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Journal
Journal of California and Great Basin Anthropology, 12(2)

ISSN
0191-3557

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Publication Date
1990-07-01

Peer reviewed

Journal of California and Great Basin Anthropology
Vol. 12, No. 2, pp. 146-157 (1990).

Submerged Tree Stumps as Indicators of Mid-Holocene Aridity in the Lake Tahoe Basin

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THE surface elevation of Lake Tahoe has in the past stood considerably lower than its present level for long periods of time. To support this statement, existing paleoenvironmental evidence and historical documentation of lower lake levels is reviewed. The magnitude of drops in the level of Lake Tahoe is presented in light of new evidence involving (1) a series of radiocarbon dates on tree stumps drowned by the rising waters of Lake Tahoe; and (2) submerged archaeological features in the lake. The implications of the mid-Holocene lowstands of Lake Tahoe are discussed in terms of local and regional paleoclimatic and archaeological trends.

PHYSIOGRAPHY

The Lake Tahoe Basin lies at the head of the Truckee River drainage, a part of the larger Lahontan system which covers a total of 40,700 square miles of the western Great Basin (Fig. 1; Snyder 1917:34). The bathymetry of the Lahontan basin is discussed in Benson and Mifflin (1986). The Lahontan basin consists of several sub-basins separated by sills of varying altitude. A sill is the lowest point on the divide separating adjoining sub-basins. Lakes fed by perennial streams (such as the Truckee River) that are located in large, wide sub-basins (such as those of Lake Tahoe and Pyramid Lake) are good recorders of high-amplitude climatic events, as lakes in these sub-basins rise and fall with changes in climate (Benson and Thompson 1987:70-71). A model chronology presenting fluctuations of Lake Lahontan for the past 50,000 years appears in Benson and Thompson (1987:84).

The Truckee River is "the largest and most important stream of the [Lahontan] system" (Snyder 1917:34). It joins two great lakes, Tahoe and Pyramid, the only lakes within the Lahontan system that did not go dry in Holocene times (Benson and Thompson 1987:80; Miller and Smith 1981). The Truckee River supplies 30% of the discharge to the Pyramid Lake and Winnemucca Dry Lake sub-basins (Benson and Thompson 1987:79). Inflow to Pyramid Lake, other than from the Truckee River, is negligible (Born 1972:45). During times when Lake Tahoe ceases to spill over into the Truckee River, the river's flow is sustained by its major tributaries (Hardman and Reil 1936:26).

Crippen and Pavelka (1972:4-5) summarized the physiography of Lake Tahoe. At an average surface elevation of 6,225 feet, and with an area of 191 square miles, Lake Tahoe is the highest lake of its size in the United States. It is 22 miles long, 12 miles wide, and holds 122 million acre feet of water, enough to cover a plane the size of the state of California to a depth of 14 inches. The lake is the third deepest in North America and the eighth deepest in the world, with a maximum depth of 1,645 feet and an average depth of 1,000 feet. It is fed by about 100 streams, and the Truckee River is its only outlet.

The level of Lake Tahoe is naturally controlled by a narrow sill at Tahoe City, where water spills over into the Truckee

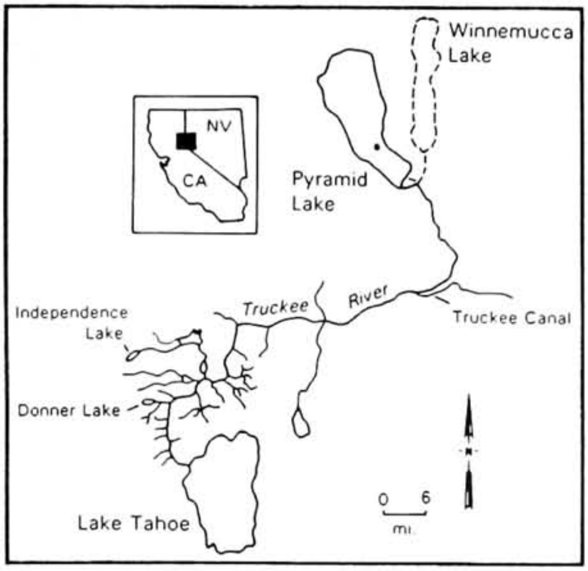

Fig. 1. Lake Tahoe and the Truckee River drainage basin.

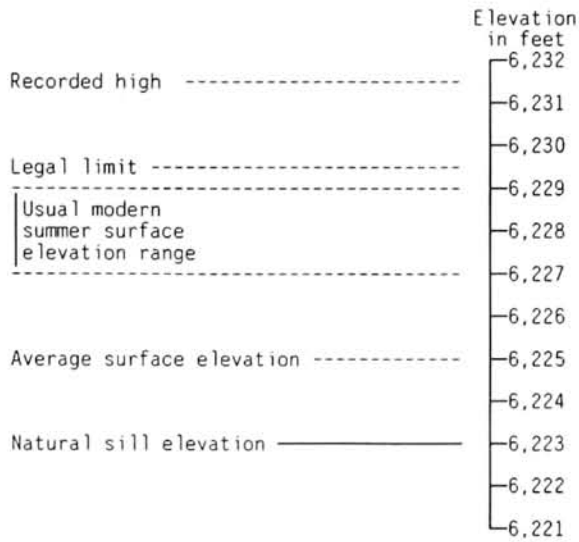

Fig. 2. Historic elevations of Lake Tahoe.

