CAN RECREATION VALUES FOR A LAKE CONSTITUTE A MARKET FOR BANKED AGRICULTURAL WATER?

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This paper presents estimates of the recreational use value to prevent the loss of a western lake threatened by diversions of upstream waters that supply it. The recreation demand model used to estimate recreation-related values is the popular repeated nested multinomial logit model. The model is specified to allow an individual to choose when to visit various sites during the season, because site choice is likely to be influenced by water levels that change over the course of the season. The values are compared to agricultural values in order to assess whether the potential recreation demand side of a market for a water bank exists. (*JEL* C25, D61, Q25)

I. INTRODUCTION

Nevada is the driest state in the union and is full of complex water allocation issues. Water allocation issues are associated with all five large lakes in Nevada. This research focuses on one of Nevada's four terminus lakes, Walker Lake, which often is thought to be dying, having lost approximately 130 feet, or about 75%, of its volume since 1880. (Walker River, which feeds Walker Lake, has its headwaters in California.) Upstream diversions by agricultural users are usually blamed for this decline, which has increased total dissolved solids (TDS), increasing the likelihood that the threatened Lahontan Cutthroat Trout, the lake's primary sportfish, and also the Tui Chub, a fish that these trout feed on, will become extinct in Walker Lake (Brussard et al. 1995). The loss of these species likely would lead to the loss of the Walker Lake fishery and all fishery related recreation.

As a possible way to halt the decline of Walker Lake as well as to address other important allocation issues, several parties in Nevada and California have begun discussing the potential for a regional or Nevada State water bank. While such banks are in operation in Idaho, California, Texas and some other states, there is no such institution in Nevada (see Loomis 1992 for a discussion of the California bank; MacDonnell et al., 1994, discuss water banks all over the United States). Fisheries and associated recreation have been important issues relating to development of these other water banks. In Idaho, water was purchased by the Idaho Power Company to augment flows during salmon migration. The Central Valley Improvement Act (California) authorizes a wide array of methods to fund and secure water for fish and wildlife purposes. Among these are a surcharge on water sold to users outside the Central Valley Project and state commitments to buy or lease water rights for wildlife refuges (Loomis, 1994).

While the jury is not in on the overall success of existing water banks, water banking provides an opportunity for enhancement of recreation and wildlife. In this paper, a model of recreation choice demand is developed and estimated, revealing the recreation values for

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enhancing water levels at Walker Lake. This was done as part of a larger project to determine whether recreators' use values for water would make water banking as a method of improving fish habitat and water levels feasible (see Fadali 1997; Fadali, et al., 1998).

The recreation demand model results presented in this paper are based on the repeated nested multinomial logit (MNL) specification. The nested MNL is a popular specification for recreation demand models (Kling and Herriges, 1995; Kling and Thomson, 1996; Kaoru, 1995; Kaoru et al., 1995), and the repeated version of it (which includes the option to not participate in recreation) is also used widely (see Montgomery and Needelman, 1997; Morey, 1998; Parsons and Needelman, 1992; Needelman and Kealy, 1995; Lupi et al., 1997; or Shaw and Ozog, 1998). Welfare measures for changes in conditions at Walker Lake are derived using a repeated MNL model. The computed recreation values are compared to agricultural values to assess whether a rental market for agricultural water exists in the region being considered.

II. AGRICULTURAL VALUES FOR WATER

The analysis begins with a simple examination of agriculture's supply of water. First, assume that the opportunity cost of agricultural water in the Walker River Basin is only determined by competing agricultural uses. This is a reasonable assumption if water is limited to uses within the basin, as there are few competing urban or industrial uses, and water cannot currently be transported outside the basin. It cannot reasonably be assumed that Walker River water can fetch a Reno urban area sales price of around \$3,000 per acre foot, a value some in Nevada suggest is appropriate (Bremmer, 1998). (Urban values of water are high, and this leads people in rural areas to fear that they will eventually lose rural water supplies to cities such as Las Vegas.)

The seller's problem is to maximize the expected value of net income with the option of a short-term sale to the bank, versus using water for crop production (e.g., Howe, 1990). Other literature suggests that water's value per acre foot in the production of crops or livestock can, in theory, be determined in a variety of ways (see Schaible, 1997, for a good review of many sources and his interregional model; see Loomis, 1994, for a discussion of agricultural values). While one or more of these valuation methods has been applied in many states, to our knowledge they have not been recently applied to estimate water's value in agricultural production in Nevada.

