IMPACT OF FLUCTUATING RESERVOIR ELEVATION ON RECREATION USE AND VALUE

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This paper reviews a series of methods for evaluating the effect of changing reservoir water elevations on recreation use and economic value. The approaches cover a range from simple to complex. 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.

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February 2000

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1.0 INTRODUCTION

Water based recreation has often been 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 recent years, the agency's emphasis has changed from providing ever increasing amounts of water storage through dam construction toward achieving more efficient use of current water supplies through water management. The gradual shift has occurred as river systems are becoming increasing over appropriated and locations for additional storage facilities harder to find. 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 re-operation has become a common characteristic of many Reclamation studies including dam safety, flood control, water supply, water quality, 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, or changes in the amount and/or timing of reservoir releases and storage, has implications for flatwater recreation due to fluctuations in reservoir elevation or water level. Water level fluctuation affects recreation use and economic 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:

- Safety: Exposing or inundating stumps, rocks, and other obstructions can create safety problems.

- Water access: As facilities become unusable, both with increasing and decreasing water depth, water access can be impacted. In addition, shoreline access to the water may be affected by the magnitude of mud flats.

- Water quality: 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.

- Aesthetics: Exposing or inundating reservoir "rings"and mud flats can affect a wide range of activities through changes in aesthetics.

- Crowding: 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 value, the magnitude of the impact is often very site and recreation activity specific.

It is typically speculated 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: physical characteristics of the lake, usable range of water access facilities, current reservoir water levels, availability of substitute sites, tolerance of recreators to water level changes, 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 unattractive and hamper shoreline access to the water. Reservoirs where physical obstructions have not been removed obviously pose a considerable threat to boating activities.

- Water access facilities, such as boat ramps and marinas, are most beneficial when they provide flexibility across a wide range of water levels as a result of length (boat ramps) or mobility (floating marinas).

- Current water levels, reflecting a baseline or starting point for water level fluctuations, provide a frame of reference for evaluating impacts. For example, if water levels are very low and most adverse recreation effects have already occurred, impacts of further water level reductions may be minor. Conversely, if water levels are high enough to adequately support recreation and a proposed drawdown causes facilities to become unusable, the effect on recreation 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. If other nearby sites exist which would be unaffected by a proposed drawdown plan, recreators may move to those 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.

- The mix of recreational activities at a given site may have an effect since certain types of recreators are less apt to be impacted by water levels (e.g., land based activities) or better suited to deal with crowding issues.[1]

Given the broad range of influential factors, changing reservoir water levels often impact recreation use and value. While not always the case, it should be noted that virtually every study reviewed for this paper showed a positive relationship between water levels and recreation use.

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[1] Webster (1993) found 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 LITERATURE SEARCH

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

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, Dialog Database, and Firstsearch Database provided a set of both published articles (journals, books) and unpublished articles (consulting firm reports, government agency reports, university working papers, conference papers). 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 38 (see Bibliography for citations of all articles).

3.0 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 general categories - impacts to recreation visitation and 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 requirements with respect to data, analytical rigor, and time/budget.

3.1 VISITATION BASED APPROACHES

The purpose of the visitation based approaches is to measure changes in recreation use only. Recreation 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 be for economic valuation, visits or trips are typically considered the preferred use measure. If data is not available in trip/visit format, additional information may be required to make the necessary conversions (e.g., days per trip, hours per day). To estimate changes in value, the visitation estimates derived from these methods must be combined with information on recreation 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.

As noted in the introduction, reservoir operations and the associated fluctuation in water levels may have dramatic effects on recreation use. For water based recreation activities, water access is a critical issue. Water access facilities such as boat ramps, marinas, and swimming beaches often have a limited useful range. Water levels above or below the usable range would imply loss of the facility. Land based recreation activities at a reservoir site may also be impacted by fluctuating water levels. Changing aesthetic values are typically a driving force with land based activities. Reservoir "rings", mud flats, or exposed objects can detract from site attractiveness at low water levels as would muddy water and flooded facilities at high water levels. Therefore, both high and low water levels can create adverse conditions for many recreation activities. High and low end water level thresholds can vary significantly across sites and activities, hence, it is often advisable to estimate visitation impacts separately by site and activity. While logical, the acceptable water level range concept is sometimes difficult to apply for certain activities because thresholds may be subjective. Facility accessibility and safety issues may be fairly straightforward, whereas acceptable aesthetic ranges may vary considerably across recreators. As a result, determining water level impacts for water based activities may be easier than for land based activities. Potential impacts to total recreation use at a site therefore could depend on water

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

levels, the various acceptable water level thresholds for each activity and facility, and the relative percent of total recreation use represented by each activity.

In addition to the concept of an acceptable range of water levels for each activity, it is often speculated that within the acceptable range, the higher the water levels the better. Improvements in safety, access, and aesthetics would be especially pronounced with increasing water levels within the acceptable range. Generally speaking, a positive relationship between water levels and recreation use often exists within the acceptable range where recreation use increases as water levels increase and vice versa. In addition to the overall change in average reservoir water levels, the amount of water level fluctuation across the recreation season may also be important. It may be possible for site managers to adjust to permanent drawdowns by extending facilities and replanting the mud zones. If reservoir operations create wide swings in water level, site managers may be hard pressed to adapt. Ultimately, the degree of water level fluctuation may be even more important than the level of drawdown. As a result, both average monthly water levels and the range in water levels across the recreation season are often used in modeling applications. In summary, changing reservoir operations leads to fluctuating water levels which impacts the quality of the site and the amount of recreation use.

