WESTERN REGIONAL RESEARCH PUBLICATION

W-133
BENEFITS AND COSTS OF RESOURCES POLICIES AFFECTING PUBLIC AND PRIVATE LAND

12TH INTERIM REPORT
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INTRODUCTION

This volume contains the proceedings of the 1999 W-133 Western Regional Project Technical Meeting on "Benefits and Costs of Resource Policies Affecting Public and Private Land." Some papers from W-133 members and friends who could not attend the meeting are also included. The meeting took place February 24^{th} - 26^{th} at the Starr Pass Lodge in Tucson, Arizona. Approximately 50 participants attended the 1999 meeting, are listed on the following page, and came from as far away as Oslo, Norway.

The W-133 regional research project was rechartered in October, 1997. The current project objectives encourage members to address problems associated with: 1.) Benefits and Costs of Agro-environmental Policies; 2.) Benefits Transfer for Groundwater Quality Programs; 3.) Valuing Ecosystem Managment of Forests and Watersheds; and 4.) Valuing Changes in Recreational Access.

Experiment station members at most national land-grant academic institutions constitute the official W-133 project participants. North Dakota State, North Carolina State, and the University of Kentucky proposed joining the group at this year's meeting. W-133's list of academic and other "Friends" has grown, and the Universities of New Mexico and Colorado were particularly well represented at the 1999 W-133 Technical Meeting. The meeting also benefitted from the expertise and participation of scientists from many state and federal agencies including California Fish and Game, the U.S. Department of Agriculture's Economic Research and Forest Services, the U.S. Department of Interior's Fish and Wildlife Service, and the Bureau of Reclamation. In addition, a number of representatives from the nation's top environmental and resource consulting firms attended, some presenting papers at this year's meeting.

This volume is organized around the goals and objectives of the project, but organizing the papers is difficult because of overlapping themes. The last section includes papers that are very important to the methodological work done by W-133 participants, but do not exactly fit one of the objectives. -- I apologize for the lack of consistent pagination in this volume.

On A Personal Note... Any meeting or conference is successful (and fun!) only because of its participants, so I would first like to thank all the people who came and participated in 1999 - listed below. I also want to thank Jerry Fletcher for all his help at this meeting and prior to it, and John Loomis who passed on his knowledge of how to get a meeting like this to work, and who continues to have the funniest little comments to lighten the meetings up. I especially thank Paul Jakus, who helped me to organize this conference and have a lot of fun during it and afterward. Finally, I want to thank Nicki Wieseke for all her help in preparing this volume, and Billye French for administrative support on conference matters.

W. Douglass Shaw, Dept. of Applied Economics & Statistics, University of Nevada, Reno.
June, 1999

P.S. P.F. and J.C. - As far as I can tell, that darn scorpion is still dead!

Draft May 4, 1999

The Effect of Fluctuating Water Levels on Reservoir Fishing

by

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Proposed Running Head: Water Levels and Fishing

ABSTRACT: The effect of Tennessee Valley Authority reservoir water levels on recreational fishing is evaluated using a time-series cross-section data set. The data were collected for fishing in East Tennessee during March through August in each of the years 1994-1997. The recreation demand model shows that water levels do not represent a major barrier to participation during the six month period. Water levels do, however, affect the number of trips that anglers take during the season. On average, maintaining TVA lakes at full pool for one additional summer month (i.e., until the end of August) would result in an additional ⅔ trip per angler, or an additional 100,000 reservoir fishing trips per year in the study region. The net benefit to anglers is, on average, about $3.75 per season, or approximately $562,500 in the region.

