making model estimation difficult. Because of the interrelated nature of site management along the Columbia River, water levels at certain sites tend to move up and down together. To allow for model estimation while simultaneously maintaining the necessary monthly orientation of the models, actual and contingent behavior data were pooled into a single dataset. The variation in water levels and visitation behavior obtained from contingent behavior results, in conjunction with the actual observed behavior data, provided sufficient variation in water levels between sites to allow for model estimation. Another benefit of the contingent behavior data is the information obtained on water level situations goes well beyond the current range of experience at these sites. Even if multicollinearity problems had not surfaced, without the contingent behavior data, model predictions would not have been possible beyond the range of observed data.

In the contingent behavior questions, during survey pretests, in became clear that individuals were having trouble separating anticipated visitation by month. As a result, the contingent behavior questions were adjusted to provide information on annual visitation. Using annual and monthly data created problems of heteroskedasticity or unequal variance. Adjustments were made in both the probability of participation and frequency of visitation models to correct for this problem.

Probability of Participation in Activity A at Site J in Month T Submodel:

$\text{Participant}_{i,a,j,m}$ = f_j (Socio_i, Own Site $\text{Quality}_{1,m}$, Cross Site $\text{Quality}_{2\text{-}J,m}$, Own $\text{Price}_{i,1}$, Cross $\text{Price}_{i,2\text{-}J}$, Activity_i, λ_{1i}, λ_{2i}, etc.)

Activity:	a = 1,...,l	
Individual:	i = 1,...,n	
Site:	j = 1,...,m	
Month	m = 5,...9	represents summer months (5= May, 6=June, 7=July, 8=August) and rest of the year (9)

where:

Dependent Variable: Binary dependent variable (1/0, yes/no) based on each Individual *i*'s participation in Activity *a* at Site *j* in Month *m*

Explanatory Variables:

Socio_i =	Age, Income, etc. of individual *i*
Own Site $\text{Quality}_{1,m}$ =	Quality of Site *1* in month *m* (e.g., water level, water quality of focus site)
Cross Site $\text{Quality}_{2\text{-}J,m}$ =	Quality of Other Sites *2-J* in month *m* (e.g., water level, water quality of other substitute or complementary sites in the region)
Own $\text{Price}_{i,1}$ =	Price/Travel Cost or Distance for individual *i* to Site *1*

	(focus site)
Cross $\text{Price}_{i,2\text{-}J}$ =	Price/Travel Cost or Distance for individual *i* to Sites *2-J* (other substitute or complementary sites)
Activity_i =	Dummy Variable for activity type (fishermen, boater, etc.)
λ_{1i} =	Inverse Mills Ratios associated with the actual behavior model from the first stage Probability of Responding to the Survey Model for each individual *i*
λ_{2i} =	Inverse Mills Ratios associated with the contingent behavior model from the first stage Probability of Responding to the Survey Model for each individual *i*

Since the objective of this probability of participation model is to explain why people decide to participate in a given activity at a given site in a given month, it is necessary to include information within the dataset on both individuals who do participate and individuals who do not participate at the site during each month. Asnoted above, this was accomplished using the recreator database since recreators don't visit all sites.

Stage 4 Model: **Frequency of Visitation in Activity A at Site J**:

This model estimates average trips per recreator at each site for the recreator. The probability of participation model for each site combined with the number of recreators in the region estimates the number of recreators at each site. Combining the trips per recreator at each site with the estimates of recreators at each site provides estimates of total number of trips at each site. Aggregating across sites, provides an estimate of the total number of trips across sites within the region.

As part of their modeling effort, Callaway, et al. (1995) constructed a second stage continuous demand model for estimating visitation per recreator across each of the summer months (May through August) and for the rest of the year. Average monthly water levels and instream flows for the four summer months were used to estimate visitation across the summer months. As noted above, the contingent behavior questions, were adjusted to ask for annual visitation. Use of annual and monthly data created problems of heteroskedasticity or unequal variance which required correction.

For ease of response, the Columbia River surveys were separated into four overlapping regions. The assumption was made that individuals took most of their trips to sites within their subregion. To construct the separate demand models for each site, site specific data was pooled over the different survey versions.