Because no estimates of shadow prices for water are available for Nevada or this region, prices of water rental in existing water banks are examined for clues as to water's value to agricultural producers in general. Estimates of the value of an acre foot (a.f.) of water from Walker River Basin (WRB) real estate transactions also are reviewed to shed light on the range of prices that might be charged to purchasers of banked water (perhaps local recreators) in the WRB.

When the California water bank was started in response to a drought emergency in 1991, water was purchased (rented for that year only) from farmers by the State for \$125/a.f. The state then sold the banked water for \$175/a.f. (Water purchased by the state in the less dire water supply conditions in 1992 was purchased at only \$50/a.f.) This \$175/a.f. purchase price was established because \$125/a.f. was thought to be slightly more than the shadow price for water used to grow crops such as corn, wheat, pasture and sugar beets (Loomis 1992; MacDonnell et al., 1994). However, the \$125/a.f. purchase price was based on foregone annual income for farmers who fallowed corn, wheat and sugar beats—higher valued crops than the alfalfa and hay grown in the WRB. Growers in the Walker River Basin primarily produce three commodities: livestock near the headwaters, small amounts of high valued garlic and onions, and hay or alfalfa. In the rural areas in the WRB, water can be purchased in total (not annually) for an average of approximately \$250 to \$500/a.f.—well below the urban purchase price mentioned above. Using a simple annuity relationship, the implied annual value of water per a.f. is in the \$12–\$45 range. To be conservative in assessing water bank potential, this lower range of agricultural values will be used in the policy section of the analysis below. This is a plausible number, as water in the WRB now is likely worth less than in California in drought years, and it meshes well with the \$50 price the California water bank used in less dire years.

III. THE RECREATION MODEL

The repeated nested multinomial logit (MNL) recreation demand model is well grounded in consumer theory. The "repeated" model assumes that an individual makes decisions independently on each "choice occasion." The model predicts trips taken in each of three "seasons," so it also must be assumed that all decisions are made at the beginning of the year so that all three seasons are available and so that a recreator may substitute between seasons. The repeated nested MNL is estimated for five alternative lakes in the region (note that one site is Walker Lake and two reservoirs are combined because they are close together), with a trip occurring in any of three seasons. Most recreation demand models estimated prior to this do not account for when the individual takes a trip—only where the trip is taken (one exception is in Cameron et al. 1996, but they model each month's trips separately from all other months. Creel and Loomis 1992 and others also allow trips to be taken in separate months, but they do not introduce a structure like ours (see also, Loomis and Creel 1992).

For our nest there are two levels: (1) whether the individual participates or not and (2) if a trip is taken, 15 choices among the five sites (including Walker Lake) and three seasons in which the trip occurs: January to April, May to August, and the remaining months. All of these decisions are assumed to be made simultaneously, not in any chronological order. Finally, unlike some models estimated using sequential estimation in a two step procedure (e.g., Parsons and Needelman, 1992; Needelman and Kealy, 1995; or Montgomery and Needelman, 1997), the model is estimated using full information maximum likelihood, which avoids inefficiency.

The specification of the model depends on the following variables: the individual's travel cost to and from the lakes, the air temperature at the site/season, and the percent deviation of the volume at each lake from the maximum volume of that lake in 1996 for each season. Travel cost is calculated using round trip distance multiplied by the State of Nevada mileage reimbursement rate for 1996 of $0.31. (The individual's opportunity cost of time is not included as there is only poor data available for this purpose, and this omission may bias the values downwards.) Air temperature is average daily air temperature at the nearest weather gauging station, averaged over the season. The water quantity variable also is based on a seasonal average for each site. The water deviation is entered as zero for the season in which the maximum occurs, or as a positive number, as lake volume at all five sites went down from the maximum during these other seasons.

Some specific constant term variables for certain lakes and seasons also are introduced into the model specification. For example, in recent years, including the years in which the data were collected, a fishing derby was held at Walker Lake at a certain time of the year. Therefore, a constant term for the probability equation for choosing a first season (January–April) trip to Walker Lake is used, as that is the period during which the derby was held.