Draft May 4, 1999

The Effect of Fluctuating Water Levels on Reservoir Fishing

The Tennessee Valley Authority (TVA) system of dams and reservoirs is designed to provide the Tennessee Valley with flood control, navigation along the Tennessee River, power generation, and economic development in the region. Current TVA policy begins lake drawdowns on August 1 of each year to generate electricity and provide downstream flood control. The drawdown date was the result of an intensive review of reservoir operations by TVA in cooperation with local government and business representatives, as well as the general public. TVA personnel have declared the process and its outcome a model of success, and cite its applicability to other water management agencies facing controversy (Ungate 1996).[1]

But the August 1 drawdown remains controversial, especially among users of tributary lakes at the upper end of the Tennessee Valley watershed. These lakes tend to have deeper channels with shallower, high elevation coves. The drawdown leaves many coves and boat ramps at these lakes landlocked for much of the year, or with a long mud-flat eventually leading to water. An extensive number of land parcels are exposed to these mud flats, depressing property values. Recreational users, including anglers, may find access limited or precluded through the drawdown. A recent study found that delaying drawdown until October 1 on two major tributary lakes could have an economic impact to just six surrounding counties as high as $7 million as people increase lake recreation in response to higher water levels (Murray et al. 1998).

The effects of the drawdown policy are likely to differ across recreational activities. While some activities such as swimming are clearly impacted in a negative way, the effect that drawdowns have on sportfishing is in question. Some say that drawdowns help anglers because fish become concentrated in smaller pools of water, improving fishing quality. Others say that access issues are more important because dry boat ramps restrict the ability of reservoir anglers to launch boats, or that the aesthetic impact of a "bathtub ring" around the lake discourages recreational fishing.

A multi-year recreational fishing data set is used to evaluate the response of reservoir anglers to the TVA water management policy. Angler response is modeled with a combined multinomial site choice/double-hurdle (MNL-DH) count data trips model, following Shaw and Jakus (1997). The MNL-DH modeling strategy allows us to model the effect of water levels not only on site choice (which reservoir to fish), but also on the "desire" to fish in reservoirs, where water levels may represent a site-quality hurdle. We also provide estimates of the benefits to anglers under alternative water level policies.

The Advantage of a Double Hurdle Approach[2]

The MNL-DH model allows us to separate the sample of anglers into three groups. The first group is composed of reservoir users, those who actually fish in reservoirs of the TVA system. The second group is potential reservoir users, those who fish other types of water bodies but would consider fishing in reservoirs under circumstances favorable to them. These people might wish to fish in reservoirs but face a hurdle that prevents reservoir fishing, e.g., a site-quality hurdle caused by inadequate water levels which may limit access or increased the chance that a boat may strike a submerged object. The final group is composed of those anglers who would rarely, if ever, consider fishing in reservoirs (e.g., the die-hard fly-fisherman), and they never get over this "participation" hurdle. The first hurdle is fundamentally economic: if site quality improves enough the consumer will move from a corner solution (no trips) to an interior solution (non-zero trips). The second hurdle is fundamentally non-economic: the feasible set of policy relevant price/quality combinations is very unlikely to move the consumer from a corner to an interior solution.

The key advantage of the MNL-DH modeling strategy is that one can specify different data generating mechanisms for the different hurdles that define each group. The probability of observing zero trips for any observation is composed of two parts: the probability that desired consumption is zero (the participation hurdle) plus the probability that desired consumption is positive, but another hurdle prevents consumption (the site-quality hurdle). Following Shonkwiler and Shaw (1996), let D_i represent the latent decision by person i to participate in reservoir fishing, with observed trips $y_i = 0$ if $D_i \leq 0$. Let Prob($D_i = 0$) = $1-\Phi(Z_i'\gamma)$ describe the probability of observing zero trips, where Z_i is a vector of factors influencing the participation hurdle. Z_i can include individual specific variables such as demographics, so that $\Phi(Z_i'\gamma)$, the cumulative normal distribution evaluated at $Z_i'\gamma$, is the probability that a person wishes to make a reservoir fishing trip. Additionally, let λ_i be the Poisson parameter describing the number of reservoir fishing trips, where $\lambda_i = \exp(X_i'\beta)$ where the X_i are variables that influence the trip making process. The probability that any observation i is a non-user with little or no interest in reservoir fishing is $1-\Phi(Z_i'\gamma)$, whereas the probability of a corner solution (potential user) is given by $[\Phi(Z_i'\gamma)]\times\exp(-\lambda_i)$. This second probability is simply the product of the probability of clearing the participation hurdle and the probability that desired trips is zero (perhaps because of site quality reasons). Finally, the probability that observation *i* is a reservoir user (clearing both hurdles) is given by $[\Phi(Z_i'\gamma)]\times[1-\exp(-\lambda_i)]$.

