Coexistence of two species of sucker, *Catostomus*, in Sagehen Creek, California, and notes on their status in the western Lahontan Basin

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COEXISTENCE OF TWO SPECIES OF SUCKER, CATOSTOMUS,
in Sagehen Creek, California, and Notes on Their
Status in the Western Lahontan Basin

Lynn M. Decker

Abstract.—The observed distribution and relative abundance of two morphologically similar species of sucker, Catostomus, have shifted dramatically over the past four decades in Sagehen Creek and nearby streams in eastern California. The mountain sucker, C. platyrynchus, formerly abundant and more numerous than the Tahoe sucker, C. tahoensis, has become relatively rare and during this study was consistently less abundant than the Tahoe sucker at all eastern California sites in 1983. Similar shifts in abundance were not seen at the three Nevada sites. Behavioral observations and data on spatial and temporal patterns of habitat use, collected in Sagehen Creek between May and September 1982 and 1983 using a snorkel survey method, indicate nearly complete overlap between mountain and Tahoe sucker habitat use and an absence of any agonistic behavioral interaction between species. The decline of the mountain sucker in these areas is likely the result of an interaction of loss of habitat due to reservoir construction and destructive management practices. These changes may have led to the elimination of isolating mechanisms between the two species and may be increasing the opportunity for introgressive hybridization.

The mountain sucker, Catostomus platyrynchus, and the Tahoe sucker, C. tahoensis, co-occur in Sagehen Creek and other streams in the Lahontan drainage basin of eastern California and west central Nevada (Moyle 1976). They are morphologically similar, and natural hybrids occur (Hubbs et al. 1943, Smith 1966). The more widely distributed mountain sucker has been considered a product of Catostomus evolution, specialized for cool waters, rapid currents, and rocky substrates (Smith 1966). The Tahoe sucker, endemic to the Lahontan Basin, is considered a stream generalist and reaches greatest size and numbers in lakes and reservoirs (Willsrud 1966, Vigg 1978, Marrin et al. 1984). Although superficially similar, the mountain sucker differs from the Tahoe sucker in morphologic trophic specializations (Smith 1966), including small terete bodies, reduction of swim bladder size, and lip and jaw modifications for scraping diatoms and algae from rocks. Moyle (1976) indicated that the two species probably segregate spatially in streams, the mountain sucker being more abundant in upper stream reaches and the Tahoe sucker more abundant in lower stream reaches; when the two species are found together, the mountain sucker is thought to concentrate in riffle sections while the Tahoe sucker inhabits pools.

In 1982, distribution, abundance, habitat use, and behavioral interactions were observed and quantified in Sagehen Creek to determine possible mechanisms allowing the continued coexistence of these two sympatric species. During this time, the mountain sucker was extremely scarce, whereas earlier surveys found the mountain sucker to be equally as abundant as or more abundant than the Tahoe sucker (Flittner 1953, Gard and Flittner 1974). Collections in nearby streams also turned up few mountain suckers. In 1983 I began an intensive survey over a full summer season to determine the distribution, abundance, habitat use, and behavioral interactions of both species in Sagehen Creek, and an extensive survey of other sites where both species had been previously located, to determine if the change in relative abundance was widespread. These results provide background data essential for evaluating the prospects for continued coexistence of these two species in light of the extensive modification of their habitats (primarily reservoir construction), which has occurred over the last four decades.

Study Areas

Principal Study Stream: Sagehen Creek

Sagehen Creek is in the Tahoe National Forest, 12.1 km north of Truckee, California
(Fig. 1). It originates from a series of small springs at an elevation of 2,256 m on the east side of the Sierra Nevada. Prior to the filling of Stampede Reservoir in 1969, Sagehen Creek meandered an estimated 20.3 linear km through several small meadows, a riparian corridor of lodgepole pine (Pinus contorta), mountain alder (Alnus tenuifolius), aspen groves (Populus tremuloides), and finally a larger meadow area with scattered lodgepole pine and willow (Salix spp.), before joining the Little Truckee River at an elevation of 1,768 m. At capacity, the reservoir inundates about 4.8 linear km and, due to the braided nature of the channel, 10.6 of the original 12.0 km of stream habitat in this area.