Measures of reservoir re-operation are typically in the form of alternative specific water levels or surface area. The following discussion summarizes how site quality measures were applied in the various visitation based approaches. The ratio method uses surface acres directly to estimate a ratio to be applied to recreation use. The facilities access approach converts monthly water levels into facility availability before estimating visitation effects. The annual use estimating model often applies start of season or seasonal average water levels and the change in water levels across the season to explain variation in annual visitation. The monthly use estimating model typically includes average or end-of-month water levels in conjunction with the range in water levels within each month to estimate monthly visitation. Contingent behavior surveys normally use pictures or sketches of reservoir facilities and scenic views before and after the proposed water level change to help respondents visualize conditions. In some surveys, impacts of water level changes have been converted into fish populations and catch rates. Finally, delphi approaches not only consider historical visitation and water level relationships, but also specific knowledge of the sites in terms of safety issues, aesthetics, etc.

3.1.1 *RATIO METHOD*

The ratio method is the most simplistic approach for measuring 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 a change in water levels or surface acres would result in a proportional change in 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 linear function of water levels or surface acreage, the approach ignores the potential for high and low end recreation use thresholds. High and low end use thresholds, or water levels at which recreation use drops precipitously, may result from access problems where facilities become unusable because of water levels being too high or low. Assuming a continuous linear 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 change beyond certain levels.

Data Requirements:

1. Baseline recreation use and value estimates
2. Baseline water levels or surface acreage
3. Alternative water levels or surface acreage

Advantages/Disadvantages:

Advantages:	1. Analytically simple 2. Limited data requirements 3. Minor time and budget requirements
Disadvantages:	1. Results are often unrealistic 2. Inappropriate when recreation to water level relationship is nonlinear 3. Not statistically based

3.1.2 *FACILITIES OR RESOURCE ACCESS METHOD*

The facilities or resource access approach attempts to measure changes in recreation use based exclusively on reservoir access. As reservoir elevations rise or fall, certain water based recreational facilities (e.g., boat ramps, marinas, swimming areas) may become inaccessible or undesirable. Typically, as the number of usable water access facilities declines, so does the amount of water based recreation.

In its simplest form, the approach uses historical visitation information by activity and facility to estimate changes in recreation use due to loss of facilities. 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 focus sites and other regional sites, the analysis could theoretically address all of the above forms of substitution except activity substitution.

Given the 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 could also be applied to improvements in access. With 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, and facility and resource carrying capacities would all be used to develop the analysis. The procedure normally involves the following steps:

Step 1: Identify Potentially Affected Recreation Activities

Assuming the reservoirs affected by the alternatives under consideration are known, the first step in the analysis is to evaluate which recreational activities at each site could be potentially impacted through reduced access to facilities as water levels drop. If boat ramp access will be affected, it is likely that boat based activities (e.g., power boating, waterskiing, sailing, boat fishing) may be impacted. Other water based activities (e.g., swimming, shoreline fishing) also could be affected, although the severity of impact may be less than activities requiring boat ramps

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[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.

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

due to their oftentimes dispersed nature.[5] Since this approach focuses on water access, generally speaking, land based activities would not be addressed.

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 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 only to 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, especially from the perspective of time substitution, 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.

[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 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 percentage 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, estimate the percent by activity, facility, and month.

Step 3: Water Level Data:

Hydrologic modeling provides the necessary water level data for each project alternative. Modeling results typically include average monthly water level, end of month water level, and/or water levels according to a weekly or daily schedule. Gathering of historic water level data allows for comparisons with historic visitation data (step 2B).

When water level is generated from the hydrologic model on a monthly basis, interpretation problems 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. Assumptions are often required to estimate average monthly water levels.

Step 4: Facility Water Level Thresholds:

For each water based facility (e.g. boat ramp, marina, swimming beach), determine at what water level use would no longer be possible or desirable. Typically, high end and low end water level thresholds are identified to account for problems associated with both too much and too little water. 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 the orientation toward current site facilities, a longer-term perspective could be achieved by considering facility mitigation options, including construction of new facilities and extension of existing facilities. To evaluate impacts with mitigation, the water level based usability thresholds for current facilities

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[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.

would need to be adjusted and information included on the new facilities. Assuming resource carrying capacity is non-constraining, new facilities would affect the analysis by adding 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 in conjunction with monthly visitation by activity and day type, the analyst can estimate the level 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, resource carrying capacities would be applied in the analysis instead of facility carrying capacities.

Step 7: Estimate Recreation Visitation with 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 monthly 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. If 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, except facility/resource excess capacity is reviewed over the remainder of the recreation season rather than during the same day. Time substitution is further complicated by the need to determine season lengths by activity (e.g., power boating during the winter months may not an option). This form of substitution implies recreators have information about potential future water levels across the recreation season. It is unlikely this information would be available to the general public. Given these restrictive assumptions, this form of substitution is typically not emphasized.

Step 8: Carrying Capacity Data for Substitute Sites

In order to consider potential substitution of recreation use to other regional sites, estimates are needed of excess carrying capacity by activity, month, and day type for each of the substitute sites. Substitute site excess capacity estimates could be developed using resource carrying capacities as opposed to facility carrying capacities unless the potential substitute sites also experience water level fluctuations and facility availability losses. The capacities could be based on reservoir size or parking lot capacities (if the lots are single activity). Current visitation by activity, month, and day type could be subtracted from the daily resource capacities by activity to estimate excess capacity by activity, month, and day type at each 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) 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 regarding willingness to substitute based on the additional distance, relative site qualities, etc.

While carrying capacity data is useful in estimating facility, time, and site substitutions, it should be noted that such data is often unavailable. Alternatively, 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: Unfortunately, much of the information necessary for the analysis is typically not collected, and as a result, the analyst may need to rely upon the judgement of site management.