The site specific frequency of visitation models used observations only from the individuals that chose to visit that site, as a result these models represented conditional demands. Since all the individuals in the dataset for this model had taken at least one trip to the focus site, statistical adjustments had to be made for the truncated nature of the data. Again, OLS was deemed inappropriate, therefore tobit estimators using a lower bound of one trip were used in model estimation.

Frequency of Visitation in Activity A at Site J in Month T Submodel:

$Trips_{i,a,j,t} = f_j$ ($Socio_i$, Own Site $Quality_{1,t}$, Cross Site $Quality_{2\text{-}J,t}$, Own $Price_{i,1}$, Cross $Price_{i,2\text{-}J}$, $Activity_i$, λ_{3i}, λ_{4i}, λ_{5i}, etc.)

Activity: a = 1,...,l
Individual: i = 1,...,n
Site: j = 1,...,m
Month: m = 1,...5 represents summer months (1= May, 2=June, 3=July, 4=August) and rest of the year (5)

where:

Dependent Variable: Continuous integer dependent variable (1,2,3,...) based on each Individual Recreator *i*'s number of trips for Activity *a* at Site *j* in Month *m*. A trip is defined as an individual leaving home to visit a site for the primary purpose of recreation in activity *a*. A trip is therefore specific to the individual and can last any length of time from 1 hour to several days. In their surveys, Callaway, et al. (1995) requested information on single destination recreation trips only, thereby avoiding the problems associated with multiple destination trips (i.e., problems associated with travel cost allocation).

Explanatory Variables:

$Socio_i$ =	Age, Income, etc. of individual *i*
Own Site $Quality_{1,m}$ =	Quality of Site *1* in month *m* (e.g., water level, water quality of focus site)
Cross Site $Quality_{2\text{-}J,m}$ =	Quality of Other Sites *2-J* in month *m* (e.g., water level, water quality of other substitute or complementary sites in the region)
Own $Price_{i,1}$ =	Price/Travel Cost or Distance for individual *i* to Site *1* (focus site)
Cross $Price_{i,2\text{-}J}$ =	Price/Travel Cost or Distance for individual *i* to Sites *2-J* (other substitute or complementary sites)
$Activity_i$ =	Dummy Variable for activity type (fishermen, boater, etc.)
λ_{3i} =	Inverse Mills Ratios from the second stage Probability of Participation Model for each individual *i* to Activity *a* for monthly data
λ_{4i} =	Inverse Mills Ratios from the second stage Probability of Participation Model for each individual *i* to Activity *a* for rest of year data
λ_{5i} =	Inverse Mills Ratios from the second stage Probability of

Participation Model for each individual *i* to Activity *a* for annual data

Data Needs:

Nonresponse Model:

- zip code socioeconomic data
- distance to sites
- sample strata

Probability of Participation Model in Activity A:

- information on which activities each individual participated in
- individual's socioeconomic data
- water levels and instream flows at each site
- travel costs for each site

Probability of Participation Model in Activity A at Site J:

- information on which sites each individual visited
- individual's socioeconomic data
- water levels and instream flows at each site
- travel costs for each site
- activities found at each site

Frequency of Visitation Model in Activity A at Site J:

- visitation by activity and site for each individual
- individual's socioeconomic data
- water levels and instream flows at each site
- travel costs for each site
- activities found at each site

Advantages/Disadvantages:

Advantages:

1. Addresses an individual's decision process in a systematic way
2. Uses more accurate individual data as opposed to zonal data
3. Can use both actual and contingent behavior data to evaluate a broad range of management options
4. Can be used to address a range of potential biases via the linking procedure
5. Uses actual, observed visitation behavior

Disadvantages:

1. Data intensive, likely requires use of surveys
2. Requires multiple equations
3. Requires sophisticated statistical modeling

4.2.2.2.2: Multi-stage, Linked Random Utility Model (RUM):

The site selection model allocates total visits within a region across the various sites. The model estimates the probability that individual *i* will visit site *j* on any given choice occasion. The number of choice occasions (trips, days, etc.) for individual *i* are generally obtained from the frequency of visitation model. Multiplying the number of annual choice occasions for individual *i* by the estimated probabilities of visiting each site *j*, provides an estimate of individual *i*'s annual visitation across sites. Averaging the resulting probabilities across individuals allows for estimation of the trip distribution between sites for the average individual (average probability of visiting each site times the average number of choice occasions). Applying trips by site for the average individual by the number of participants in the region provides an estimate of total visitation by site.