The study reach, located in the lower meadow area, was chosen after preliminary observations in 1982 because it contained the majority of the sucker populations, its boundaries were well defined by beaver dams above and Stampede Reservoir below, and few obstacles would be encountered in obtaining data by a snorkel survey method. The reach is 1,200 m in length and is contained in Sec. 3, T18N, R16E, and Secs. 34 and 35, T19N, R16E, of the U.S. Geological Survey Map, Hobart Mills, California, NW/4 Truckee Quadrangle. The reach was marked into 12 sections, 100 m each, making location of observations more easily quantifiable. Sections were numbered beginning at the upper end of the reach and were added as the reservoir level decreased. Elevations at the section markers were referenced to the known surface level elevation of the reservoir, and altitudinal differences along the stream gradient were determined with an Abney level.

The stream meanders through a series of runs with side pools and shallow riffles. The upper 400 m is shaded by lodgepole pine, and the lowermost 800 m is open meadow with occasional willow clumps on the bank edges. The streambed is low gradient (1%), and the substrate is mostly gravel and cobble deposited on the lacustrine sediments of former Pleistocene Lake Truckee. Stream depths in late July (mean daily discharge, 0.54 m³/sec) ranged from 0.03 m in riffle sections to approximately 1.7 m in the deepest pool. Average depth from 25 cross sections was 0.35 m, and average width was 5 m. The water was clear and visibility was 2 m or greater on all snorkel observation days.
In addition to Tahoe and mountain suckers, seven other species of fish inhabit the study reach either as residents or migrants: mountain whitefish (*Prosopium williamsoni*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), brook trout (*Salvelinus fontinalis*), Lahontan speckled dace (*Rhinichthys osculus robustus*), Lahontan redside (*Richardsonius egregius*), and Paiute sculpin (*Cottus beldingi*).

Extensive Site Comparisons from Previous Surveys

**Little Truckee River**, Sierra Co., California, 100 m upstream of the Highway 89 bridge crossing 18 km north of Truckee, California, in Sec. 20, T19N, R16E, U.S.G.S. Truckee, California-Nevada 15 min. Quad. 1955. Elevation 1,877 m. This site was the same as that of Hubbs et al. (1943).

**Sagehen Creek**, Sierra and Nevada cos., California, two sections within the 1.2-km reach above Stampede Reservoir. Secs. 34 and 35, T18N, R16E, Sec. 3, T19N, R16E, U.S.G.S. Truckee, California-Nevada 15 min. Quad. 1955. Elevation 1,815 m (est.). These are two of three sites (Stations VII and IX) used by Flittner (1953) and Gard and Flittner (1974). The third site and possibly portions of the lower section (IX) surveyed in 1983 are inundated by Stampede Reservoir.

**Prosser Creek**, Nevada Co., California, 50 m below the Highway 89 bridge crossing 7.2 km north of Truckee, California, Sec. 22, T18N, R16E, U.S.G.S. Truckee, California-Nevada 15 min. Quad. 1955. Elevation 1,756 m. This site is about 1.7 km upstream from the 1942 old highway bridge survey site (Hubbs et al. 1943), which was inundated when Prosser Reservoir was impounded in 1963. The difference in elevation between the 1942 and 1983 sites is about 50 m.

**Martis Creek**, Nevada Co., California, reach below Martis Reservoir (Moyle and Vondracek 1985). Secs. 5 and 8, T17N, R16E, U.S.G.S. Truckee, California-Nevada 15 min. Quad. 1955. Elevation 1,740 m (est.). This site is below the 1939 survey area (Alex J. Calhoun, California Academy of Sciences, San Francisco, unpublished data), which was inundated when Martis Reservoir was impounded in 1971.

**Tributary to the Carson River** at Dayton, Lyon Co., Nevada. The tributary enters the Carson River under Ricci Road Bridge crossing. Sec. 23, T16N, R21E, Nevada Department of Transportation map 6-12, 1980. Elevation 1,463 m (est.). This tributary flows into the Carson River at the 1942 (Hubbs et al. 1943) survey site.

**Hot Creek**, Eureka Co., Nevada. Sec. 9, T28N, R52E, Nevada Department of Transportation map 4-5. 1959. Elevation 1,585 m (est.). This site was the same as that of Hubbs et al. (1943).

**North Fork of the Humboldt River**, Elko Co., Nevada, at Interstate 80 bridge crossing between Elko and Wells, Nevada. Sec. 3, T38N, R57E, Nevada Department of Transportation map 3-4, 1976. Elevation 1,585 m (est.). This site was the same as that of Hubbs et al. (1943).