1) For each site directly affected by water level fluctuations associated with project alternatives, gather data on the following:

- Potentially affected recreation activities
- Water based facilities by activity
- Visitation data by primary recreation activity and month for as many years as possible
- Percentage of visitation, by activity and month, which occurs on weekends/holidays versus weekdays
- Percent of visitation by facility for each activity
- Water level data (monthly, weekly, daily)
- High and low water level thresholds for each facility.
- Daily facility and resource based carrying capacity data by activity

2) For each substitute site, gather data on:

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

Advantages/Disadvantages:

Advantages:

1. 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.

2. Can be developed without gathering data from the general public.
3. The extended approach attempts to address various possible forms of substitution. Substitution effects are frequently dismissed or ignored within recreation analyses.

Disadvantages:

1. The analysis is oriented toward addressing impacts to water based activities (e.g., boating, fishing, swimming). 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).

2. Since the approach is based upon utilization of existing facilities, it has a current orientation unless information about future facilities is available.

3. 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.

4. Given the large number of assumptions required of the analysis, fairly minor changes in the assumptions can create large differences in the results.

5. The approach measures changes in visitation only, valuation is not addressed.

6. No statistically basis.

3.1.3 *STATISTICAL USE ESTIMATING MODELS (UEM)*

Use estimating models apply regression techniques to estimate statistical relationships between visitation and a wide range of explanatory variables. Model selection is often determined by the type of data available. Hydrologic data on water level fluctuation is generally provided on a monthly basis implying use of a monthly oriented UEM. Unfortunately, visitation information is often only available on an annual basis. In cases where monthly visitation cannot be estimated, annual UEMs provide a less involved but viable option to the monthly UEM.

Both monthly and annually oriented UEMs can be estimated using either total visitation or visitation separated by recreational activity. Given it is possible that only certain activities would be impacted by water level fluctuations (e.g., water based activities such as boating, waterskiing, fishing, swimming), more appropriate model definition may involve targeting only the impacted activities. Using total visitation instead of visitation for only the impacted activities may lead to misleading modeling results due to the influence of non-impacted activities on the statistical relationships.

A problem with estimating an activity specific model is that visitation may not be broken down by activity. Categorizing visitation by activity is complicated by the possibility of multiple activity trips. Typically, estimates of visitation by activity are based on the primary activity. While not perfect, this technique generally provides adequate estimates of visitation by activity.

While water based recreation activities may be impacted the most by a change in reservoir water level, the potential for impacts to land based activities should not be dismissed. Many land based activities may benefit from the scenic qualities associated with the reservoir. Consequently, 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.

3.1.3.1 **Annual Visitation Model**

Bowker et al. (1994) developed annual UEMs for Shasta and Trinity Lakes in northern California. While monthly water level data were available, 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.

The following briefly presents the general model used by Bowker et al. (1994) in terms of structure (activity, site, year orientation), variable definitions (both dependent and explanatory), and expected signs for the explanatory variables (in parenthesis under each variable). Some elaboration is provided on the expected signs of the water level based site quality variables.

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) at site *j* in year *t*. Considered to be somewhat of a measure of natural conditions. The expected sign on this variable was positive. Recreation seasons with higher starting water levels generally experienced greater annual visitation.

Drawdown_{jt} = Amount of drawdown between beginning of season water levels and September water levels at site *j* in year *t* as measured by the drop in feet of average monthly water levels between May and September. The expected sign on this variable was negative where the smaller the seasonal drawdown, the greater the total visitation

Year_{t} = Annual time variable

Data Needs:

1. Total visitation or total visitation by activity
2. Beginning and end of season water levels

Advantages/Disadvantages:

Advantages:	1. Simplicity 2. Minor data needs 3. Statistically based
Disadvantages:	1. Fails to consider month by month water levels 2. No valuation 3. Limited to measuring changes within historical range of water level and visitation data

3.1.3.2 **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).

$$\text{Monthly Visitation}_{jmt} \text{ or Monthly Visitation by Activity}_{ajmt} = f(\underset{(?)}{\text{Month}_m}, \underset{(+)}{\text{Year}_t}, \underset{(varies)}{\text{Water Level}_{jmt}}, \underset{(varies)}{\text{Water Quality}_{jmt}}, \underset{(varies)}{\text{Weather}_{jmt}}, \underset{(-)}{\text{School}_{jmt}}, \underset{(+)}{\text{Socio}_{jmt}})$$

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. The expected sign for the average or EOM water level variable would be positive, where higher water levels are associated with higher use. Conversely, the expected sign on the monthly monthly range variable would be negative, where higher fluctuation leads to lower use.

Water $Quality_{jmt}$ =	Monthly average water quality by site and year. Water quality can be influenced by water levels, with improved quality typically associated with higher water levels. The relationship between water quality and visitation depends on the water quality measure.
$Weather_{jmt}$ =	Monthly average temperature, total monthly precipitation, etc. by site and year
$School_{mt}$ =	Binary variable indicating whether school is in session by month and year (out=0, in=1)
$Socio_{mt}$ =	Population, income and other socioeconomic variables for market area, by month and year

Data Needs:

1. Monthly visitation, by activity if available
2. Monthly water levels
3. Monthly water quality
4. Monthly weather conditions
5. Socioeconomic/demographic variables (population, income, education, age, etc.)