River. The elevation of this natural sill is 6,223 feet. However, since the early 1870s, fluctuations of the lake have been artificially regulated within a six-foot range by the construction of a series of small dams at its outlet. Official measurements, maintained since 1900, show fluctuations ranging from about two feet below to eight feet above the natural sill elevation (Fig. 2). The legal limit of the lake surface is established at 6,229.10 feet. The average post-dam surface elevation is 6,225 feet, and the modern summer surface elevation, as reported weekly in the local newspaper *Tahoe World*, usually is regulated between 6,227 and 6,229 feet. The highest known surface elevation, in July 1907, reached 6,231.26 feet (Crippen and Pavelka 1972:7). Since 1900, official measurements record that the lake fell below the level of the natural sill eleven times The surface elevation of Lake Tahoe currently is below that of its natural sill for the second consecutive year. During the 1930s, the level dropped below the natural sill for six consecutive years and reached a recorded low of 6,221.79 feet in December 1934 (*Tahoe World*, April 21, 1988, Fig. 2).

ANCIENT SUBMERGED TREE STUMPS

There are trees growing around much of the shore of Lake Tahoe on ground just above elevation 6,229 feet. Their large size and corresponding age indicate that the lake has not risen above this elevation during the lives of these trees. Compelling evidence of Lake Tahoe's substantially lower levels comes from tree stumps submerged along the south shore, well below the natural sill (Figs. 3 and 4).

During the drought of 1934, Harding (1965:132-140) observed a cluster of 11 well-rooted stumps, which had emerged from the receding water at Tallac (Fig. 5). These stumps once grew on ground of present elevations up to two feet below the natural sill of the lake. Harding (1965) later reported the analysis of three radiocarbon samples taken from two of these stumps (Table 1). One stump, at an elevation of 6,222.75 feet, dated at 4,250±200 and 4,790±200 years B.P. The remaining stump, at an elevation of 6,222.7 feet, dated at 4,460±250 years B.P.

Six of the stumps observed by Harding were relocated during a study in 1985 of a prehistoric site at Tallac, near the mouth of

Fig. 3. Submerged tree stumps beneath the waters of Lake Tahoe. The stump pictured at the left is 7 feet tall and 3.5 feet across.

Taylor Creek (Fig. 5). At this time, the stumps were deeply submerged below the usual summer surface elevation of nearly 6,228 feet. These submerged features are fully described and illustrated in Lindström (1985). Elevations for these six stumps were obtained using an alidade and stadia rod and ranged between 6,223.3 feet and 6,220.7 feet. During this study, two more samples were taken for radiocarbon dating from the lowermost stump in Harding's cluster (elevation 6,220.70 feet) (Table 1). The sample from the inner core of the stump was dated at 4,870±60 years B.P. The sample from the outer-most portion of the stump was dated at 4,520±60 years B.P. If these dates are correct, this may indicate that the tree reached an age of 350 years. Tree-ring counts on these deeply submerged stumps were unobtainable. Stump diameters measured between 30 and 45 inches. Harding's rough tree-ring counts on the remaining portions of exposed stumps he observed indicate ages up to 150 years for trees located at the elevation of the sill and 100 years for trees which grew two feet below the elevation of the sill. The estimated age of these drowned trees may indicate a lowstand of Lake Tahoe that stabilized for a period of 100 to 350 years, long enough for these trees to become established and grow to this age. However, such assessments may require adjustment,