A. *Welfare Measures*

The welfare or consumer's surplus measures for the random utility models would be the exact Hicksian measures, the compensating and equivalent variation (CV and EV), but in the absence of income effects they can be interpreted as Marshallian measures, as the CV is equal to the EV. The assumption of no income effects is made to allow a closed form expression for the CV. This allows a straightforward calculation of the CV for changes in a site characteristic, or for price (travel cost) changes. It is possible to simulate the elimination of a site by letting the site price go to infinity, which, as illustrated by Montgomery and Needelman (1997), forces the probability of a visit to zero. This gives a standard choke-price welfare calculation and may have some real meaning for Walker Lake if it were to dry up or otherwise become unusable for recreation.

The resulting welfare measures from the repeated MNL are utility-theoretic and allow derivation of annual welfare measures. The repeated model yields a welfare measure per choice occasion, and by multiplying by the number of choice occasions in the year, one obtains the annual welfare measure (for example and discussion, see Tomasi and Lupi, 1997).

IV. THE DATA

In this section we discuss the data, paying particular attention to how our sample may differ from a larger population of recreators. The final sample of recreators used for estimation of the recreation demand model includes 573 individuals from a slightly larger sample of 858 respondents. The sample from which these individuals are drawn comes from two sources. The sources are generated from a sampling strategy developed to maximize the number of potential recreators for the analysis based on an extremely small sampling budget (for an example in marked contrast in this regard, see Lupi et al., 1997). The first sample source is from an intercept survey of recreators conducted at several regional waters (including the five lakes we analyze below, Donner Lake, Bridgeport, Twin Lakes, and the Truckee, Carson and Walker Rivers) in the summers of 1995 and 1996. During primary contact the recreator was asked if he or she would be willing to be part of the mail survey. Approximately 800 recreators agreed to be part of the study. The second sample source is a mailing list of individuals who participated in a Walker Lake fishing derby sometime during the past five years. About 1,200 names were on the original list of derby participants, who may go to the lake to try to catch a particular tagged fish each year and win a cash prize for so doing.

The combined total initial group was sent a mail survey questionnaire between November 1995 and March 1996. The mail survey was implemented using some of the guidelines suggested by Dillman (1978), but the budget for this project precluded extensive efforts to obtain a return from those who failed to respond. Approximately 44% of the questionnaires were returned, after subtracting those surveys that were returned because of bad addresses.

The mail survey asked participants to record all 1996 trips taken to regional waters and the months the trips were taken. While data on trips to rivers in the region are available, the demand for rivers is not explicitly modeled due to difficulties in obtaining accurate trip information about the river destinations (for example, many respondents did not identify the closest landmark to the point of the river they visited). However, the nonparticipation alternative in the model could be interpreted to include visiting a river or other regional lake or reservoir during a choice occasion. The five lakes examined for the analysis are Walker Lake, Lahontan Reservoir, Topaz Reservoir, Pyramid Lake, and Boca/Stampede Reservoir (the combined site). There are many more lakes in the region, but the five lakes are chosen because they are similar in the kind of recreation opportunities offered, and geographically positioned so that each could easily be visited on a given trip taken by people who live in the area.

Walker, Pyramid, and Lahontan are located in Nevada, while Boca/Stampede is located in California and Topaz Reservoir is split between the two states. Pyramid and Walker are both natural terminal desert lakes much larger than the other sites, and both offer good winter season fishing. Because of their size, Pyramid and Walker Lake water levels in any one year do not change as dramatically in percentage terms as can be observed at the reservoirs, but both lakes have exhibited a very large decrease in volume over a long time period. Lahontan, Topaz and Boca/Stampede are all reservoirs subject to large variations in water level. Finally, the Walker River feeds Topaz and Walker, while Pyramid, Lahontan and Boca/Stampede are part of the Truckee and Carson River systems.

After excluding illogical responses and incomplete or unusable trip data, 573 recreators remain in the sample. Of these, 467 recreated at one of our five lakes during the observed period and the other 106 did not. The 573 recreators took, on average, approximately 19 trips to any water body in the region, about 11 to one of the five lakes in our study, and about three trips to Walker Lake.