Advantages/Disadvantages:

Advantages:	1. More comprehensive than annual model from the perspective of explanatory power 2. Addresses water level changes on a monthly basis 3. Statistically based
Disadvantages:	1. Greater data requirements and more statistically complex compared to the annual model 2. No valuation 3. Limited to measuring changes within historical ranges of water level and visitation

3.1.3.3 **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 (e.g., a change in water levels) 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 predict how they would react to a hypothetical water level change in terms of visitation as opposed to value (e.g., some respondents have difficulty in assigning dollar values in contingent valuation scenarios). To address some of the criticism regarding the hypothetical nature of the contingent approaches, researchers have begun asking follow-up questions to gauge how sure 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.[7] 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 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 (WTP) 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 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:

1. For the stand alone approach, no pre-survey data would be required other than a sample of recreators should a mail survey be conducted.
2. 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.

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

Advantages/Disadvantages:

Advantages:	1. Unhampered by historical data. The survey provides flexibility in the range of data collected.
	2. Recreators respond to questions about visitation behavior as opposed to willingness-to-pay
	3. Results can be combined with other estimation approaches
Disadvantages:	1. Requires a survey of recreators which can be time consuming, costly, and demanding of technical expertise
	2. Relies on hypothetical visitation behavior, not verifiable until after the fact
	3. Contingent behavior questions evaluate change in recreation use only

3.1.4 *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 tapping the knowledge base of recreation experts is not new to recreation studies.

A panel of knowledgeable residents 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 (Cordell 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:
1. Very flexible in data obtained
2. Relatively inexpensive, fast approach to gathering data
3. Based on professional judgement

Disadvantages:
1. Subjective
2. Responses become questionable beyond range of observed behavior
3. Not statistically based

3.2 VALUATION BASED APPROACHES

Contrary to the visitation based approaches, valuation approaches are primarily concerned with estimating changes in recreation economic value. Recreation value is measured in terms of consumer surplus or recreators WTP over and above what they actually pay. Three general methods are presented: contingent valuation, travel cost, and hedonic price. The valuation approaches can directly estimate total changes in value or can estimate changes in value per trip for application with visitation estimates obtained elsewhere.

As described under the introduction to the visitation based approaches section, fluctuating water levels may affect site quality and visitation. Changes in site quality can also impact trip values. As water levels decline, value per trip may also decline because the quality of the recreation experience has diminished. Even if water access is unimpaired, lower water levels could create more safety hazards, water quality problems, unattractive rings and mud flats, reduced fish populations and catch rates, and increased crowding. When estimating potential changes in total value, it is important to consider both effects on visitation and value per trip. While changing visitation levels often generate the majority of the change in total value, changing value per trip can also play a significant role. While unusual, it is possible that value per trip may vary significantly with a given change in water levels, while visitation remains reasonably constant.

The concepts of an acceptable water level range and a positive relationship to water levels within the acceptable range, as presented in the visitation based approaches section, also hold for valuation. In terms of typically applied water level variables, the contingent valuation and travel cost approaches generally follow the discussion presented in the visitation section for contingent behavior and use estimating models. To summarize, the following site quality variables are often used: average or end of month water levels, average or end of month reservoir size (surface acres typically estimated using a formula based on water level), facility availability, range in monthly or seasonal water levels/surface acres, fish abundance/catch rates, and water quality. All of these measures either directly represent or are indirectly influenced by water levels.

In addition to model and variable selection based on economic theory and data availability, these same factors influence the selection of functional form and statistical/econometric technique. Typical functional forms, or assumed curve shapes, used in recreation demand studies include linear, semi-log (log-linear and linear-log), and double log. 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.

3.2.1 *CONTINGENT VALUATION METHOD (CVM) MODELING*

Contingent valuation models apply WTP results obtained from a survey of site users. Respondents are presented a scenario with information on changing water levels, facility availability, fishing conditions, etc., and are asked to react in terms of annual or per trip WTP. Considerable efforts are taken to present the hypothetical scenario in realistic terms.

3.2.1.1 **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. Since all respondents react to the same water level fluctuation scenario, no variation exists within the water level measures to allow for inclusion as explanatory variables.

Bowker et al. (1994) estimated six equations for three management scenarios under 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 WTP may also vary considerably under drought and non-drought conditions. This idea is analogous to the starting point concept discussed in the introduction. 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.

$$\text{Annual Household WTP}_{ij} = f\,(\text{Site Quality}_{ij}, \text{Income}_i, \text{Substitutes}_i, \text{Nonlocal}_i, \text{Payment}_i, \text{Lake}_j)$$

(+) (+) (-) (?) (?) (?)

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

where:

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

Explanatory Variables:

$Quality_{ij}$ = 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)

Another example of the alternative specific CVM approach is found in Loomis (1989, 1990). These studies evaluated two scenarios for increasing water levels and bird populations at Mono Lake in California. Incremental open-ended and closed-ended WTP questions were asked about moving from the baseline condition to each improvement scenario. Separate equations were developed for each scenario and elicitation approach. The closed-ended/dichotomous choice procedure presented respondents with WTP bids for each scenario. Bids amounts were varied across the sample to provide variation and incorporation of the upper bound. Acceptance or rejection of the stated bid amount reflects the dependent variable in the logit modeling effort briefly described below.

Yes/No response to bid $amount_{is}$ = f(Bid $Amount_{is}$, Income/Education/Age_i, $Experience_i$,)

(-) (+)/(+)/(-) (+)

Individual: i = 1,...,n
Scenario: s = 1,...,q

where:

Dependent Variable: Willingness-to-pay the proposed amount for individual *i* for scenario *s*

Explanatory Variables:

Bid $Amount_{ijs}$ =	Randomly selected amount that individual *i* would have to pay in monthly water bills to obtain the water level associated with each scenario *s*
Income/Education/Age_i =	Series of income, education, and age variables for individual *i*
$Experience_i$ =	Experience or knowledge of the site for individual *i*

An interesting side note associated with this study is that two surveys were conducted of the same population sample using the same survey to check the reliability of WTP responses over time under both open-ended and dichotomous choice approaches. Results were mixed. WTP responses proved consistent in half of the comparisons. In addition, neither elicitation approach proved more reliable than the other.