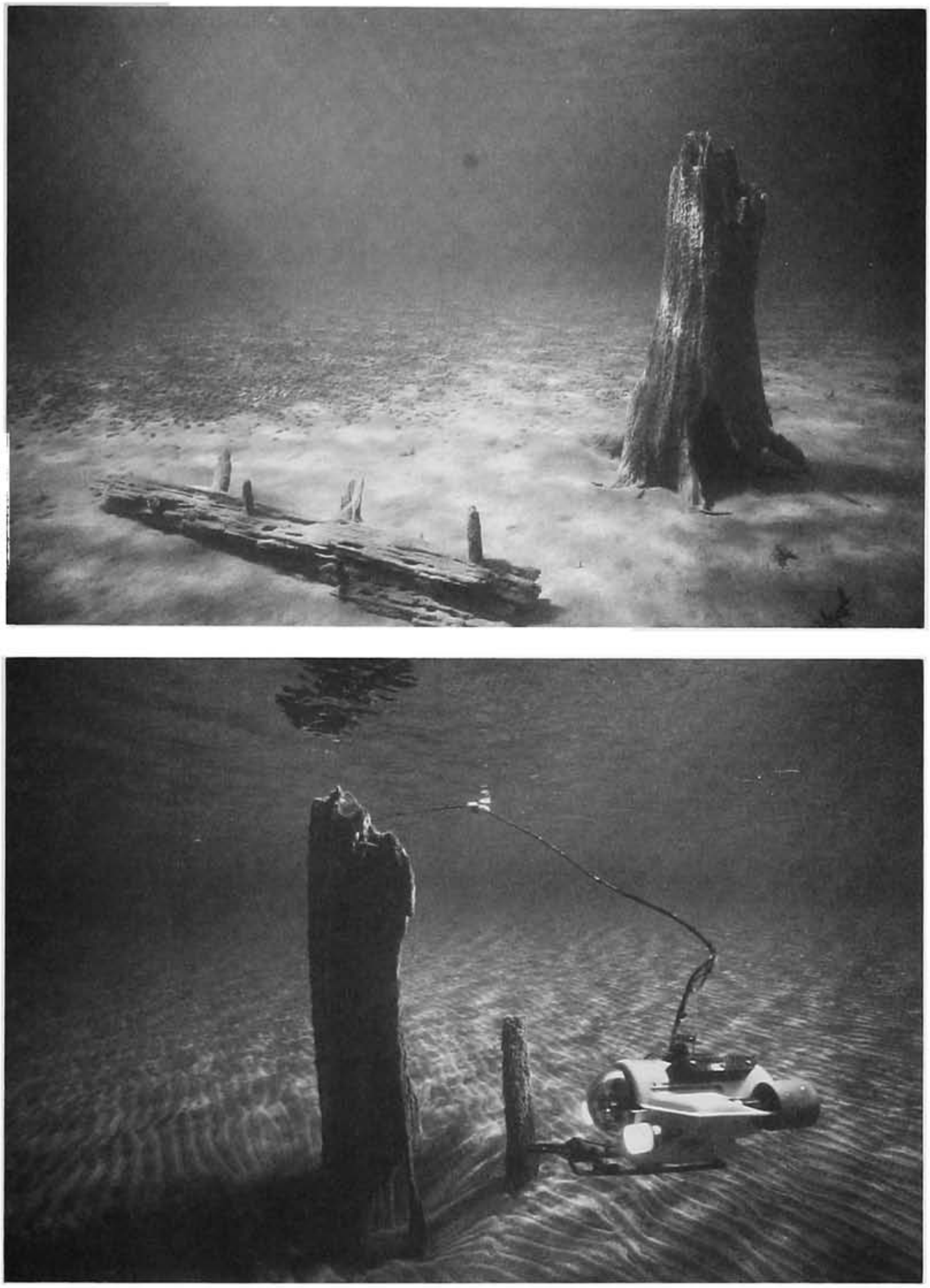

Fig. 4. Submerged tree stumps beneath the waters of Lake Tahoe. The stump shown in the upper photo is the same as shown in Figure 3, left. Both photos by Emory Kristof, (c) National Geographic Society.

pending the ultimate determination of their species. Different pines vary in their ability to tolerate high water tables.

During 1989-1990, 15 more stumps were discovered between Emerald Bay and Stateline at or below the level of Lake Tahoe's natural sill: nine are along Baldwin Beach, one is at the mouth of Emerald Bay, four are at Al Tahoe, and one is at El Dorado Beach in Stateline (Fig. 5). Samples were extracted from most of these stumps. They were taken from different places on the stumps and exact sample locations were not consistently recorded. Consequently, dates may vary depending on exactly where in the array of growth rings the sample was obtained. Stump depths were measured from a tape measure, which extended from the base of the stump to the surface of the lake. Depths were then computed from the official surface elevation, published weekly in the newspaper *Tahoe World*.

Most of these stumps are well preserved. The deepest stump is over seven feet tall and 3.5 feet across. The stumps located farthest below Lake Tahoe's rim probably have not been exposed long to air since they were first submerged; otherwise, they would since have decayed. This is suggested by badly decomposed stumps located at the sill elevation, which have been exposed to the air 11 times since 1900.

To date, a total of 21 stumps have been inventoried along the Lake Tahoe shore zone at elevations between 6,223.25 feet and 6,210.8 feet. The deepest stump is rooted more than 12 feet below the natural sill. Fourteen radiocarbon dates, taken from stumps at or below the sill, range from 5,510±90 B.P. to 4,250±200 B.P. (Table 1). The 14 dates represent 10 separate stumps. These data are slim and their analysis runs the risk of misinterpretation due to limited sample size and skewing from mixing samples derived from both the outermost wood and the core of the stump. Regardless, an apparent correlation exits between the elevation and age of these stumps. The oldest stumps are generally from the deepest water. In Figure 6, radiocarbon dates from the 10 stumps are plotted (averaging multiple dates taken from the same stump). In the same figure, all 14 radiocarbon dates are plotted individually. These data may be interpreted in at least two ways. A more generalized interpretation indicates an overall rise in the level of Lake Tahoe after 5,510 B.P., during which the surface elevation did not reach the natural sill elevation until after about 4,200 B.P. A finer-

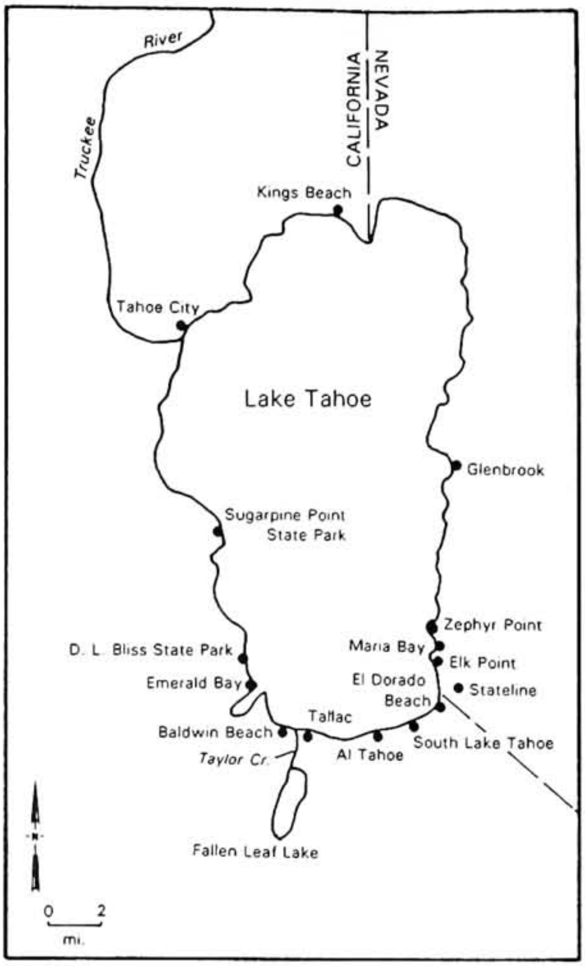

Fig. 5. Locations referred to in the text, Lake Tahoe and environs.