Several sources of potential bias exist for our sample (see Table 1), as compared to recreators in a broader population. These include endogenous stratification and truncation (see Shaw 1988) for the sample group recruited on-site. Put simply, these respondents do not have a purely random chance of appearing in the sample; rather, they are observed in some relationship to their taking trips to the site where they are intercepted and no one takes zero trips. Endogenous stratification may also pertain to the group drawn from the fishing derby lists. There is also a possible bias for those who volunteered to be in the mail survey analysis and those who returned the survey (Cameron et al., 1996, deal with the problem of correcting recreation mail survey return bias). Because of the potential bias due to avidity, other sources of data on recreation

TABLE 1
Repeated Nested Multinomial Logit Results

Variable	Nested Model Coefficient (White's Standard Error)*
Travel cost	–0.019 (0.002)***
Water value (% deviation from maximum)	–0.023 (0.004)***
Average air temperature	0.014 (0.003)***
Walker/February (Derby) constant term	0.889 (0.131)***
Lahontan Summer constant term	0.092 (0.087)
Constant	3.65 (0.450)***
Gender	–0.365 (0.153)***
Age	0.005 (0.007)
Income (per period)	0.001 (0.0004)**
Nesting parameter	1.85
Log Likelihood	–37185
Number of individuals	(N = 573)

*** Significant at the 1% level. White's standard errors take into account possible specification errors and are thus considered potentially more robust than the uncorrected ones.

** Significant at the 5% level

* White (1982)

are used to help interpret and bolster the estimated results. Some caveats about the applicability of the welfare measures are offered later in the paper.

The main source of alternative data is a telephone survey sample to determine recreation participation in the region. As part of the overall study, but separate from the on-site sampling, a stratified sample of the general population is drawn from listed telephone numbers. Counties surrounding the Walker River Basin were oversampled as compared to other counties in California and Nevada. For estimates in this paper, phone survey data for only nearby Nevada counties is used, which assumes that no visitors came from California or faraway Nevada counties and likely yields a very conservative estimate of total visitation.

About 3,000 telephone calls were made. Of these, 2,082 people agreed to answer our survey questions. Contacts were first asked if they had participated in any water-based recreation in 1996. If they had, they were asked if they had taken trips to waters in our region, and finer detail on these trips was collected (see Fadali et al., 1998, for other details). The most important results from the telephone survey pertain to participation in water-based recreation and avidity. Respondents' other answers are used to make inferences from our sample to a broader population; policy ramifications are discussed in section VI below.

V. ESTIMATED RESULTS

As shown in Table 1, all estimated parameters on the variables used in the specification are significantly different from zero except the summer visit constant for Lahontan Reservoir and the age variable for the nonparticipation alternative. Where our priors were clear as to the direction of influence, the variables have the expected sign. The sign on the water volume deviation could be positive or negative,

TABLE 2
Comparison of Different Mail Survey Groups

Variable	All	On-Site Only (N = 300)	Derby Only (N = 273)
% Male	81%	70%	93%
Age	47	45	48
Education	14	14.7	13.6
Income	$56k	$61k	$51.2k
Average Trips to:			
Five Lakes	11	9.5	13.2
Walker Lake	3	1.6	5
Annual Consumer's Surplus	$83	$35	$188

as there are all sorts of recreational uses indicated as preferences by our sample. For example, those participating in shoreline activities might favor a lower lake volume because more beach is available, while boaters might prefer a higher water volume to ease entry and exit from the lake and to avoid hitting objects in shallow water. The independent variable is the deviation from the maximum, so a negative sign indicates that, overall, the sample has a lower probability of choosing an alternative the larger the deviation from the maximum. In other words, as a group, the sample is likely to prefer higher water.

The nesting parameter must be greater than or equal to one for the model to be consistent with utility maximization (the specification used follows McFadden, 1998). If it is equal to 1 then the nested probability structure collapses to the simple non-nested model. As a Wald's test shows, our parameter is significantly different than one at the 0.10 level—i.e., the nested model is a probably a better fit than the non-nested model (see Kling and Herriges, 1996). The IIA holds for a level of the nest, but not across levels of the nest. Thus, in our model, nesting allows the decision to go or not to go on a given choice occasion to be in one level and the decision to go to one of 15 site/season combinations to be in the second level of the nest. IIA does hold across the 15 site/season combinations but not between the decision not to go and the 15 choices.