Combining a multinomial logit site choice model with a double-hurdle count data model allows us to gauge the influence of water levels not only on site choice, but also on participation in reservoir fishing. To see this, recall that in linked site choice/trips models some form of the inclusive value, the summary measuring capturing all characteristics of all sites, is passed on to the trips portion of the model. The inclusive value is part of the X_i vector, and is an argument of λ_i.[3] With site water levels appearing in the MNL site choice model, it is easy to gauge the impact of water levels on potential users by calculating the probabilities described above.

Study Area and Data Sources

The study area consists of a set of thirteen reservoirs located in a 35 county region of East Tennessee. Nearly all of the reservoirs are located adjacent to an Interstate highway and stretch along a corridor from Bristol, TN to Chattanooga, TN. The reservoirs in the northeast portion of the study area are tributary reservoirs subject to relatively large drawdowns in the fall; the most popular tributary reservoirs are Cherokee, Douglas, and Norris reservoirs. Water levels on Norris Lake, for example, range from a March 1 elevation of 995 feet, to a peak elevation of 1023 feet about June 1 (Figure 1). Douglas receives 750,000 visitor-days per year, Cherokee 950,000 visitor-days, and over 2 million visitor-days per year at Norris (Murray et al. 1998).

Recreational fishing data were collected between 1994 and 1997, a four year period. A random digit dial survey was used in each year to contact and identify people who fished in Tennessee.[4] Once identified, anglers were asked about all fishing activities during the six month time period (March 1 through August 31) immediately preceding the survey. We did not contact the same anglers each year, so we do not have a panel data set; rather, we have four different cross-sectional data sets. The final data set is composed of 977 East Tennessee anglers from whom complete trip and income data were obtained.[5] Not all anglers fished in reservoirs during the six month period; they could have fished in private ponds, trout streams, or warmwater streams.

Daily water level information for each lake were obtained from the Tennessee Valley Authority. The four year time period showed considerable variation in water levels for the tributary lakes. Figure 1 shows the daily elevations for a typical tributary lake, Norris Lake, located about 30 miles north of Knoxville, TN. The figure shows that 1996 and 1997 were relatively "normal" years as the reservoir filled during the spring, but in 1994 the lake filled very rapidly while in 1995 the lake filled very slowly. In 1994 and 1996 "full pool" was reached around May 15, whereas in 1995 and 1997 full pool was reached on roughly June 1. On August 1, TVA's policy of maintaining a full pool expires, and the agency begins unrestricted lake drawdown. Relative to the 1996 drawdown, the lake was drawn down swiftly in 1995 and 1997, while in 1994 it remained near full pool. The seasonal pattern of water levels on Norris was similar to that experienced by the other two major tributary reservoirs (Douglas and Cherokee). For contrast, Figure 2 shows the change in elevation for a typical "run-of-the-river" reservoir

(Fort Loudon, located in Knoxville) not subject to large drawdowns. None of the downstream reservoirs are subject to large drawdowns (on average, about 4 to 6 feet elevation change).[6]

Water level data augments the recreation data for each year and, by "stacking" the data for all years, the variation in water level across years can be exploited to identify the effect of water levels on fishing participation and reservoir choice. The data must capture both the "fill" rate and the "drawdown" rate for each reservoir, so the periods April 15 through May 15 (fill) and August 1 through August 31 (drawdown) were chosen. For each time period in each year the average daily water elevation was calculated. The water level characteristic for each reservoir was calculated as deviations from the 1996 "base" year. Water levels above those in 1996 were measured as positive values whereas levels that were lower than 1996 had negative values.

Empirical Results

The full sample consisted of 977 East Tennessee anglers, of whom 55.2% were reservoir users. Simple statistics from the recreational data indicate that water levels may be important to anglers. During the high pool water year in 1994, over 62% of anglers fished in reservoirs, whereas during the low pool water year of 1995 fewer than 50% of anglers fished in reservoirs (Table 1). This is evidence that water levels may be part of a significant site quality hurdle as suggested by Cameron et al. (1996). Further, the average number of trips by reservoir anglers was lowest in 1995 and highest in 1994.