Table 1
RADIOCARBON AGES OF SUBMERGED TREE STUMPS AT LAKE TAHOE

Elevation in feet[a]	Laboratory Number	Location	Radiocarbon Years B.P.	Calibrated Years B.P.[b]
6,210.87	Beta-33878	Baldwin Beach	5,510±90	6,304
6,218.64	Beta-32851	Emerald Bay	4,980±80	5,730
6,220.70	Beta-13654	Tallac	4,870±60	5,640
6,222.75	LJ-503	Tallac	4,790±200[c]	5,527
6,218.64	Beta-32852	Emerald Bay	4,720±70	5,380
6,219.00	Beta-33879	Baldwin Beach	4,650±70	5,324
6,222.50	Beta-32847	Al Tahoe	4,610±90	5,313
6,223.25	Beta-32848	Al Tahoe	4,610±90	5,313
6,223.25	Beta-32846	Al Tahoe	4,580±60	5,300
6,220.70	Beta-13655	Tallac	4,520±60	5,197
6,222.50	Beta-32849	Al Tahoe	4,500±60	5,126
6,222.70	LJ-604	Tallac	4,460±250[c]	5,149
6,222.50	Beta-32850	Al Tahoe	4,370±80	4,931
6,222.75	LJ-605	Tallac	4,250±200[c]	4,846

[a] 6,223.00 feet is elevation of natural sill of Lake Tahoe.
[b] University of Washington, Quaternary Isotope Lab Radiocarbon Calibration Program, 1987, Rev. 1.3.
[c] Harding 1965.

grained interpretation suggests the possibility of fluctuating lake levels in which Lake Tahoe may not have approached the level of its present natural sill until around 4,790 B.P., with a subsequent drop around 4,720 B.P., a rise to the natural sill around 4,610 B.P., another drop around 4,520 B.P., and surface elevations remaining below the natural sill until sometime after 4,250 years B.P. When calibrated radiocarbon years are plotted, the time frame is pushed back another 700 years.

In addition to the tree stumps in Lake Tahoe, submerged stumps have been observed in water bodies elsewhere within the upper reaches of the Truckee River drainage. From a cluster of 10 stumps, all rooted well below the pre-dam level of Independence Lake, three additional radiocarbon samples, dating between 690±50 years B.P. (Beta-32857) and modern times, were obtained. Similarly, samples from several submerged tree stumps at pre-dam elevations in Donner Lake have been extracted also. There are reports of stumps rooted deeply below the surface of Fallen Leaf Lake. These data have not yet been analyzed and the relationship between trees drowned by rising lake levels in Independence, Donner, and Fallen Leaf lakes and submerged stumps in Lake Tahoe remains to be demonstrated. However, the widespread presence of submerged tree stumps is suggestive of larger-scale climatic trends.

PALEOCLIMATIC INDICATIONS

Harding (1965) offered two alternative hypotheses to account for the presence of submerged tree stumps in Lake Tahoe, one climatic and one tectonic. The tectonic argument assumes a structural rise in the elevation of Lake Tahoe's sill and/or subsidence of the south end of the basin. Accordingly, tectonic movements may have affected the relative altitude of Lake Tahoe's strandline and lowered the ground on which the trees grew during the mid Holocene. In contrast, the climatic explanation maintains that mid-Holocene declines in lake level resulted from a drying trend in the Tahoe Sierra, an event which is well documented elsewhere in the western Great Basin (Antevs