The values we report can be interpreted as an average per choice occasion maximum willingness to pay (WTP) to bring about an improvement, or to avoid a degradation in conditions. For the analysis we consider the "elimination" of Walker Lake. The WTP per choice occasion to prevent site elimination is quite small for all five waters, ranging from about 30 to 50 cents. Annual WTP per choice occasion multiplied by the number of choice occasions (165) ranges from about $48 (Boca-Stampede) to about $98 to prevent elimination of Lahontan. On average, the 573 sample recreators are willing to pay about $83 per season to avoid the loss of Walker Lake. For purposes of comparison, we also estimated models and consumer's surplus for two groups separately—the on-site only and fishing derby groups. Table 2 shows that, on average, the derby group has a much higher frequency of trips to Walker Lake and, not surprisingly, a much higher annual value ($188 versus about $35). We next attempt to make inferences from the sample to a population of impacted recreators, and these comparative numbers will be important.

VI. POLICY RELEVANCE

Potentially interested parties in the region are considering the creation of a local water bank. Part of the success for the bank depends on whether a market exists for the water. It is particularly interesting to know if the demand for Walker Lake water for recreational purposes is high enough to justify the purchase of enough water to prevent losing the fishery. As stated earlier, suppliers would likely be upstream agricultural users who can profitably deposit water in a given year without fear of long-run forfeiture. Of course, depositors wish to know their potential net rate of return, given by the difference between the value foregone in some use and the value of the water obtained via the bank's rental/lending price. Suppliers then would logically compare this return to the return from using the water in agriculture, and assumed to be between $12 to $45 per acre-foot per year.

A. *Recreation Analysis*

Walker Lake already is effectively "dead" in some respects well before being completely emptied of water because many recreators visit this site to fish. On-site surveys indicate that about 40% of recreators at Walker Lake go there primarily to fish, and in our small sample of winter season visitors, as many as 85% came primarily to fish. Fishing is impossible when the lake falls below a certain level because the primary sport fish will be unable to survive the salinity levels associated with that level. Anecdotal evidence from focus groups and comments from those participating in the on-site survey indicates that boating and swimming also may be negatively impacted by the salinity of Walker Lake. Another popular activity among our recreators, birdwatching, also is affected by the salinity level. This is because piscivorous birds such as loons, mergansers, pelicans and cormorants who feed at the lake will migrate elsewhere as salinity reduces food (Brussard et al., 1995).

The exact water level that would cause major changes in the ecosystem is difficult to ascertain, but hydrologists and biologists seem to agree that the lake must, at minimum, take in as much water as it currently loses to evaporation—about 140,000 acre feet per year (Thomas, 1995) to prevent loss of the fishery, since effects already occurring in the fish seem to indicate that this threshold is close to being reached at current lake levels. On average, somewhere between 80,000 to 110,000 acre feet reach Walker Lake from rainfall, run-off in high water years, and other sources, but it is not enough, on average, to make up for evaporation losses. This means that approximately 30,000 and 60,000 additional acre feet are needed to prevent the loss of Walker Lake's fishery. Therefore, assume that at least 50,000 additional acre feet need to be purchased annually to prevent further water level declines from the 1996 levels.

The model predicts the annual WTP to prevent elimination of Walker Lake, which we assume corresponds to adding 50,000 acre feet to historical average flows. The welfare measure corresponds to a choke price loss, and to keep the analysis simple, we assume that preventing site elimination corresponds to avoiding annual losses from evaporation. To know whether recreation values are large enough in total to transfer 50,000 acre feet of water from agriculture to the bank, we need to know the number of potentially impacted recreators. First, working from the supply side (50,000/a.f. times $12 to $45 per acre foot), it appears that $0.6 to $2.25 million is needed annually to forestall further declines in lake level.

B. *Adjustments to Values*

Several adjustments should be made to the model estimates. In theory, the model includes individuals who are recreators but who may not have participated in 1996—i.e., inferences cannot be made for nonrecreators but can be made for known recreators who do not necessarily visit Walker Lake. Perhaps the most problematic issue relates to the potentially biased nature of the mail survey sample and the way in which members of the sample were recruited.