Site Choice Portion. As noted above, water levels during two time periods, April 15 through May 15 and August 1 through August 31, were used to characterize the spring "fill" and late summer "drawdown" phases of this reservoir characteristic. Other reservoir characteristics included travel cost, the number of boat ramps at each reservoir, and the average catch rate (summed over all species and averaged across anglers).[7] A dummy variable indicating the presence/absence of a fish consumption advisory was the final reservoir characteristic.[8]

All variables in the site choice portion of the model had the expected sign and were statistically significant (Table 2). Rising travel costs made a site less likely to be visited (the negative sign); more boat ramps–a measure of site access–made a site more likely to be visited (a positive sign); higher catch rates made a site more likely to be visited (a positive sign); a fish consumption advisory made a site less likely to be visited (negative sign).

Focusing now on the role of water levels in site choice, a positive coefficient means that a site is less likely to be visited when water levels are below 1996 levels, whereas a negative coefficient means a site is more likely to be visited if water levels are below 1996 levels. The site choice model shows that low water levels in the late summer negatively impact site choice: relative to the 1996 water levels, low water made a site is less likely to be visited whereas higher water levels made a site more likely to be visited. The coefficient for spring water levels was negative, but was not significant at conventional significance levels.

Trip Frequency/Participation Portions. The information contained in the site-choice model is passed to the trip frequency model via the inclusive value. The inclusive value contains both economic information (the effect of travel cost) and site quality information (e.g., the effect of water levels). The sign of the inclusive value is positive, as expected, and is statistically significant. Trip frequency also increases as income increases. In the participation portion of the model, anglers who fish waters other than reservoirs were less likely to participate in reservoir fishing. College educated anglers are more likely to fish reservoirs relative to anglers with a high school education or less. Anglers who were nonwhite were less likely to fish reservoirs than white anglers. Residence in an urbanized county was statistically insignificant, indicating that participation in reservoir fishing was independent of the angler's residence.

Evaluating Baseline and Alternative Water Level Scenarios

Two alternative water level scenarios were considered in comparison to a "baseline". The baseline is the historically experienced water level in the sample. The first alternative scenario assumes that the August water levels experienced in 1996 were standard and held in the spring/summer season of each year contained in the sample period. The water levels in 1996 represent a relatively slow drawdown through the month of August. The second alternative is that advocated by local lake user groups: maintain a full pool through the end of August. The full pool scenario is reasonably close to the water level experienced in 1994, so that neither policy alternative would result in a site quality characteristic level that is outside what respondents' have already experienced.[9]

Water Levels as a Site Quality Hurdle. In the MNL-DH model the influence of water levels on participation is captured in the inclusive value index passed from the site choice portion to the hurdle portion. Following the formulas presented in the methodology section, the probability of any angler being a user (someone who fished in a reservoir), a nonuser (someone who would not fish reservoir regardless of the water level) and a potential user (someone who would fish reservoirs if water levels were high enough) were calculated (Table 3). It is also possible to calculate the expected number of reservoir fishing trips.

Under all policy scenarios the probability of being a nonuser is constant because the inclusive value index does not enter this hurdle. The mean probability of being a nonuser was constant at just over 44.7 percent. The other two probabilities–being a user or a potential user–do change as alternative policies change. Under the baseline (actual) policy, the mean probability of being a user is just under 55.3 percent, while the mean probability of being a potential user is very small (5.9×10^{-5} percent). The mean expected number of reservoir fishing trips, conditional on being a user, is 14.61, while the unconditional estimate of mean trips is 8.15.

As water levels are raised under the alternative policies, the probability of being a user rises while the probability of being a potential user falls. The change is quite small: for the change from baseline scenario to the full pool scenario the probabilities change by only 2.0×10^{-5} percent. Additional water in August does not appear to draw anglers from a corner solution (no reservoir fishing) to an interior solution (making at least one trip), suggesting that August water levels are not a major hurdle for potential reservoir anglers. This makes some intuitive sense in that lakes are at full pool from roughly late May through July 31. If water levels were a "make or break" site characteristic reservoir anglers would choose to fish during this portion of the season.