The model assumes that trips within the relevant time period (e.g., year, season) are taken independently of each other. This assumption may or may not be realistic depending on the type of trips. Day trips may be more independent than longer duration trips. This model assumes that trip decisions are made one at a time as opposed to all at once at the beginning of the season.

On each choice occasion, the decision to visit a site is assumed to be based on utility (satisfaction) maximizing behavior. Individual *i* visits site *j* only if the expected utility derived from visiting site *j* exceeds that of all other sites within an individual's choice set.

$$Prob\ [\text{visit}\ j] = Prob\ [V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}\ \text{all other}\ k]$$

where:

V_{ij} = the observable utility of individual *i* visiting site *j*
ε_{ij} = the unobservable, random utility component from visiting site *j*
V_{ik} = the observable utility of individual *i* visiting all other sites
ε_{ik} = the unobservable, random utility component from visiting all other sites *k*

The most common approach to estimating these site selection probabilities involves use of a multinomial logit (MNL) model estimated using maximum likelihood techniques. The probabilities can be expressed using the following formula for individual *i* to site *j*. The numerator reflects the utility associated with site *j* and the denominator the utility for all other sites:

$$Probability_{ij} = \frac{\exp^{B_0 + B_1 TC_{ij} + B_2 SQ_{ij\ or\ j}}}{\sum_{k=1}^{j} \exp^{B_0 + B_1 TC_{ij} + B_2 SQ_{ij\ or\ j}}}$$

Individual $i = 1,...,n$
Site $j = 1,...,m$

exp = exponential function, base *e*(see footnote below)[10]

where:

Dependent Variable	=	0 if nonparticipant, 1 if participant (statistical estimation via limited dependent variable model—multinomial logit)

Explanatory Variables:

travel cost (*TC*)	=	out-of-pocket costs of travel and time costs of travel for individual *i* to site *j*
site quality (*SQ*)	=	site characteristics, possibly including catch rates, water quality, water quantity and flow, etc. for individual *i* at site *j* (catch rates will vary by individual at the same site, other characteristics such as water quality would not vary by individual at the same site, need variation over time or sites)

Individual socioeconomic characteristics are not included in the model. For a given individual, socioeconomic characteristics do not vary and therefore do not aid in the explanation of an individual's site choice. Also note that a specific site substitution variable is not included in the model. The model accounts for substitution by comparing the desirability between sites as represented by the denominator of the equation. Because variables included in the probability function include both travel costs and site quality, two variables used to help define site substitution, these models have proven especially attractive when attempting to estimate complicated substitution effects.

[10] *e* is a nonrepeating irrational number (2.718...) which reflects a frequently occurring exponential growth value.

An assumption of the MNL model is that the error terms are independently and identically distributed. A feature of assuming independence of the error terms is called the independence of irrelevant alternatives (IIA) property. The IIA property means the ratio of choice probabilities between pairs of sites is independent of the existence or attributes of other sites. Alternatively stated─choices between two sites are made without considering other sites. This statement implies that the probability ratios remain constant when new sites are added to the choice set. The advantage of this property is that new choice alternatives can be added without re-estimating the model , the disadvantage is that it fails to allow for dependency between sites. When adding another site to the choice set, this property results in the new site drawing proportionally from all other sites.[11] This property may be overly restrictive resulting in illogical behavioral choices.

To avoid this property, nested multinomial logit models have been applied. The nested model uses a decision tree format where certain choices are conditioned on previous choices (e.g., assume one first chooses reservoir recreation over river recreation, the second decision becomes a conditional choice between reservoir sites

[11] Proportional redistribution can be problematic as illustrated by the classic red bus-blue bus problem from the transportation literature. Assume individuals have the option to commute to work by auto, bus, or train. Say we paint half of the buses blue to differentiate them from their original red color. We would expect only the bus users to redistribute between the two color buses. The IIA property would imply a reallocation of trips from all modes, not just the bus mode.

exclusively). As a result, only similar types of sites are affected by the addition of a new site, as opposed to proportionally drawing from all possible sites. Although the lower level decision is conditioned upon the upper level decision, the upper decision is made in anticipation of the utility associated with lower level options.