Data Needs:

1. Annual WTP for each household from the contingent valuation survey
2. Recreators site quality perception
3. Household income
4. Location of residence
5. Household's substitute sites

Advantages/Disadvantages:

Advantages:	1. Survey requirement implies flexibility, can ask a wide range of questions (not constrained by available data) 2. Fairly simple modeling
Disadvantages:	1. Requires survey and associated time, cost, and technical requirements 2. Doesn't address visitation or number of recreator households 3. Hypothetical responses, not verifiable until after the fact 4. Not adaptable to other management actions

3.2.1.2 **Multiple Alternative Modeling Approach**

While Bowker et al. (1994) and Loomis (1989, 1990) estimated different models for each alternative under consideration, 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). 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 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 and boat ramps) at each reservoir under each water level scenario. The semi-log logit model was estimated as follows:

$$\text{Yes/No response to scenario}_{ijs} = f(\underset{(-)}{\text{Bid Amount}_{ijs}}, \underset{(+)}{\text{Recreation Budget}_i}, \underset{(+)}{\text{Experience}_i}, \underset{(+)}{\text{Gender}_i}, \ldots \underset{(?)}{\text{Reservoir}_j}, \text{ and } \underset{(+)}{\text{Alternative}_s})$$

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

where:

Dependent Variable: Annual 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
$\text{Recreation Budget}_i$ =	Percent of individual’s household income spent on recreation
Experience_i =	Years of participation at the reservoir divided by age
Gender_i =	Female = 0, male = 1
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 1993 specified this variable to

reflect each alternative, one could theoretically use water levels/surface acres in lieu of this variable to make the model more flexible). The expected sign was positive to reflect the increasing water level/surface acre situation across the alternatives.

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 WTP 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 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 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:

1. Individual's yes/no responses to the contingent scenarios
2. Household recreation budgets
3. Individual's years of experience at the site, gender, age, other socioeoconomic and demographic variables
4. Reservoir water levels/surface acres should the model be so defined

Advantages/Disadvantages:

Advantages:

1. Survey provides flexibility in data collected
2. Model adaptable to a range of water level/surface acre scenarios
3. Reasonably simple modeling

Disadvantages:

1. Requires survey and associated time, cost, and technical requirements
2. Doesn't address visitation or number of recreator households
3. Hypothetical responses, not verifiable until after the fact

3.2.2 *TRAVEL COST METHOD (TCM) MODELING*

The TCM estimates recreation visitation and value as a function of travel costs and other explanatory variables. The basic premise of the approach is that travel costs act as a 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 WTP (i.e., consumer surplus). As a result, these approaches provide estimates of both visitation and value.

3.2.2.1 **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 around the site. These approaches are typically less data intensive as compared to the individual TCM approach (presented below) since 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.

3.2.2.1.1 *Zonal TCM Model*

The zonal TCM model estimates total site visitation as a function of site specific quality variables (e.g., water levels/surface area, water quality, recreation facilities, fish catch rates, weather), general user population variables (e.g., travel distances, population), and socioeconomic characteristics (e.g., average income, education, race, age). In addition, distance and site quality characteristics for other sites in the general vicinity of the study site are typically included to account for the interrelationship between sites.

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

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, including fish catch rates, water quality, water quantity and fluctuation range, recreational facility availability, weather, etc. for site *j* in time period *t* (variation created by pooling sites or gathering time series data). The expected sign would vary based on the measures used. For most water oriented site quality variables, the expected sign would be positive. The range in water levels would be an exception where recreators normally prefer lower levels of fluctuation.

$Substitutes_{ijt}$ = 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 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:

$$\frac{Trips_{ij}}{Population_i} = \frac{Trips_{ij}}{Recreators_{ij}} \;\mathbf{V}\; \frac{Recreators_{ij}}{Population_i}$$

(*Trips per Capita*) = (*Frequency of Visitation*) **V** (*Probability of Participation*)

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.

A study of Rye Patch Reservoir in Nevada provides a recent example of an aggregate single site time series model (Huszar et al. 1998). The authors developed a two stage bio-economic recreational fishing model where both stages were estimated as a function of reservoir water levels. The model's initial stage estimated fish catch by county based on water levels and pounds of fish stocked. The second stage fishing demand model, used the catch estimates from the first stage, along with water levels, travel costs, and population estimates to predict visitation by zone.

Seventeen years of monthly visitation and water level data provided the necessary fluctuation to estimate the aggregate time series count data model.

A multiple site model was used to calculate of total recreation benefits at four Pecos River reservoirs in New Mexico (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) 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 (Corps) 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 range 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 breakdowns, 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 with two primary conclusions: model derived benefits estimates appeared to be more accurate than model derived use estimates, and 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 frequently 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 emphasized 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[8] or surface area estimates. Variation in monthly, weekly, or daily 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 in the context of a pooled site regional model, using only water level data can be troublesome in that a full 1,500 acre reservoir would generate as much visitation as a half-full 3,000 acre reservoir, all else being equal. The half-full reservoir would likely be much less appealing due to large mud flats, unsightly rings, and facility unavailability. 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, and water quality. 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 and Associates 1989, 1990) have relied upon on-site surveys to gather the necessary travel cost, site quality, and demographic data.

Data Needs:

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

1. Visitation data by zone (source: site management)
2. 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)
3. 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)
4. Zonal socioeconomics data (source: U. S. Census Bureau): population, income, education, age, sex, etc.