On balance, the $83 average annual value is likely inappropriate for all regional recreators who might be potentially impacted by changes at Walker Lake. Recall that the fishing derby group pulls the average value way up (Table 2) and that these individual anglers are likely atypical users of Walker Lake and the five sites, evidenced by their avidity for both. For this reason, the values obtained from the model using only on-site recreator data are used, although the on-site group has a higher frequency of use than the typical recreator does in the telephone survey. The average value for this group may even be large for those who do not visit any of the five waters.

To further address the potential biases in welfare for the on-site/mail survey sample, we appeal to other information, examining descriptive features of our on-site and derby groups of sample recreators and features of other recreators from a variety of sources. We are looking for evidence that our sample is different than the population of recreators in ways that might make their values higher (or lower, for that matter). These features need to be tied to the model. For example, the model predicts that more females and higher income increase the probability of nonparticipation (age does also, but it is not significant in estimation). Our mail survey sample has roughly 75% males, while there is evidence that the population of anglers (16 and older) is closer to 73% male (U.S. Department of Interior, 1996). If the mail survey sample had more females, one might expect slightly less participation at our lakes, which lowers value (cetaris paribus). Similar analysis pertains to income. Finally, the mail survey sample is clearly much more avid than the typical recreator as represented by those in the telephone data, and avidity is thought to increase seasonal values. Note again that the derby group takes more than twice as many trips to Walker Lake as does the on-site group (Columns 3 versus 4 in Table 2).

Nearly 20% of the on-site sample group recreate at Walker Lake, whereas phone survey data estimates indicate that only 11% of the regional recreators from Nevada oversampled counties recreate at Walker Lake. Because of this, the mean WTP to prevent Walker Lake elimination for the Walker Lake recreators in our sample (from the model estimated using on-site only data), or \$147, is used to reflect the value for Walker Lake recreators in the population, and the mean value for sample recreators who did not visit Walker Lake (only \$8) is used to reflect the value for recreators in the population who do not visit Walker Lake. The latter may be appropriate for those who wish to keep their option of choosing Walker Lake open. Using these, findings can be expanded to the general population of recreators.

C. *Extrapolation to Population of Recreators*

Exact estimates of the number of potentially impacted recreators are not easily uncovered. The telephone survey of the stratified regional sample indicates that approximately 185,000 Nevadans from the oversampled areas took at least one water-based recreation trip to a water within our region in 1996 (the oversampled counties included for this estimate are Carson City, Churchill, Douglas, Esmeralda, Lyon, Mineral, Storey, and Washoe counties). This estimate assumes that those who were contacted but who did not wish to participate in the survey were not regional recreators and that no recreators come from California or far away counties in Nevada. An estimated 120,000 recreators visited at one or more of the five sites included in the model. Of these, an estimated 20,000 visited Walker Lake in 1996. Using the values found above and extrapolating to this population, the total annual value for Walker Lake is approximately \$4,000,000. Based on these calculations, which are quite conservative, the demand for Walker Lake recreation water definitely exists, and indeed may be large enough to purchase or rent water rights to save the Lake's fishery.

VII. SUMMARY AND SUGGESTIONS FOR FUTURE RESEARCH

The values reported using our repeated nested multinomial logit model are important for policymakers. The implied value the potentially impacted recreators have for water at Walker Lake may be of interest to agricultural water rights holders who wish to deposit excess water in the bank in a given year. However, much research remains before exact purchase and sales prices can be identified.

Future research topics on water banking include the need to address nonuse values and potential transaction costs between parties interested in exchanging water. Nonuse values have not been addressed in this paper but likely are very important. California's Mono Lake, which has some similarity with Walker Lake, was saved because of concerns that related to individuals' use and non-use values for that lake. Finally, estimates of transaction costs will help in examining ways to eliminate what could be serious free rider problems in developing a functioning water bank and, more simply, will shed light on the practical feasibility of distributing upstream supplies to a variety of possible downstream reservoirs. Loomis (1992) reports that of the \$175 per acre foot sale price in California, only \$5.00 was allocated to cover contract negotiation and administration costs. However, Howe et al. (1990) find that transaction costs for water rights transfers in Colorado depend on the size of the transfer, priority date of the water right being transferred, and the amount of legal opposition. Hopefully, with a bank in place—having been agreed to in principle by those in the community—knowledge of priority water rights will improve in Nevada, and legal opposition will be minimized.

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