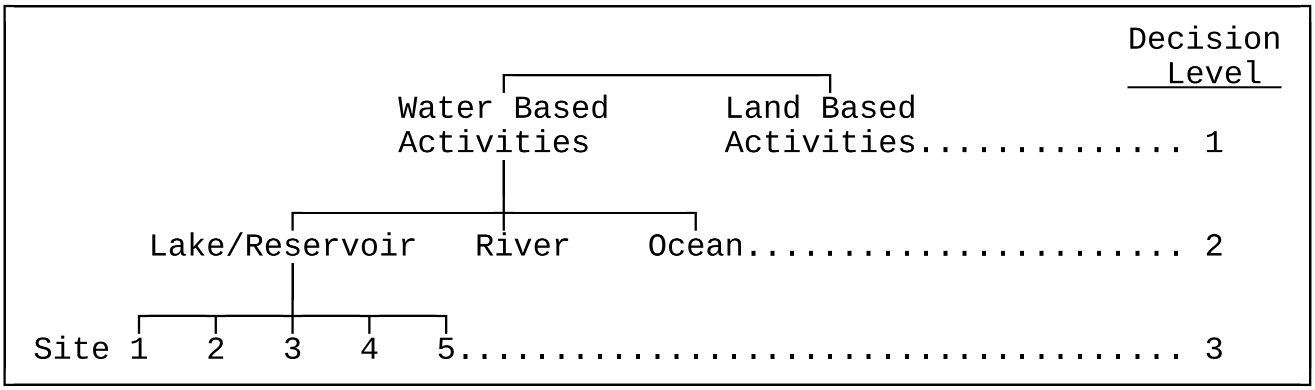

Figure 1. - Illustration of decision levels.

The various levels of the overall decision process, as illustrated on Figure 1, are modeled sequentially, often linked using inclusive values. Inclusive values are explanatory variables which incorporate information and anticipated utility from the lower level choice options directly into the upper level decision model. For example, when modeling the choice between site type (reservoir, river, ocean), inclusive values incorporate information from the various site selection options associated with each site type.

The nested multinomial logit model provides for a more complete accounting of the range of substitution and site quality effects, while simultaneously allowing for an individual's nonparticipation at certain sites (i.e., corner solutions). The nested model, although an improvement, still suffers from decision process questions (what is the sequence of decisions, how should the tree be structured), estimation difficulties, and choice occasion estimation requirements.

Caulkins et al., 1986 used a two stage probabilistic model where the first stage estimates the probability that a lake recreator will take a lake recreation trip on a given day and the second stage estimates the conditional probability of selecting a given site from the individual's choice set. Multiplying these two probabilities provides the joint probability of a lake recreator selecting a lake trip to $site_j$ on any given day. Multiplying this joint probability by 365 days provides an estimate of the number of day trips taken by that individual to $site_j$ in a year. Averaging the number of day trips per year to each site across the recreator sample and then multiplying by the number of regional recreators would provide an estimate of total number of day trips at each site for that year. Obviously, the authors had an estimate of the number of lake recreators in the region, should this information be unavailable, another modeling step would involve estimating the probability of participation in lake recreation within the general population and then multiplying that probability by the size of the general population. The site selection decision in particular is based on the characteristics of each site (distance, site quality, etc.). As a result, this modeling framework specifically addresses site substitution and site quality.

Data Needs:

- Information on which sites each recreator visited
- Travel costs to each site for each recreator
- Site quality characteristics at time of visit for each recreator (water levels/surface acres, water quality, fish harvest rates, etc.)

Advantages/Disadvantages:

Advantages:

1) Provides a good format for handling substitution
2) Consistent with economic theory (utility theoretic)
3) Handles both corner (zero trips to site) and interior solutions (positive trips to site)

Disadvantages:

1) Very data intensive
2) Requires sophisticated econometrics
3) Assumes independent trip occasions
4) Requires surveys of individuals behavior

4.2.3 *HEDONIC PRICE METHOD (HPM) MODELING*:

The basic assumption behind hedonic price modeling is that the variation in the market price of certain goods can be used to estimate values for characteristics of those goods. That is, imbedded in the price of the good lies the value of the good's many characteristics. Variation in housing prices are often used to determine the value of implicit characteristics. Numerous studies have estimated the value of lake characteristics based on the reduction in housing prices as distance from the lake increases. Housing characteristics specific to the time of sale are regressed on housing prices. The partial derivative of price with respect to each of the significant characteristics reflects the marginal value of that characteristic.