**Methods**

Principal Study Stream: Sagehen Creek

**Distribution and abundance.**—Surveys to estimate the total distribution and abundance of suckers within the entire 1,200 m Sagehen Creek study reach were completed once every two weeks from 7 June to 30 August 1983 and again on 22 September 1983. Number, age class (juvenile or adult), and location of each surveyed individual were recorded. Additional observations were made of the composition of fish assemblages when fish appeared in groups and of characteristics of the habitat.

High water on 7 June and 22 June made visibility poor. Surveys were therefore completed by electrofishing from the bottom to the top of the study reach using a Smith-Root Type V backpack electrofisher. Remaining surveys were completed by snorkel survey (Goldstein 1978).

Observations were made while I pulled slowly upstream along the bottom in a shallow switchback pattern looking for fish at the banks, near or under obstructions, among rocks, in riffles, and in the mainstream. By this method, I observed fish upstream without having an obvious effect on their behavior.

**Environmental factors.**—A U.S. Geological Survey stream gauging station, 7.9 km below the headwaters of Sagehen Creek, measures the discharge from a drainage area of 27.2 km² (Fig. 1). Continuous stage and discharge records have been collected since
December 1953. Stream temperature is recorded at the Sagehen Creek Field Station by a Taylor continuous recording air and water thermograph, calibrated monthly. Stream temperatures also were taken in the study reach with a Taylor pocket thermometer for comparison with temperatures at the field station. Reservoir level elevation was provided by the U.S. Bureau of Reclamation. A water-stage recorder with a mercury-column manometer located at Stampede Dam has been in operation since August 1969.

**Microhabitat Use.**—Microhabitat use of the two sucker species was quantified in Sagehen Creek in both 1982 and 1983. Fish were located using the snorkel survey method described. The following data were recorded for each fish observed: stream section (riffle, pool, pool-run edge, or run), general location of fish and description of site, water temperature, water velocity taken at fish snout (focal point velocity), water velocity taken at 0.6 total depth (mean water column velocity), depth of water column at fish (maximum depth), distance from the water surface to the fish (focal point depth), substrate composition in a 0.25 m² area beneath the fish, amount and type of aquatic vegetation including an estimate of filamentous algae cover on the stream bottom, amount of shade, and description and proximity of the closest cover.

Water current velocities were measured to the nearest 0.3 cm sec⁻¹ with a Gurley Pygmy Current Meter mounted on a top-setting wading rod. Depths were measured to the nearest 3 cm directly from the rod. I estimated visually the substrate size composition based on a modified Wentworth particle size scale (Bovee and Milhous 1978).

Because of time constraints and the scarcity of fishes in the reach during many sample periods, I used an opportunistic (thus nonrandom) sampling scheme to collect microhabitat measurements. Measurements were taken systematically, working from the bottom to the top of the reach between the hours of 1100 and 1500 and quantifying microhabitats as fish were encountered. These measurements were taken independently of distribution and abundance surveys. The Spearman's rank correlation is used as a descriptive tool to display and compare similarity of the ranked frequency distributions of various microhabitat factors between the two species for each observation.

**Behavioral Observations.**—Throughout the study, I observed at each site the species, number, and size of associated fish, and any interaction among fishes. In 1982 I observed fish by snorkeling at sites in the study reach for two to five 30-minute intervals on seven different occasions. In 1983 fish were observed for 30- to 45-minute intervals in the study reach on three separate occasions. In addition, over the two-year study period, 434 separate observations of behavior were collected in association with the microhabitat-use measurements.

For comparison, the diel behavior and activity patterns of both species of sucker were quantified in an underwater stream observation tank at the Sagehen Creek Field Station, where flows and water depth are regulated at the top and bottom of a diversion channel. The observation area was 9.1 × 2.6 m, with a grillwork at each end to keep the fish inside. Dividers were also used to confine fish in three enclosures, each roughly 3.0 × 1.2 m, next to the glass. Artificial cover was provided by floating a small piece of plywood in each enclosure.