Just because water levels were not a major *hurdle*, however, does not mean that levels were unimportant. Water levels had a large impact on the estimated number of reservoir fishing trips. The mean number of fishing trips, conditional on being a reservoir user, is 14.73 for the 1996 scenario and 15.27 for the full pool scenario. Thus, the full pool proposal put forth by advocacy groups within the study area would result in, on average, an additional ⅔ trip per season per reservoir angler. Given that approximately 150,000 people in the study region fish in reservoirs, this means that maintaining full pool through August 31 would result in an additional 100,000 fishing trips.

Willingness to Pay for Alternative Policies. Willingness to pay measures were calculated for each of the alternative policy scenarios for the linked site choice/trips MNL-DH model. For the "1996" policy the seasonal WTP measure was $0.64, with a 95% confidence interval (CI) between $0.04 and $1.30. For the full pool scenario the mean seasonal WTP was $3.75 (with 95% CI $0.07 - $8.46). With 150,000 reservoir anglers in the East Tennessee study region, the aggregate benefit of a full pool policy would be approximately $562,500.

The estimated welfare change is similar to recent study of anglers in Nevada, but is still relatively small in comparison to most of the past literature. Shaw et al. (1999) studied a Nevada lake that had been drained in 1992, killing all the fish. Their model found an aggregate benefit to anglers of $100,000 to have maintained the "average" minimum pool in 1992 rather than having the lake drained (a per trip measure could not be calculated). Cordell and Bergstrom (1993) estimated the aggregate benefit for a policy holding four TVA lakes in North Carolina at full pool for one additional month as $5.1 million. The Cordell and Bergstrom estimate is about nine times as large as the estimate for the Tennessee lakes, but also includes benefits accruing to recreationists other than anglers (i.e., campers, hikers, picnickers, etc.). Fadali and Shaw (1998) estimated the benefit for keeping a volume of water sufficient to avoid fish kill at a remote Nevada lake with few substitutes. The per trip benefit was just under $30, with an aggregate benefit of $4.2 million. The range of benefits for maintaining water levels in lakes is clearly quite wide; the estimate from this study is within this range, though at the smaller end of the scale. Our estimate of aggrgegate benefits, however, may be somewhat understated because TVA does not maintain a "standard" policy for post-August 1 drawdowns. An established, predictable drawdown policy might yield surplus gains in excess of this amount if anglers, especially out-of-state anglers with little access to lake-level information, could rely upon a full pool until August 31.

Conclusions

The MNL-DH model indicates that lake water levels in the month of August are important to anglers. August water levels do not appear to act as a hurdle to participation (anglers will fish in reservoirs before the August drawdown), but water levels do affect the number of trips that anglers make. Assuming the full pool scenario advocated by local lake user groups is adopted, anglers would make an extra 100,000 trips per season. The aggregate consumer surplus of this policy is approximately $562,500.

Economic development is a primary goal of TVA, and development could be stimulated by the additional 100,000 fishing trips a full pool policy would spur. But a water management agency such as TVA is often faced with multiple and, sometimes, conflicting objectives. TVA, for example, is also responsible for providing flood control, downstream navigation, and hydroelectric power. A full pool policy can stimulate economic development, but may also engender costs associated with increased risk of flooding, increased risk of barge accidents if downstream channels are shallower, and decreased power generation. Future research would evaluate the full pool policy against costs of not meeting these additional objectives.

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Table 1. Angler Visitation to Tributary Reservoirs, by Year

Year	% of Anglers Visiting Reservoirs	Average # of Visits to All Reservoirs
1994	62.3%	16.40
1995	49.6%	12.90
1996	54.0%	15.32
1997	55.2%	14.72

Table 2: Combined Site Choice/Trips Model for Reservoir Fishing

Variable	
Site Choice Portion	
Travel Cost	-0.04* (-9.13)
# Boat Ramps	0.03* (6.92)
Fish Consumption Advisory	-0.34* (-2.61)
Catch Rate	0.10* (3.04)
August Water Level Dev.	0.07* (2.02)
4/15 - 5/15 Water Level Dev.	-0.05 (-1.53)
Trip Frequency Portion	
Intercept	2.17* (9.01)
Inclusive Value	0.18** (1.76)
Income ($1000)	0.005* (1.99)
Participation Portion	
Intercept	1.22* (11.92)
Fish Other Waters	-1.17* (-14.03)
College Education	0.32* (2.78)
Nonwhite	-0.30** (-1.70)
Live in Urbanized County	0.09 (1.41)
# Observations	977

[a] Number in parentheses is the ratio of a coefficient to its asymptotic standard error. Standard errors determined using White's general covariance matrix.