Recent studies of Lake Travis in Texas have gone a step farther to actually estimate the recreational and aesthetic value of lake water levels using the hedonic approach (Lansford and

Jones, 1995a and b). In addition to finding the standard relationship between housing prices and distance from the lake, the authors also discovered relationships with water levels, scenic view, and waterfront location/lake access. Significantly higher housing prices were found within the data for periods with higher lake elevations. As a result, the conclusion was made that lake management practices do influence housing prices and recreation and aesthetic values. In addition, the authors speculate both lake level and fluctuation in lake level are playing a role. Generally speaking, homeowners prefer high water levels and less annual/seasonal fluctuation. However, as would be expected, the higher water level preferences only hold within a given range, beyond which flooding becomes a problem.

House Price_{it} = f (Date_t, Square Footage_i, Garage_i, Construction Quality_i, Condition_{it}, Waterfront_i, Lake Levels_t, View_i, Distance to Lake_i, School District_i, Distance to City_i, etc.)

Individual $i = 1,\ldots,n$
Time $t = 1,\ldots,o$

where...

Dependent Variable: Sales price of house

Explanatory Variables:

Date_t	= date of sale
Square Footage_i	= improved/heated area
Garage_i	= # of garage/carport spaces
Construction Quality_i	= quality rank
Condition_{it}	= condition is often related to age
Waterfront_i	= indication of ease of water access
Lake Levels_t	= deviation from average water level at time of sale
View_i	= presence of scenic view
Distance to Lake_i	= distance (in feet) from property to lake
School District_i	= school district of property
Distance to City_i	= proximity to shopping

Data Needs:
- Daily, monthly water levels
- Dates of each sale
- Prices of houses
- House/Lot characteristics

Advantages/Disadvantages:

Advantages:
- Uses exiting data
- Theoretically appealing (witness diminishing marginal values

with increases in a given beneficial characteristic)

Disadvantages:

- Complex
- Known relationships may not be present in the data
- Typical requires a large amount of data

5.0 SUMMARY AND CONCLUSIONS

This paper presents a series of approaches for estimating the effect on recreation use and value of fluctuating reservoir water levels. The approaches covered range from simplistic to extremely complicated and are separated into visitation based and valuation based approaches. All the approaches have advantages and disadvantages, no one approach stands out as being clearly superior in predicting recreation effects.

Generally speaking, the visitation based approaches are less involved than the valuation based approaches. The ratio, facilities or resource access, and annual or monthly use estimating model methods utilize existing data. Given these approaches aren't concerned with valuation, data requirements are somewhat narrower. An exception is the contingent behavior approach which requires a survey of recreators. Use estimating models are the only visitation based approach which requires statistical analysis.

The valuation based approaches tend to be more data intensive, often requiring information from surveys of recreators and/or the general public (e.g., contingent valuation, individual travel cost methods). Although, the zonal travel cost, gravity, and hedonic price models typically use existing data, the scope of the data requirements can be quite large depending on the extent of the model. With the possible exception of the contingent valuation approach, where surevy results could be used directly, all of the valuation based approaches involve some form of modeling and therefore statistical regression analysis. The individual travel cost model has numerous data and statistically oriented advantages, but also appears to be the most complicated of all the reviewed approaches.