Advantages/Disadvantages:

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

Disadvantages:
1. Individual characteristics lost in zonal aggregates
2. Weighting may be necessary with zones of unequal populations
3. Greater probability of multicollinearity and heteroskedasticity in grouped data
4. Questionable handling of multiple site and purpose trips
5. Cannot handle urban sites (lack of variation in travel cost)

3.2.2.1.2 *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 estimates of total recreation use across sites in a given region. This approach has been somewhat less popular with economists since it doesn't apply visitation-origin data and therefore may be less accurate in predicting recreation use at individual sites. Economists typically prefer using visitation-origin data to predict visitation and value by site. Using a bottom up approach, visitation and value are summed across sites to represent an entire region. Gravity models work in the opposite direction. Total visitation for an entire region is estimated first (trip generation submodel), followed by use of the gravity concept where the total estimated visitation is allocated across sites based on relative attractiveness (trip distribution submodel). The aggregate gravity model concept is similar in some 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 data set. 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 (i.e., 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: (Probability of Participation and Frequency of Visitation Submodels)

$$\text{Participation (yes/no)}_{ia} \ \text{or} \ \text{Visitation}_{ai} = f(\underset{(+)}{\text{Education}_i}, \underset{(+)}{\text{Gender}_i}, \underset{(+)}{\text{Household Size}_i}, \underset{(+)}{\text{Income}_i}, \underset{(-)}{\text{Rural vs Urban}_i}, \ldots \underset{(-)}{\text{Recreation Opportunities}_{ai}})$$

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

where:

Dependent Variables:

1) Probability of Participation =	Whether each household in the sample participates in activity *a*
2) Frequency of Visitation =	Total visitation in activity *a* across all sites for household *i*, given household *i* participates in activity *a*

Explanatory Variables:

Education_i =	Head of household education level
Gender_i =	Head of household gender (female = 0, male = 1)
Household Size_i =	Number of household members
$\text{Household Income}_i$ =	Combined income across household members

Rural vs $Urban_i$ = Residence in a rural or urban setting (rural = 0, urban = 1)

Recreation $Opportunities_{ai}$ = Index of household *i*'s regional freshwater recreation opportunities for activity *a*

Trip Distribution (Gravity) Model:

$Visitation_{aij}$ / S $Visitation_{aij}$ = f (Travel $Costs_{ij}$, Site $Quality_{aj}$, Socio/$Demo_i$, Recreation $Opportunities_{ai}$)
(-) (+) (varies) (-)

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). For all these site quality variables, the expected sign would be positive.

Socio/$Demo_i$ = Socioeconomic/demographic characteristics of each zone (e.g., population, age, income, education, sex, race)

Recreation $Opportunities_{ai}$ = Site substitution index for activity *a* and zone *i*

Data Needs:

1. Household visitation by activity preferences by zone (household survey data)
2. Zonal travel cost data (sources: Zip Fip/PC Miler for distance by zone, U. S. Department of Transportation for variable cost per mile)
3. 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)
4. Zonal socioeconomics data (source: U. S. Census Bureau): population, income

Advantages/Disadvantages:

Advantages:
1. Accounts for both participation and frequency decisions
2. Estimated using OLS/WLS procedures (except for participation model)

	3. Less data intensive than individual model (doesn't require visitation-origin data), more data intensive than zonal TCM 4. Some of the data would be available from existing sources (site management, U.S. Census Bureau, etc.) 5. While the typical gravity model deals with only visitation, the Wade et. al, 1988 approach allows to valuation estimation
Disadvantages:	1. Individual characteristics lost in zonal aggregates 2. Cannot handle urban sites (lack of variation in travel cost) 3. Not based on observed origin-destination data 4. May be less accurate than site specific TCM model developed with visitation-origin data

3.2.2.2 **Individual TCM Model**

The individual TCM uses information specific to each individual in the dataset to estimate visitation and value for the average recreator. This approach is substantially more data intensive as compared to the aggregate approaches since all information must be on an individual 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 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 the prior selections, how many trips by activity will be taken to each site? The second and third decision steps are reversed for some models. Assuming this decision structure, individual TCMs are estimated via a series of equations reflecting each decision step.

3.2.2.2.1 *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 study include the following: incorporation of a survey response model to address nonresponse biases (this model is not discussed since water level fluctuation was irrelevant to the survey response issue), linking of the sequential submodels using latent variables (Inverse Mills Ratios), monthly orientation of the model to address monthly water level fluctuation, and use of pooled actual and contingent behavior data.

An extensive survey of recreators at reservoir and river sites throughout the Columbia River system was conducted in 1993. Despite using a sample of recreators only, the percentage of zero visit observations was still quite large. This is because recreators typically visit only one or two sites, implying zero visitation at all others. The overall model therefore had to address individual visitation greater than or equal to zero at each site. The model was separated into several parts, the primary elements being 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) statistical procedures. The probability of participation model uses a discrete (yes/no) probit procedure to estimate the average probability of visiting a given site. The frequency of visitation model used a tobit procedure to estimate the average annual number of trips taken at each site per recreator. The tobit procedure takes into consideration truncation inherent in the sample data (i.e., all site users take at least one trip). An advantage of separating the visitation modeling into two stages is that different variables can be used in each modeling stage.

Applying the estimated average probabilities of participation for each activity, site, and month to 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. The overall number of recreators within the region was considered reasonably fixed, and therefore generally unaffected by fluctuations in reservoir water levels. Despite the requirement of the probability of participation model for data on both participants and nonparticipants, the recreator sample was used since recreators do not visit all the sites.

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. The monthly orientation was necessary to estimate monthly fluctuation in visitation due to the 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 moves in tandem. Collinear variables basically explain the same facet of variation in the dependent variable making model estimation difficult. The interrelated nature of site management along the Columbia River implies that water levels at certain sites 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. Water level and visitation behavior obtained from contingent behavior responses, when combined with actual observed behavior, provided sufficient variation across sites to allow for model estimation.