* = significant at α=0.05
** = significant at α=0.10

Table 3: Evaluating Water Levels as a Hurdle: Mean Probabilities for the Sample

	Baseline	1996 Standard	Full Pool through 8/31
P(Nonuser) = $1 - \Phi(Z'\gamma)$	0.44700502	0.44700502	0.44700502
P(Potential User) = $\Phi(Z'\gamma) \times \exp(-\lambda)$	5.9×10^{-7}	5.5×10^{-7}	3.9×10^{-7}
P(User) = $\Phi(Z'\gamma) \times [1 - \exp(-\lambda)]$	0.55299439	0.55299443	0.55299459
E(Trips|Trips>0)	14.61	14.73	15.27
E(Trips)	8.15	8.22	8.51

Table 4: Mean WTP for Water Level Scenarios

	1996 "Standard" Drawdown	Full Pool through August 31
Site Choice/Trips Model		
Mean WTP	\$0.64 (\$0.04 - \$1.30)	\$3.75 (\$0.07 - \$8.46)
Mean Δ E(Trips|Trips>0)	0.12	0.66

[a] 95% CI calculated by Krinsky-Robb method.

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Figure 1.

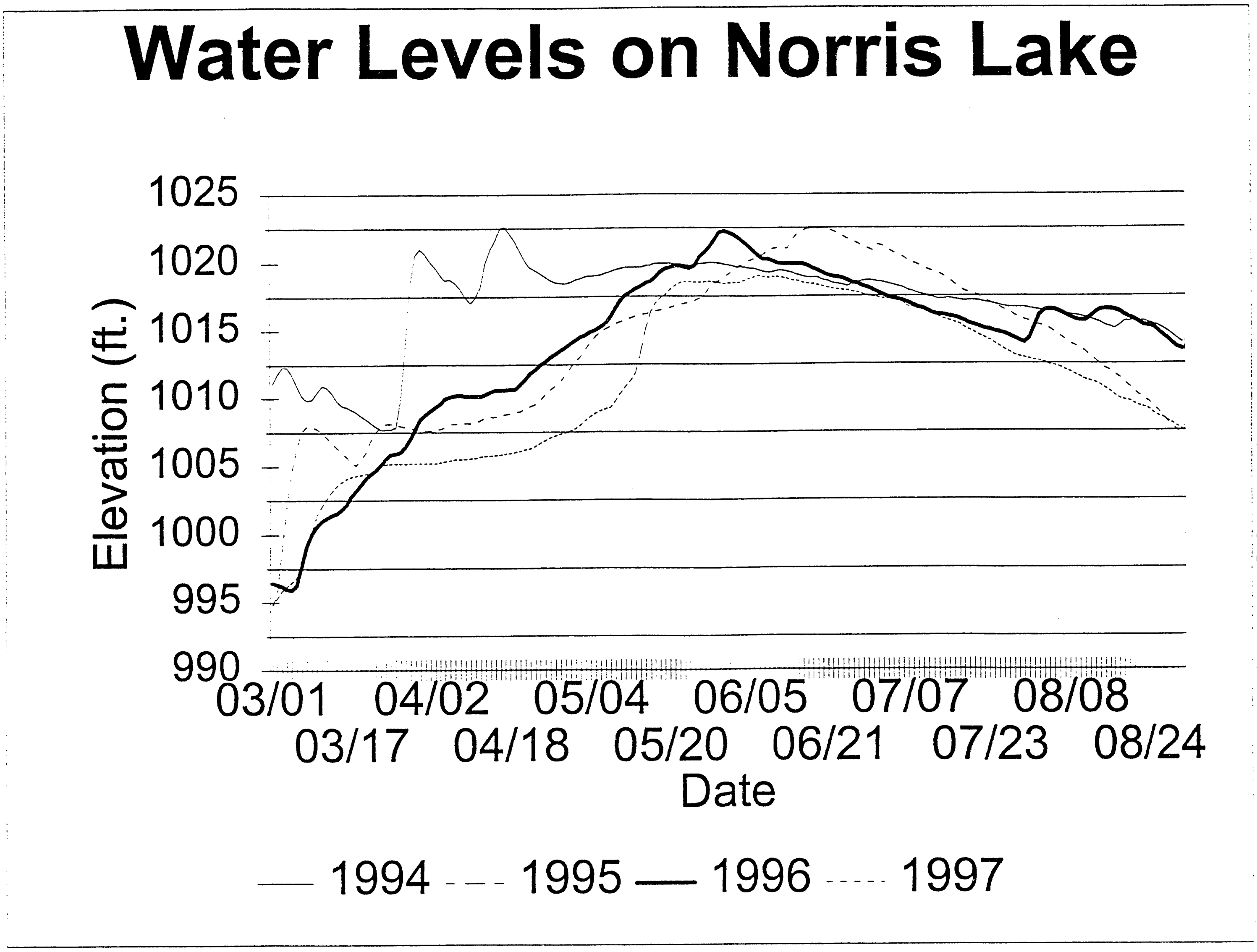

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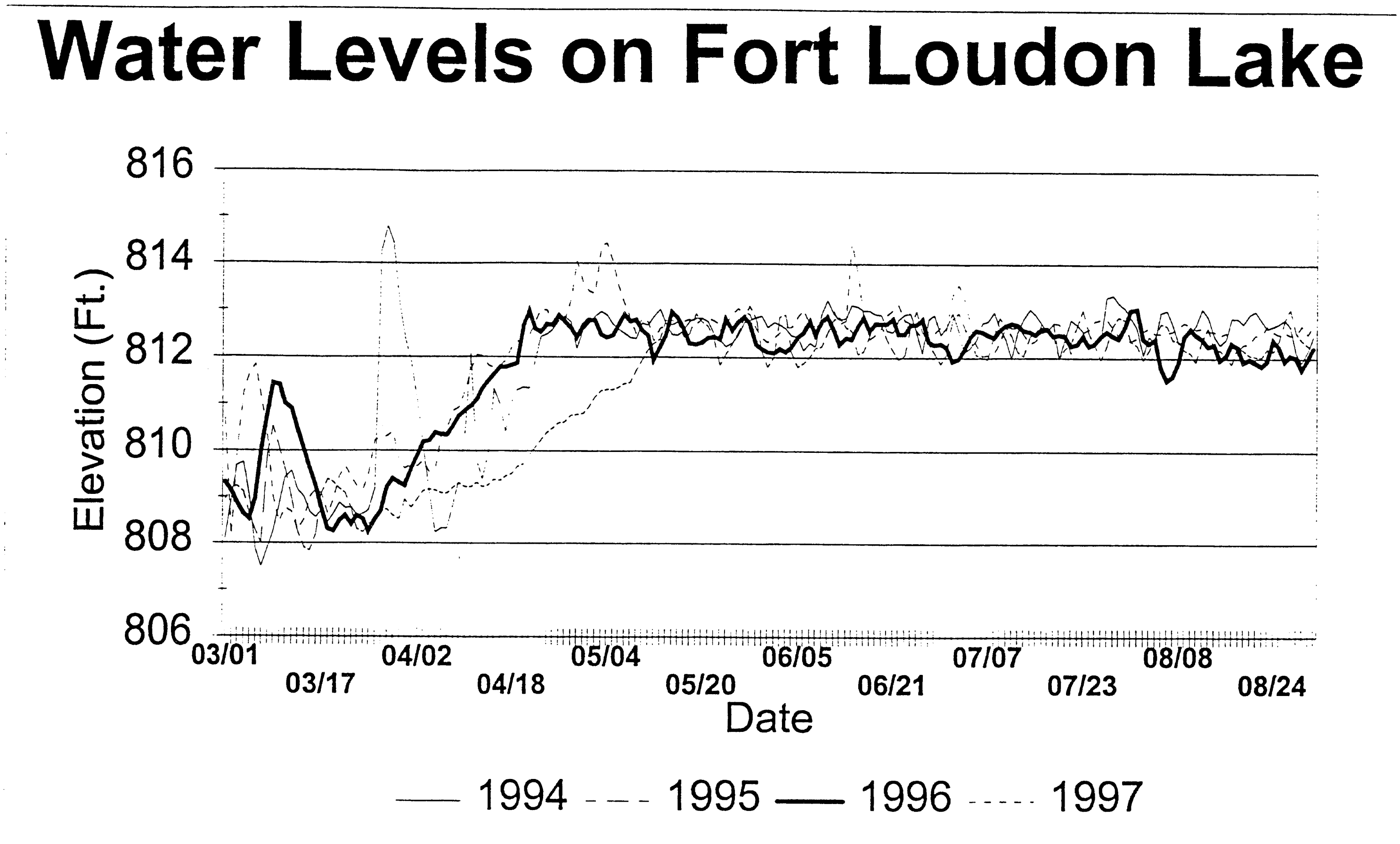
Figure 2.