Fish were captured by electrofishing in Sagehen Creek and nearby Little Truckee River, and were then transported to the field station in chests containing cooled stream water. Fish were weighed, measured, and placed in the enclosures for a two-day acclimatization prior to the observations. Three sets of observations were made of the behavior and activity of the two species between 21 July and 6 September 1982. The first two sets were composed of twelve 4-hr periods (twice covering the full 24 hrs), conducted over two 2-week periods. The final set was composed of twelve 2-hr periods (once covering a full 24 hrs) of observation over one week. In the first two sets I recorded behavior and activity of Tahoe suckers at three densities: 1, 5, and 6 fish per enclosure (0.3, 1.4, and 1.7 per m²). In the final set I recorded the interaction of Tahoe and mountain suckers in two mixtures: 2 Tahoe and 4 mountain suckers, 5 Tahoe suckers with 1 mountain sucker, and, for comparison, 6 Tahoe suckers alone. These densities were similar to observed densities in lower Sagehen Creek for similar areas where suckers commonly occurred in groups ranging
Table 1. Temporal distribution, abundance, and group size of suckers within the Sagehen Creek study reach from 7 June to 22 September 1983 (* indicates that fishes were present only in a diversion of the main stream).

<table>
<thead>
<tr>
<th>Survey date</th>
<th>Total distribution (meters)</th>
<th>Distribution through sections</th>
<th>Total sites where present</th>
<th>Sucker abundance</th>
<th>Group size</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/7</td>
<td>1*</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>6/21</td>
<td>570</td>
<td>6-12</td>
<td>9</td>
<td>0</td>
<td>8.1</td>
</tr>
<tr>
<td>7/5</td>
<td>630</td>
<td>6-12</td>
<td>18</td>
<td>0</td>
<td>4.2</td>
</tr>
<tr>
<td>7/19</td>
<td>588</td>
<td>4-10</td>
<td>14</td>
<td>0</td>
<td>5.6</td>
</tr>
<tr>
<td>8/2</td>
<td>855</td>
<td>2-11</td>
<td>32</td>
<td>51</td>
<td>7.6</td>
</tr>
<tr>
<td>8/16</td>
<td>840</td>
<td>4-12</td>
<td>26</td>
<td>75</td>
<td>7.4</td>
</tr>
<tr>
<td>8/30</td>
<td>630</td>
<td>4-10</td>
<td>16</td>
<td>44</td>
<td>5.0</td>
</tr>
<tr>
<td>9/22</td>
<td>392</td>
<td>7-11</td>
<td>4</td>
<td>8</td>
<td>2.3</td>
</tr>
</tbody>
</table>

from 1 to 40 (x = 5.3, Table 1). During all sets, the type and number of activities (feeding, swimming, resting on the stream bottom) per fish per minute in each enclosure were recorded (10 minutes at each enclosure, and two 10-minute periods per enclosure per hour). The results are based on a total of 71.3 hours of observation.

Extensive Site Comparisons from Previous Surveys

I examined the relative abundance of suckers at seven Lahontan Basin sites between July and August 1983 where previous data were available (Hubbs et al. 1943, Flittner 1953, Erman 1973, Gard and Flittner 1974) (Alex J. Calhoun, California Academy of Sciences, San Francisco, unpublished data; Don C. Erman, University of California, Berkeley, unpublished data; Joseph J. Cech, and Peter B. Moyle, University of California, Davis, unpublished data). Seven stream segments that could be precisely relocated from original field descriptions were resurveyed. Six sites were sampled with Smith-Root backpack electrofishers. The North Fork of the Humboldt River site was sampled with a 457 × 183 × 0.64-cm mesh seine.

Stream temperature, sample section length, average width and depth, characteristics of the stream bottom, aquatic vegetation present, and water clarity were noted. A general description of the area and the degree and type of human or animal disturbance evident at each site was also documented. Fishes were identified, counted, and usually released at the sites. Specimens collected for further analysis or for use as museum specimens (deposited at California Academy of Sciences, San Francisco) were preserved immediately in 10% buffered formalin and later transferred to 70% ethanol solution for storage.

Sampling was systematic and based on current knowledge of technique, stream conditions, and behavior of the target populations. These criteria are considered to have been met by the earlier surveys used for comparison. In a purely statistical sense, between-year samples employing different techniques are noncomparable; however, I felt the systematic method of sampling (past and present) should produce representative estimates of the Tahoe-to-mountain sucker ratios at each site and would allow use of the chi-square test for descriptive purposes. Previously, Dauble and Gray (1981) compared use of a small seine and backpack electroshocker, finding similar catch frequencies for catostomids with both types of gear.