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. For a discussion of the adjustments made in both the probability of participation and frequency of visitation models, see Callaway et al. (1995).

The following model reflects both the probability of participation and frequency of visitation submodels. Callaway et al. (1995) used many of the same explanatory variables in both of these modeling steps, the primary difference being the various Inverse Mills Ratio variables used to link the submodels.

Probability of Participation and Frequency of Visitation in Activity A at Site J in Month T Submodels:

Participant$_{i,a,j,m}$ = f_j (Socio$_i$, Own Site Quality$_{1,m}$, Cross Site Quality$_{2\text{-}J,m}$, Own Price$_{i,1}$, ...
(varies) (+) (-) (-)

Cross Price$_{i,2\text{-}J}$, Activity$_i$, ?$_{1i}$, ?$_{2i}$)
(+) (varies) (?) (?)

Trips$_{i,a,j,t}$ = f_j (Socio$_i$, Own Site Quality$_{1,m}$, Cross Site Quality$_{2\text{-}J,m}$, Own Price$_{i,1}$, ...
(varies) (+) (-) (-)

Cross Price$_{i,2\text{-}J}$, Activity$_i$, ?$_{3i}$, ?$_{4i}$, ?$_{5i}$)
(+) (varies) (?) (?) (?)

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 Variables:

1) Probability of Participation = Binary dependent variable (yes/no) based on each individual *i*'s participation in activity *a* at site *j* in month *m*

2) Frequency of Visitation = 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). The expected sign would likely be positive since as water levels increase, recreation use increases (assuming water levels are within the acceptable range of the given activity).

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). As water levels at substitute sites increase, visitation at the study site is likely to decrease (negative expected sign).

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.)

?$_{1i}$ = Inverse Mills Ratios associated with the actual behavior model from the first stage probability of responding to the survey model for each individual *i* (used in probability of participation model[9]).

?$_{2i}$ = Inverse Mills Ratios associated with the contingent behavior model from the first stage probability of responding to the survey model for each individual *i* (used in probability of participation model).

?$_{3i}$ = Inverse Mills Ratios from the second stage probability of participation model for each individual *i* to activity *a* for monthly data (used in frequency of visitation model).

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[9] 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 site participation model. The inclusion of the IMR's in the site participation model provides a statistical correction for any systematic response bias. In addition, 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 sequential modeling steps were directly linked.

?$_{4i}$ = Inverse Mills Ratios from the second stage probability of participation model for each individual *i* to activity *a* for rest of year data (used in frequency of visitation model).

?$_{5i}$ = Inverse Mills Ratios from the second stage probability of participation model for each individual *i* to activity *a* for annual data (used in frequency of visitation model).

Data Needs:

1) 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

2) 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

3.2.2.2.2 *Multi-stage, Linked Random Utility Model (RUM)*

The random utility/site selection model allocates an individual's total visits within a region across sites. The model estimates the probability that individual *i* will visit site *j* on any given choice occasion. The number of choice occasions (e.g., trips, days) for individual *i* are generally obtained from a 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 site selection probabilities and the number of choice occasions across individuals allows for calculation of trip distribution between sites for the average individual. Multiplying 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 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.

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:

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

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, 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). While the expected sign on site quality depends on the selected measure, for most measures, own site quality is expected to be positive and cross site quality is expected to be negative. As noted elsewhere, the expected signs of water level range variables would be the reverse.

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.

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 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

[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.

sites. Although the lower-level decision is conditioned upon the upper-level decision, the upper-level decision is made in anticipation of the utility associated with lower-level options.

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+)))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))),
*                                                         Decision *
*                         +))))))))))))))),                  Level  *
*                    Water Based      Land Based                   *
*                    Activities       Activities.............. 1   *
*                         *                                        *
*               +))))))))))3))))))))),                             *
*       Lake/Reservoir   River    Ocean....................... 2   *
*               *                                                  *
*      +)))0)))3)))0))),                                           *
* Site 1   2   3   4   5...................................... 3   *
.))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))-
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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. 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 multiplying by the number of regional recreators provides 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 multiplying that probability by the size of the general population.

Parsons and Kealy (1992) provide an example of how to develop a nested multinomial logit model when the number of site choices becomes large. As an alternative to grouping sites and thereby site characteristics within a given region (regional aggregation), the authors randomly selected a relatively small number of sites from a much larger choice set. The authors data included information on visitation to over a thousand Wisconsin lakes in 1978. The authors split the state into northern and southern regions. The nested choice model first assumed a recreator would choose between the northern and southern regions followed by choice of a particular site within the selected region. The models were estimated with randomly selected sites ranging from 3 to 23. In an application, they concluded that useful value estimates could be obtained with as little as 6 of the 1,000+ substitute sites incorporated into the model.

Data Needs:

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

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

3.2.3 *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. Alternatively stated, 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, b). In addition to finding the standard negative 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.

$$\text{House Price}_{it} = f(\underset{(+)}{\text{Date}_t}, \underset{(+)}{\text{Square Footage}_i}, \underset{(+)}{\text{Garage}_i}, \underset{(+)}{\text{Construction Quality}_i}, \underset{(+)}{\text{Condition}_{it}}, \ldots$$

$$\underset{(+)}{\text{Waterfront}_i}, \underset{(-)}{\text{Lake Levels}_t}, \underset{(+)}{\text{View}_i}, \underset{(-)}{\text{Distance to Lake}_i}, \underset{(?)}{\text{School District}_i}, \ldots$$

$$\underset{(-)}{\text{Distance to City}_i}, \text{etc.})$$

Individual: $i = 1,...,n$
Time: $t = 1,...,o$

where...