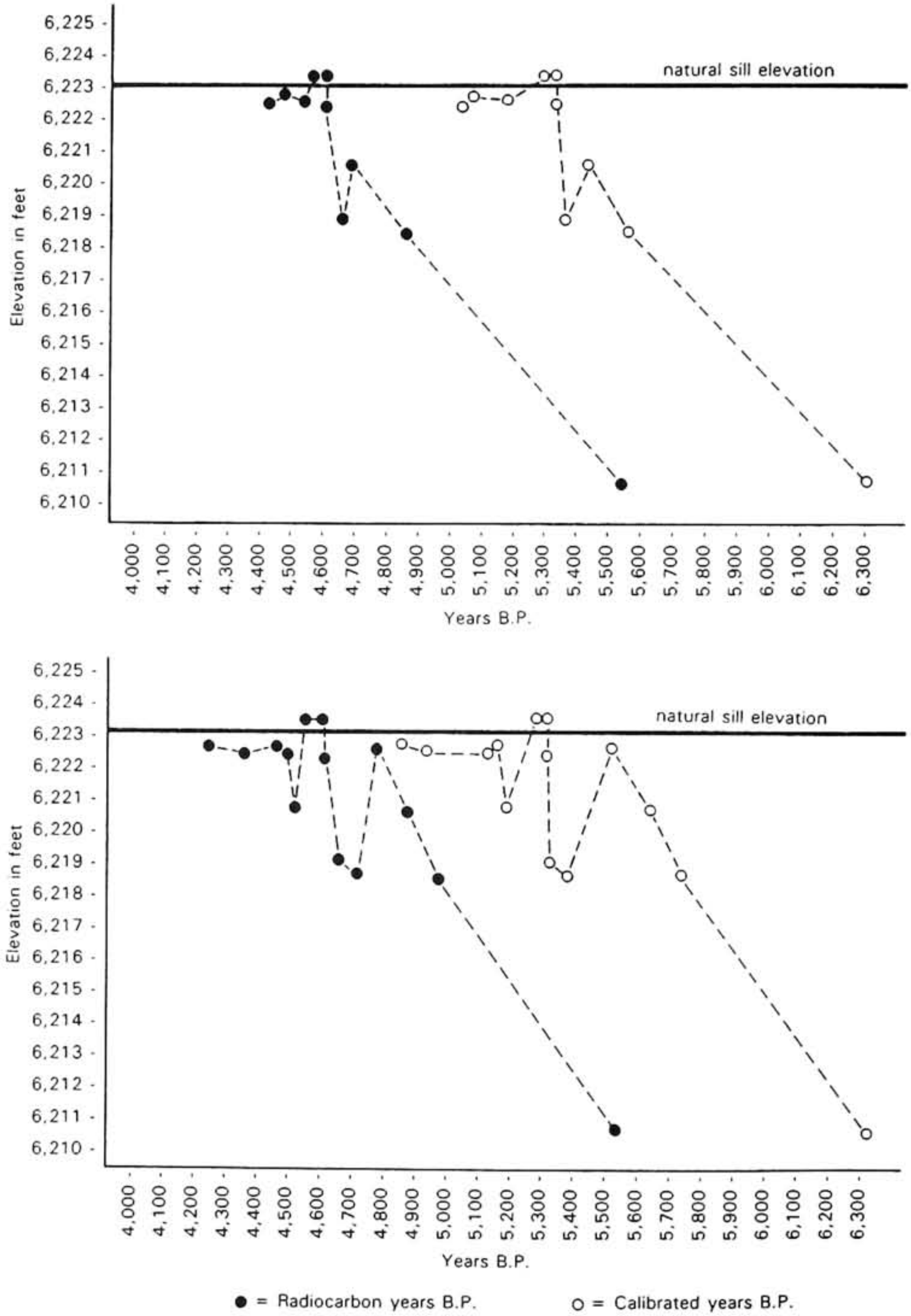

Fig. 6. Relationship between radiocarbon years and calibrated years versus elevation of stumps. Upper: dates from 10 stumps are plotted (averaging multiple dates taken from the same stump); lower: all 14 dates are plotted individually.

1953; Mehringer 1986). Research by Davis (1982) has modified this notion, suggesting that the mid-Holocene climate may have been not so much hotter and dryer overall, but more variable.

Benson and Thompson (1987:80) favored the tectonic explanation for the occurrence of submerged tree stumps in Lake Tahoe and believe the lake did not fall below sill level for any significant time in response to a mid-Holocene period of aridity. Their reasoning is based upon the fact that, during the mid-Holocene, Pyramid Lake never fell below its historic preagricultural lowstand (3,860 feet elevation). They reasoned that with the historic lowering of Pyramid Lake to its minimum level, emerald trout (*Salmo smaragdus*) did not endure and cui-ui (*Chasmistes cujus*) survival was contingent upon artificial propagation in fish hatcheries external to the lake. Consequently, Benson and Thompson maintained that the persistence of these two fish species up to the time of the historic decline of Pyramid Lake proves that the lake never fell below this historic lowstand to a point at which it could not support the fish.

Benson and Thompson's (1987) contention that Lake Tahoe did not fall below sill level (6,223 feet elevation) for any significant time in response to mid-Holocene aridity is an issue for future debate. For the present, however, note is made of the faulty reasoning employed in their argument against a climatically induced drop in the level of Lake Tahoe. First, although Snyder (1917:80-81) described emerald trout as a species of trout from the Lahontan basin, it is not a true native but represents a hybrid between the Lahontan cutthroat trout (*Salmo clarki henshawi*) and the introduced rainbow trout (*Salmo gairdnerii*) (Behnke 1972). Accordingly, the demise of the hybrid emerald trout can be explained by the fact that it is not as drought adapted as the native cutthroat (Behnke 1979), the latter of which may have endured lake levels below the historic lowstand of Pyramid Lake. Second, it is true that the cui-ui, an endangered species endemic to Pyramid Lake, is thought to be the sole surviving genetically pure member of its genus (Miller and Smith 1981). Its persistence is widely cited as evidence that Pyramid Lake never approached lowstands lethal to cui-ui survival. However, historic diversions of the Truckee River for agricultural and municipal uses caused reductions in water inflow and a build-up of Truckee River delta sediments (Hardman and Venstrom 1941:77; Born 1972). These factors inhibited cui-ui spawning (Sumner 1940; Scoppettone et al. 1986:2). Decades of limited access to the river (La Rivers 1962) and poor hatching success in the lake during low-water times (Johnson 1958; Chatto 1979) gravely endangered historic cui-ui populations (Buchanan and Coleman 1987:431), despite their individual longevity of over 40 years (Scoppettone et al. 1986:13). Because the demise of emerald trout and the threatened survival of cui-ui can be attributed to historical circumstance, Benson and Thompson (1987) used this line of evidence inappropriately to support their argument against climatic causes for lowering the level of Lake Tahoe in mid-Holocene times.