Results

Sagehen Creek

Distribution and Abundance.—Tahoe suckers were distributed throughout the Sagehen Creek study reach and occurred in both 1982 and 1983 as far upstream as 400 m above the Highway 89 bridge crossing. In 1982 one Tahoe sucker was caught entering the Kiih Meadow tributary 5.6 km above the highway bridge (Fig. 1). The distribution of mountain suckers was limited to the lower 1,100 m of the study reach in both years.

In the initial survey, during a period of high discharge on 7 June 1983, 5 adult Tahoe suckers were present at one site about 260 m above the reservoir (Fig. 2). Between the 7 June and
Fig. 2. Temporal abundance of suckers in the study reach with corresponding measurements of mean daily discharge and maximum and minimum daily stream temperatures at University of California’s Sagehen Creek Field Station.

21 June surveys, mean daily discharge decreased and stream temperatures increased. Correspondingly, the number of Tahoe sucker adults observed increased to 73. On 22 June, Tahoe suckers were observed spawning in an open gravel riffle at the 790-m mark.

Mountain suckers were first observed in the reach on 19 July, when one individual was found. By the following survey of 2 August, the observed number of mountain suckers increased to 37, and Tahoe sucker juveniles also appeared in the reach (Fig. 2). Tahoe sucker juveniles occurred in groups with, and were always more abundant than, the similarly sized mountain sucker adults. Observed numbers of mountain sucker (37) and Tahoe sucker adults (154) peaked on 2 August. Numbers of juvenile Tahoe suckers peaked (75 individuals) in abundance on 16 August. As individuals counted began to decline, stream temperature was also declining (Fig. 2). Mountain suckers were not seen in the reach after the 30 August survey. I assumed that they had spawned, as breeding tubercles were present on most individuals, but spawning was not observed. Young-of-the-year suckers of either species were not observed in 1983. By the final survey of 22 September, very few Tahoe sucker individuals remained; only 1 adult and 8 juveniles were found in the reach.

Between 7 June and 21 June, when the first large group of Tahoe suckers migrated into the reach, they were distributed from Sec. 6, 160 m above the existing influence of the reservoir, through Sec. 12, 730 m above the reservoir (Fig. 3). The total longitudinal distribution of suckers observed in the study reach increased with increasing fish abundance and receding reservoir level (Fig. 3).
Table 2. Tahoe and mountain sucker microhabitat use measurements in Sagehen Creek, 1982–1983 summary.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Tahoe sucker</th>
<th>Mountain sucker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focal point velocity (m/sec)</td>
<td>0.20, 0.15</td>
<td>0.20, 0.09</td>
</tr>
<tr>
<td>Focal point depth (m)</td>
<td>0.56, 0.24</td>
<td>0.61, 0.09</td>
</tr>
<tr>
<td>Mean water column velocity (m/sec)</td>
<td>0.24, 0.13</td>
<td>0.15, 0.09</td>
</tr>
<tr>
<td>Water column depth (m)</td>
<td>0.56, 0.68</td>
<td>0.20, 0.09</td>
</tr>
<tr>
<td>Substrate size category</td>
<td>5.2, 385</td>
<td>6.1, 39</td>
</tr>
<tr>
<td>Shade (%)</td>
<td>49, 42.6</td>
<td>45, 41.8</td>
</tr>
<tr>
<td>Algae cover (%)</td>
<td>38, 49.0</td>
<td>75, 12.6</td>
</tr>
<tr>
<td>Stream section occurrence (frequency)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pool</td>
<td>0.41</td>
<td>0.33</td>
</tr>
<tr>
<td>Pool-run</td>
<td>0.20</td>
<td>0.49</td>
</tr>
<tr>
<td>Run</td>
<td>0.39</td>
<td>0.18</td>
</tr>
<tr>
<td>riffle</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total fish represented</td>
<td>385</td>
<td>39</td>
</tr>
<tr>
<td>Juveniles</td>
<td>53</td>
<td>0</td>
</tr>
<tr>
<td>Adults</td>
<td>332</td>
<td>39</td>
</tr>
</tbody>
</table>