Dependent Variable: Sales price of house

Explanatory Variables:

Date_t =	Date of sale
Square Footage_i =	Improved/heated area
Garage_i =	Number of garage/carport spaces
$\text{Construction Quality}_i$ =	Quality rank
Condition_{it} =	Condition is often related to age
Waterfront_i =	Indication of ease of water access (expected sign is positive since improved access is associated with higher housing prices).
Lake Levels_t =	Deviation from average water level at time of sale (expected sign is negative because the further the deviation from average water levels the lower the housing prices (note that the deviation is typically on the downside))
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:

1. Daily, monthly water levels
2. Dates of each sale
3. Prices of houses
4. House/Lot characteristics

Advantages/Disadvantages:

Advantages:
1. Uses exiting data
2. Theoretically appealing (witness diminishing marginal values with increases in a given beneficial characteristic)

Disadvantages:
1. Complex
2. Known relationships may not be present in the data
3. Typical requires a large amount of data

4.0 SUMMARY AND CONCLUSIONS

This paper presents a series of approaches for estimating the effect of fluctuating reservoir water levels on recreation use and economic value. The approaches 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 are not 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 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, data requirements can be extensive depending on the scope of the model. All of the valuation based approaches involve some form of statistical analysis with the possible exception of the contingent valuation approach. The individual travel cost model has numerous data and statistically oriented advantages, but also appears to be the most complicated of the evaluated approaches.

Approach selection typically depends on type of output required, output accuracy, data availability, and time/budget constraints. When developing a recreation analysis of reservoir fluctuation, the first step is to determine the nature of the required output. For example, are economic values needed? If so, would values require estimation or could they be obtained from existing sources (i.e., benefits transfer)? Lack of existing valuation options would necessitate value estimation via one of the valuation based approaches. If valuation is unnecessary or if values are readily available from other sources, perhaps only visitation estimates would be required using one of the visitation based approaches. Once the type of output has been addressed, the second step in the approach selection process involves consideration of accuracy requirements. Would a “ballpark” estimate suffice, or is estimate accuracy important. If a ballpark estimate is all that is required, perhaps a visitation estimate using the ratio or facilities access approaches could be combined with a benefits transfer value. If more than a ballpark 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 proposed alternatives be explained with available data? If water levels for the study alternatives fall outside the historic range or if visitation data is unreliable or nonexistent, contingent behavior/valuation surveys may be required. Alternatively, if there exists a sizable residential community around the reservoir, hedonic approaches could be investigated. Finally, the analyst always needs to keep in mind time and budget constraints. Frequently, the most appropriate approach(es) as determined from the above process, must be scaled back given study constraints.

For various reasons, applications of a given approach may prove unsuccessful. It is often prudent to allow for a range of options to maximize analytical flexibility. Particularly in situations where surveys are involved, it may be advisable to gather data for several approaches. Different approaches could be attempted and results compared. If results prove reasonably close across approaches, that may provide additional confidence in the estimates (validity check). It is also possible that different approaches may be used to address different ranges of water level fluctuation or at different points in the analysis.

The recreation economic literature generally suggests a positive relationship between water levels and recreation use and value. In other words, as water levels increase or decrease, so does recreation use and value. However, this relationship typically holds only within an acceptable range of water levels. Water levels above or below the acceptable range lead to reductions in visitation and value as problems associated with safety, access, water quality, site attractiveness, and crowding arise. Obviously, the acceptable range of water levels would vary by reservoir and across activities at each reservoir. Therefore, it is often desirable to estimate impacts separately for each activity and reservoir. Given the concept of an acceptable range is somewhat more subjective for land based activities as compared to water based activities (i.e., facility access and safety issues associated with water based recreation are normally controlled by site managers, whereas aesthetic water level preferences associated with land based recreation may vary across recreators), the impacts to water based activities may be easier to estimate.

Despite that fact that most of the papers reviewed for this study showed a significant positive relationship between reservoir water levels/surface acres and recreation use and value, it should be noted that this relationship did not always hold. In a few cases, no significant relationships were found. It is possible that for certain activities, access may be the primary issue and all water levels within the acceptable range would be equally satisfactory. Therefore, it should be acknowledged that difficulty in finding a relationship between recreation use/value and water levels may simply be due to the lack of such relationship for a particular activity, site, and range of water levels, as opposed to any fault with the selected approach.

Finally, a distinction should be made between drawdown and seasonal fluctuation. A permanent reduction in average water levels or drawdown, while potentially creating adverse recreation effects in the short-run, may be adjusted for in the long-run. Recreation managers could extend water access facilities and replant mud flat zones to compensate for a permanent decline in average water levels. The analyst must therefore take into account the duration of the impact when evaluating effects of a drawdown. Estimates of impact duration could be developed using information regarding the estimated time required to physically make planned site adjustments.

Fluctuation in water levels across the recreation season may be more important to recreators than the extent of the drawdown. Sites characterized by broad fluctuations in water levels may be less attractive to the average recreator since wide water level fluctuations are generally difficult to mitigate. While facilities could be adjusted to be usable across a wider range of water levels (typically at a significant cost), aesthetic values may be permanently reduced given the long-run problems with mud flats and contour discoloration (i.e., reservoir rings). At the very least, such sites would certainly require more effort by the recreator to stay informed of fluctuating water levels from the perspective of trip planning. More frequent access, safety, and aesthetic problems would likely adversely affect visitation and value. While most of the modeling efforts reviewed for this paper simply used an estimate of average or end of month water levels as a site quality variable, several studies also identified significant water level range variables, thereby emphasizing both the drawdown and seasonal fluctuation concepts.

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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