Contrary to Benson and Thompson's (1987) findings, Davis et al. (1976) interpreted Harding's (1965) submerged stumps as evidence of a mid-Holocene drying trend, during which time Lake Tahoe fell below the level of the natural sill that governs spill of this lake into the Truckee River. Similarly, the stumps reported here and associated archaeological data (Lindström 1985) also counter Benson and Thompson and render support for the climatic model of mid-Holocene drying in the Tahoe Basin. In addition, certain features of the geomorphology and palynology of Tahoe Basin offer other independent and collaborative evidence that points to climatically induced changes in the level of the lake. These data include 15- to 20-foot-high dune formations at Kings Beach (Harding 1965), drowned shorelines and marshes damned by sand spits along the south shore (Birkeland 1965:61; Davis et al. 1974:45), submarine canyons along the east and west sides (Hyne in Davis et al. 1974:46), buried lakeshore deposits on the south end (Blackard 1985), sediment cores from the lake bottom (Goldman and Byron 1986:4; E. Byron, personal communication 1990), and pollen cores from bogs and marshes within the Tahoe Basin (Adam 1967; West 1985).

Another related climatic factor that may account for fluctuations in the level of Lake Tahoe stems from new and unanalyzed data suggesting an increase in the height of the natural sill due to accumulated sediments. Cores taken inside the outflow channel of the lake by the U.S. Forest Service (Hug 1989:4) and the U.S. Bureau of Reclamation (Hawkins et al. 1986:20-21) reveal 12-foot-thick sediments in the vicinity of Lake Tahoe's sill, which originally was thought to be a bedrock rim (Davis et al. 1974:44). Such sediment accumulations, which likely resulted from reduced outflow from the lake, lend additional support for a mid-Holocene period of aridity accounting for the presence of the submerged stumps.

The accumulation of 12 feet of sediments which raised Lake Tahoe's natural sill at the north end, along with the presence of 12-foot-deep stumps inundated along its south shore, presents a provocative correlation from which two hypotheses are posed for testing.

1. A mid-Holocene drying trend accounts for dramatic drops in the level of Lake Tahoe, as documented by submerged tree stumps up to 12 feet below the level of the present natural sill. During this time Lake Tahoe fell below the level of the present natural sill that governs spill of this lake into the Truckee River.

2. Lake Tahoe did not fall below natural sill level for any significant time during the mid Holocene. Rather, the height of the natural sill rose 12 feet due to the gradual accumulation of sediments, which are attributed to reduced outflows due to periods of mid-Holocene aridity. Accordingly, the surface elevation of Lake Tahoe also rose. This lake-level rise gradually drowned trees which once colonized mid-Holocene land surfaces, located about 12 feet below the present natural sill.

If mid-Holocene drops in the level of Lake Tahoe prove to be climatically induced, this phenomenon should be reflected in climatically sensitive wetlands elsewhere in the upper reaches of the Truckee River drainage. The discovery of a growing body of evidence in support of a mid-Holocene drying trend is anticipated. Localized data from the Tahoe Sierra will modify and add significant detail to the larger regional model of Holocene climatic change.

ARCHAEOLOGICAL IMPLICATIONS

During historic times, receding water has exposed numerous archaeological features on the shore of Lake Tahoe. Fifteen bedrock milling features, containing over 60 grinding cups/milling slicks, have been observed within the active shore zone, between 6,229 and 6,222.5 feet elevation. While many other possible milling features have been identified, they are not discussed here. Weathering and erosion associated with changing lake levels tend to destroy the smooth surfaces of the grinding depressions and obscure a clear determination of their cultural origins.