ENDNOTES

1. Controversy over reservoir drawdown policies is not new or unique to TVA, and a small economic literature addressing the issue has developed. A sampling of recent literature includes Ward (1989) who estimated a four reservoir demand system to gauge the economic losses of draining three reservoirs in New Mexico. Cordell and Bergstrom (1993) used contingent valuation methods to estimate the impact of TVA drawdown policies on four TVA lakes in North Carolina. Cameron et al. (1996) examined recreationists' actual behavior in the Columbia River Basin in the Pacific Northwest, finding that low water levels affected the decision to recreate at all, as opposed to affecting the number of times a lake was visited. Ward et al. (1997) used a CES demand system to evaluate various water level policies at New Mexico reservoirs. Fadali and Shaw (1998) looked at a remote lake in Central Nevada, using a nested logit model to estimate anglers' WTP to prevent water volume losses that would cause the fishery ecosytem system to collapse. Shaw et al. (1999) estimated angler losses of a fish kill that resulted from draining a lake in Northern Nevada.

2. This section draws heavily upon Shonkwiler and Shaw (1996), who provide a very lucid development of the double hurdle count data model, which can be extended to a mix of discrete and continuous distribution functions. Yen and Adamowicz (1994) and Haab and McConnell (1996) also present hurdle count data models.

3. The inclusive value is calculated as $IV = \ln [\Sigma_j^J \exp(W_j'\tau) + 0.577]$, where W_j is a vector of characteristics of site j, τ is the coefficient vector, and the summation is over all J sites. Whether or not the inclusive value is the appropriate index to pass from the site choice model to the trips model is the subject of current research. Shaw and Shonkwiler (1999) argue that the inclusive value is not utility theoretic and propose an alternative aggregate demand measure and an alternative price index. They do not, however, propose a quality index.

4. Details about each survey are available upon request.

5. The sample was relatively uniform in its composition between the different years: 25.3%, 26.7%, 25.4%, and 22.6% from 1994, 1995, 1996, and 1997 respectively.

6. The exception is Hiwasee Reservoir in the southwestern mountains of North Carolina, about 1 hour east of Chattanooga. While this lake is included in the study as an important potential substitute site, it receives only 1.5% of all trips made by East Tennessee reservoir anglers.

7. The catch rate measure used in this study results in the errors-in-variables problem recently highlighted by Morey and Waldman (1998). The solution proposed by these authors does solve this problem, but Train et al. (1998) demonstrate that the Morey-Waldman solution only works when there are no omitted site attributes, measurement error in other variables or

"other random events". If these problems cannot be eliminated, then the Morey-Waldman method introduces correlation between the residuals and the catch rate coefficient. In effect, the analyst trades one type of bias for another. Train et al. conclude that the standard procedure "...is consistent under weaker and more realistic assumptions...". The standard procedure is adopted for our study.

8. See Jakus et al. (1997) and Jakus, Dadakas, and Fly (1998) for other reservoir fishing models that have included fish consumption advisories as a site characteristic.

9. This problem is why Cameron et al. (1996) and Cordell and Bergstrom (1993) had to use hypothetical valuation methods to augment their actual behavior models.