The overall purpose of the paper is to present details on a range of potentially applicable methods to aid in the approach selection decision and the estimation process. When attempting to develop a recreation analysis of reservoir fluctuation, one first needs to determine the nature of the output required of the analysis. Are economic values needed? If so, would the values need to be determined or could they be obtained from other sources? If values need to be determined as part of the analysis, the valuation based approaches should be considered. If valuation is not necessary or available from other sources, the visitation based approaches may be of more interest. Once the type of output has been addressed, one needs to consider estimate accuracy/precision requirements. Would a quick and dirty ballpark estimate suffice, or is estimate accuracy/precision more of an issue. If a ballpark visitation estimate is all that is required, perhaps the ratio or facilities access approaches would be appropriate. If a ballpark valuation estimate also necessary, perhaps the visitation estimate could be combined with a benefits transfer application. If more than a "back of the envelope" estimate is required, the analyst would need to consider the adequacy of available data. Do we have sufficient, reliable data to estimate travel cost or use estimating models? Can the hydrologic characteristics of the proposal be explained with available data? If water level/fluctuations fall outside the historic range of the data or if available data is unreliable or if visitation data is nonexistent, contingent behavior/valuation surveys may be required. Alternatively, if there exists a sizable residential community around the reservoir, hedonic approaches could be investigated. Should surveys be required, perhaps it might make sense to gather data for several approaches. Different approaches could be attempted and results compared. Should results prove reasonably close across approaches, that would provide somewhat of a validity check. It is also possible that different approaches may be used for different ranges of water level fluctuation or at different points in the analysis. Finally, the analyst always needs to keep in mind time, budget, or staffing constraints. Frequently, the most appropriate approach(es) as determined from the above process, must be scaled back given existing study constraints.

Despite that fact that virtually every research project reviewed for this study showed a significant positive relationship between reservoir water levels/surface acres and recreation use and value[12], it should be acknowledged that difficulty in finding a recreation-water level relationship may simply be due to the lack of such relationship at the particular site or within a range of water levels at the site, as opposed to any fault with the selected approach.

[12] This could be a result of those sites focusing on the most noticeable or controversial recreation projects.

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Appendix A:

Literature Search Procedures

Components of Literature Search: A series of keyword literature searches were pursued for this study. After identifying relevant keywords, searches were pursued using four major information sources: Dialog System Database, CARL System Database, Firstsearch System Database, and the INTERNET.

I. KEYWORDS USED: (?) implies any continuation of the word (e.g., recreation(?) pulls in recreational)

- Reservoir(?) or Lake(?) and Recreation(?)
- Reservoir(?) or Lake(?) and Recreation(?) and Water Level(?)
- Reservoir(?) or Lake(?) and Recreation(?) and Water Elevation(?)
- Reservoir(?) or Lake(?) and Recreation(?) and Drawdown(?)
- Reservoir(?) or Lake(?) and Recreation(?) and Reservoir Operation(?)
- Reservoir(?) or Lake(?) and Recreation(?) and Surface Acreage(?)

II. DATABASES SEARCHED:

A. DIALOG SYSTEM: Reclamation library personnel conducted searches of the following DIALOG databases:

1. Business Economics:

    15 ABI/INFORM
    139 Economic Literature Index
    148 Trade and Industry Index

2. CAS:

    6 NTIS (National Technical Information Service)

3. Humanities:

    7 Social Scisearch
    35 Dissertations Abstracts Online
    38 Academic Index

4. Leisure/Recreation/Sport:

    48 Sport
    50 CAB Abstracts 1984+
    166 GPO Publications Reference File

5. Science and Technology:

265 Federal Research in Progress
434 Scisearch

6. Social Science: Databases duplicated in other sections

7. Water and Water Quality:

   117 Water Resources Abstracts
   245 Waternet

8. Other:

   102 ASI
   77 Conference Papers Index
   60 CRIS/USDA

B. CARL SYSTEM: The CARL System accesses a group of Colorado university research libraries (e.g., CU, CSU, UNC, etc.)

C. OCLC FIRSTSEARCH SYSTEM: Firstsearch is a broad database of published and unpublished social science research. Databases searched within Firstsearch include the following:

   1. EconLit (Published Economic Literature)
   2. Agricola (Published Agricultural Literature)
   3. Dissertations Abstracts Online
   4. Article 1st
   5. Books in Print
   6. GPO (Government Publications)
   7. PapersFirst (Conference Papers)
   8. Proceedings (Conference Papers)
   9. SocSciAbs (Social Science Abstracts)
   10. WorldCat (International Literature)

D. INTERNET:

   1. Conducted the following searches within the Natural Resources Research Information page.

      - Searched government agency funded research (U. S. Army Corps of Engineers Waterways Experiment Station, U. S. Department of Agriculture research, etc.).

- Searched Social Sciences in Forestry

- Searched Library of Congress databases.

2. Used the Open Text search engine

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