At Tahoe City, an historic photograph taken during the 1920s-1930s when Lake

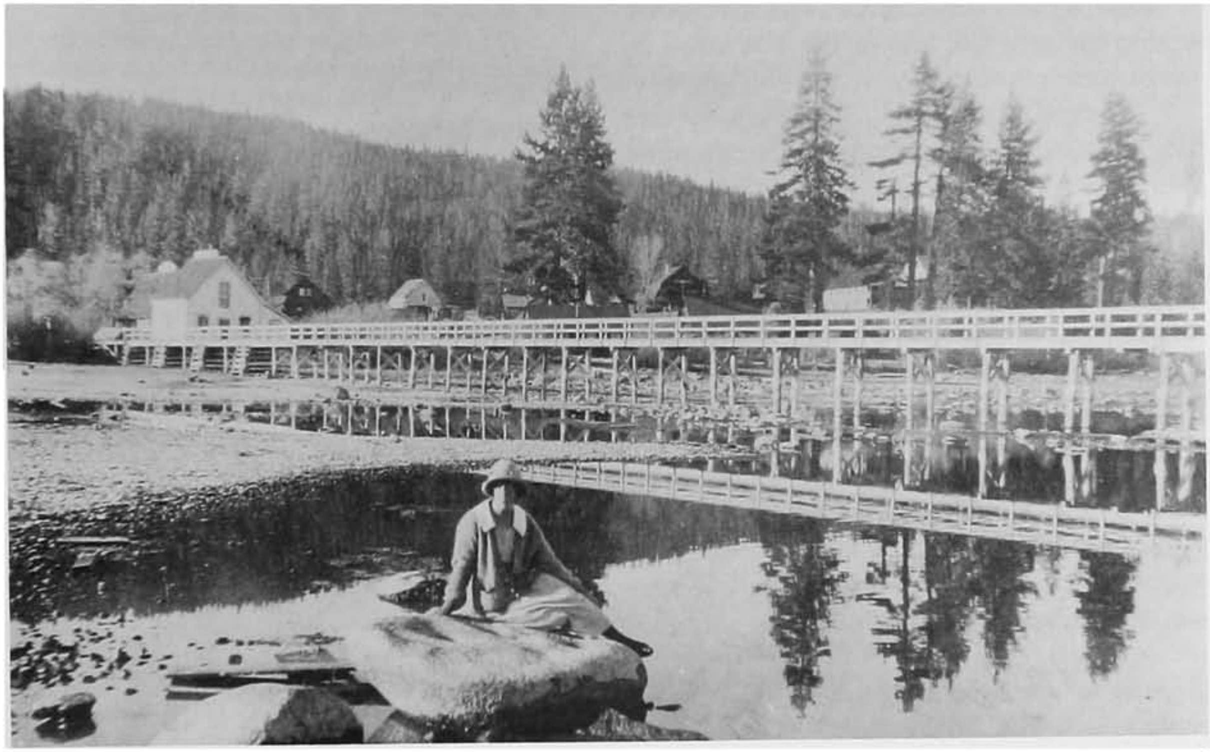

Fig. 7. Bedrock mortars (next to seated woman) exposed during the 1920s-1930s low-water period near the outlet of Lake Tahoe. Courtesy of Jim Bell, Tahoe City.

Tahoe fell to the elevation of its natural sill documents a bedrock mortar within the lake's outlet (Fig. 7). This large, flat boulder, containing six mortar cups, currently is on display in a local museum. Another bedrock mortar with two cups remains within the outlet channel. One portable milling slab is exposed at the natural sill elevation in Kings Beach. A bedrock mortar containing several cups occurs at Glenbrook at an elevation of 6,225 feet. At Zephyr Point, one rock with 15 milling slicks is at an elevation of 6,222 feet (U.S. Forest Service, Lake Tahoe Basin Management Unit, Cultural Resource Files 1990). Another bedrock milling feature with numerous cups is located below Lake Tahoe's natural sill elevation in Marla Bay (U.S. Forest Service, Lake Tahoe Basin Management Unit, Cultural Resource Files 1990). At Elk Point, one bedrock mortar containing six mortar cups is located at an elevation of 6222.5 feet. At Tallac, one milling feature containing seven grinding cups occurs at an elevation of about 6,225 feet. Another feature with two cups and grinding slicks is located within Lake Tahoe's modern summer splash zone at about 6,229 feet elevation. One bedrock mortar feature containing approximately five cups occurs at Lake Tahoe's sill elevation at D. L. Bliss State Park. Five bedrock mortar features containing 12 cups and one basin milling slick are at an elevation of 6223.5 feet at Sugar Pine Point State Park.

These new data bear upon archaeological studies in the Tahoe Sierra. Evidence of prehistoric occupation from the mid Holocene may remain beneath the historic artificially high water level of Lake Tahoe. Consequently, archaeological site inventories that focus upon the ground surface above the usual summer surface elevation of Lake Tahoe may underrepresent the use of the lakeshore by prehistoric populations.

Davis et al. (1974:41, 56) concluded that few sites around the lakeshore seemed older than around 3,500 years B.P. They suggested that earlier sites, located on lower and older shorelines of Lake Tahoe, may now be inundated, lost by erosion, or buried by marsh deposits. Their preliminary conclusions are generally supported by subsequent work in the Tahoe Basin (U.S. Forest Service, Lake Tahoe Basin Management Unit, Cultural Resource Files 1990). Here, the inventory of mid- to late-Archaic sites (dating from about 4,000 to 1,500 B.P.) far outnumbers that representing the early Archaic (dating from about 7,000 to 4,000 B.P.). Similar observations regarding the sparseness of the mid-Holocene archaeological record have been made elsewhere in the western Great Basin (Elston 1982; Zeier and Elston 1986), suggesting a link to widespread phenomena such as climatic trends.

ACKNOWLEDGEMENTS

I thank Eloise Barter, California Department of Parks and Recreation, and Penny Rucks, U.S. Forest Service, Lake Tahoe Basin Management Unit, for funding radiocarbon dating. Efforts of John Foster and other members of the California Department of Parks and Recreation diving team are greatly appreciated. Marty Rose, of the Desert Research Institute, figured calibrations for radiocarbon dates. Chuck Blanchard reported submerged features during a canoe reconnaissance of the nearshore zone. Craig Meacham assisted in many mask and snorkel surveys. James G. West kindly provided information on cores taken in the outlet channel of Lake Tahoe and shared his thoughts on their significance.

REFERENCES

Adam, D. P.
1967 Late Pleistocene and Recent Palynology in the Central Sierra Nevada, California. In: Quaternary Paleoecology, E. J. Cushing and H. E. Wright, Jr., eds., pp. 275-302. New Haven: Yale University Press.

Antevs, Ernst
1953 The Postpluvial or Neothermal. Berkeley: University of California Archaeological Survey Report No. 22:9-23.

Behnke, Robert. J.
1972 The Rationale of Preserving Genetic Diversity. Proceedings of the Western Association, State Game and Fish Commission 52:559-561.
1979 The Native Trouts of the Genus *Salmo* of Western North America. Prepared for the U. S. Forest Service, U.S. Fish and Wildlife Service, and U.S. Bureau of Land Management. MS on file at the Bureau of Land Management, Region 6, Denver, CO.

Birkeland, Peter W.
1965 Reno to Mount Rose, Tahoe City, Truckee and Return. In: INQUA 7th Congress Guidebook for Field Conference I. Northern Great Basin and California, pp. 48-59. Lincoln, NE: Nebraska Academy of Sciences.

Blackard, John
1985 Investigation of Soil Profiles. In: Archaeological Investigations at Tallac Point (CA-ELD-184), South Lake Tahoe, California, by Susan Lindström, pp. 194-209. MS on file at the U.S. Forest Service, Lake Tahoe Basin Management Unit, South Lake Tahoe.

Born, S. M.
1972 Late Quaternary History. Deltaic Sedimentation and Mudlump Formation at Pyramid Lake, Nevada. Reno: University of Nevada, Desert Research Institute, Center for Water Resources Research.

Buchanan, Chester C., and Mark E. Coleman
1987 The Cui-ui. In: Audubon Wildlife Report, Roger L. DiSilvestro, ed., pp. 425-436. Orlando, FL: Academic Press.

Chatto, D. A.
1979 Effects of Salinity on Hatching Success of the Cui-ui. Progressive Fish-Culturist 41:82-85.

Crippen, R., Jr., and B. R. Pavelka
1970 The Lake Tahoe Basin, California-Nevada. U.S. Geological Survey Water Supply Paper No. 1972.

Davis, Jonathan O.
1982 Bits and Pieces: The Last 35,000 Years in the Lahontan Area. In: Man and

Environment in the Great Basin, David B. Madsen and James F. O'Connell, eds., pp. 53-75. Society for American Archaeology SAA Papers No. 2.

Davis, Jonathan O., Robert G. Elston, and Gail Townsend
1974 Preliminary Archeological Reconnaissance of Fallen Leaf Lake. MS on file at the U.S. Forest Service, Lake Tahoe Basin Management Unit, South Lake Tahoe.

Elston, Robert G.
1982 Western Great Basin Prehistory. In: Man and Environment in the Great Basin, David B. Madsen and James F. O'Connell, eds., pp. 186-206. Society for American Archaeology SAA Papers No. 2.

Goldman, Charles R., and Earl Byron
1986 Changing Water Quality at Lake Tahoe. Davis: University of California Institute of Ecology, Tahoe Research Group.

Harding, Samuel T.
1965 Recent Variations in the Water Supply of the Western Great Basin. Berkeley: University of California Water Resources Center, Archives Series Report No. 16.

Hardman, George, and O. E. Reil
1936 The Relationship between Tree Growth and Stream Run-off in the Truckee River Basin, California-Nevada. Reno: Nevada Agricultural Experiment Station Bulletin 141.

Hardman, George, and Cruz Venstrom
1941 A 100-Year Record of Truckee River Runoff Estimated from Changes in Levels and Volumes of Pyramid and Winnemucca Lakes, U.S.A. Transactions of the American Geophysical Union, Reports and Papers 1941:71-90.

Hawkins, Fred F., Roland LaForge, and Roger A. Hansen
1986 Seismotectonic Study of the Truckee/Lake Tahoe Area, Northeastern Sierra Nevada, California, for Stampede, Prosser Creek, Boca, and Lake Tahoe Dams. Denver: U.S. Bureau of Reclamation, Geological Services Branch, Seismotectonic Report No. 85-4.

Hug, William L.
1989 Tahoe City Visitors Center Foundation Investigation, Lake Tahoe Basin Management Unit. MS on file at the U.S. Forest Service, Lake Tahoe Basin Management Unit, South Lake Tahoe.

Johnson, V. K.
1958 Fisheries Management Report, Pyramid Lake. Reno: Nevada Department of Wildlife, Federal Aid in Fish Restoration Project FAF-4-R.

La Rivers, Ira
1962 Fishes and Fisheries of Nevada. Reno: Nevada State Fish and Game Commission.

Lindström, Susan G.
1985 Archaeological Investigations at Tallac Point (CA-ELD-184), South Lake Tahoe, California. MS on file at the U.S. Forest Service, Lake Tahoe Basin Management Unit, South Lake Tahoe.

Mehringer, Peter J., Jr.
1986 Prehistoric Environments. In: Handbook of North American Indians, Vol. 11, Great Basin, Warren L. d'Azevedo, ed., pp. 31-50. Washington: Smithsonian Institution.

Miller, R. R., and G. R. Smith
1981 Distribution and Evolution of *Chasmistes* (Pisces: Catostomidae) in Western North America. University of Michigan Museum of Zoology Occasional Papers No. 696.

Scoppettone, G. Gary, Mark Coleman, and Gary A. Wedemeyer
1986 Life History and Status of the Endangered Cui-ui of Pyramid Lake, Nevada. Washington: U.S. Department of the Interior, Fish and Wildlife Service, Fish and Wildlife Research No. 1.

Sumner, Francis H.
1940 The Decline of the Pyramid Lake Fishery. Transactions of the American Fisheries Society 69:216-224.

West, James G.
1985 Exploratory Palynology of Taylor Marsh. In: Archaeological Investigations at Tallac Point (CA-ELD-184), South Lake Tahoe, California, by Susan Lindström, pp. 210-217. MS on file at the U.S. Forest Service, Lake Tahoe Basin Management Unit, South Lake Tahoe.

Zeier, Charles D., and Robert G. Elston
1986 The Archaeology of the Vista Site 26-WA3017. MS on file at the Nevada Department of Transportation, Carson City.