Peak storage in the reservoir occurred on 7 June when an area encompassing 540 m of the stream reach was inundated (Fig. 3). Water was gradually released from the reservoir, and by the 2 August survey date 12 sections of the study reach were exposed stream. As water was released and lower stream sections were exposed, the distribution of suckers expanded downstream. Observed maximum upstream distribution was attained by the 21 June survey for Tahoe suckers but not until the 16 August survey for mountain suckers. As the number of suckers increased in the reach, the pattern of the distribution sample changed from 5 suckers present at one location on 7 June to 242 suckers distributed along 855 m of the reach and 32 different sites on 2 August (Table 1). Although lone suckers were sometimes present at a site, they usually occurred in groups around cover. The observed mean group size increased as the total number and total distribution of suckers increased, with the exception of the 21 June sample (Table 1). Group size decreased as suckers began leaving the stream in late August. Rarely were solitary individuals of either species found in the stream. Only 4% of Tahoe suckers (673 observations) and 5% of mountain suckers (88 observations) occurred in the absence of other individuals of either species. In addition, mountain suckers occurred in mixed-species groups with Tahoe suckers at 93% of the mountain sucker sites (n = 88 observations) between 19 July and 30 August.

Microhabitat use.—The most important microhabitat factor for the Tahoe and the mountain sucker appeared to be the presence of cover. Of the 434 microhabitat measurements of sites with fish, 70.8% were recorded in, among, or very near exposed willow or tree root masses in the stream; 9.5% near undercut banks; 9.0% near log jams; and 2.5% among large boulders. Only 8.2% of the sites with fish lacked cover.

In other respects, suckers used a fairly broad range of overlapping microhabitats, with substantial variability around the means for all microhabitat variables (Table 2). Even less affinity was apparent for particular values of focal point velocity, mean water column velocity, and depth when measurements attributable to cover (willow or tree root masses) were accounted for in each distribution. Microhabitat use by mountain suckers appeared less variable than that by Tahoe suckers, but these results may reflect the small sample size (39) for mountain suckers: 8 in 1982 and 31 in 1983. Tahoe suckers seem to utilize a smaller substrate size than mountain suckers (Table 2). Mean substrate size was in the gravel category for the Tahoe sucker and in the rubble/cobble category for the mountain sucker, although the ranked frequencies were similar (Spearman’s rank, rs = .750; p < .05 [Steel & Torrie 1960]). Comparison of the distributions of ranked frequencies of the microhabitat use measurements for mean water column velocity (rs = .604; p < .05) and focal point velocity (rs = .809; p < .001) also showed correlation between Tahoe and mountain sucker use, indicating the species appeared to use similar proportions of the
range of each habitat factor. As neither species occurred off the stream bottom, no appreciable correlation occurred between depth-use distributions (r = .427; p < .05).

In both 1982 and 1983, algae on the substrate became evident during the second week of July. Prior to this time only Tahoe suckers were present in the stream, and no algal cover beneath fish was observed. Comparison of estimated algae cover after the second week of July showed no difference (p > .05) between mountain sucker and Tahoe sucker sites in 1982 but some difference between sites in 1983. In 1982, mean algae cover for mountain sucker sites was 81% (S.D. = 11; n = 8) and for Tahoe suckers, 61% (S.D. = 41; n = 5). In 1983, mean algae cover was 73% (S.D. = 14; n = 31) and 49% (S.D. = 35; n = 181) for mountain suckers and Tahoe suckers, respectively.

Both species were distributed in pool, pool-run edge, or run habitats; no suckers were found in riffle sections (Table 2). Of habitats where Tahoe suckers occurred, 41% were in pool habitats, 39% in runs, and 20% in pool-run edges (Table 2). Mountain suckers most often occurred in pool-run edges (49%), with 33% in pool and 18% in run habitats (Table 2).

Behavior.—Both Tahoe and mountain suckers rested on the bottom of the study reach near some type of cover during the majority of daylight hours. Feeding was seldom observed until early July, and then only in the afternoon. The arrival of mountain suckers in the reach was coincident with increased algal abundance on the substrate, and mountain suckers were observed feeding substantially more often than Tahoe suckers. Mountain suckers and juvenile Tahoe suckers almost always were observed together in the reach, where they rested side-by-side on the stream bottom. Agonistic encounters were never observed during this study.

Results from the stream observation tank reinforced results of daylight observations made in the study reach. Both species were highly gregarious. They rested side-by-side, often touching under the provided cover. This behavior occurred in both mixed- and single-species groups. When movement occurred, the group acted as a unit, regardless of its make-up. Activity patterns fluctuated at low levels from early afternoon until early morning, with a 6-hour period of less activity begin-

ning just after dawn (Fig. 4). Both species appeared more active at night. Feeding intensity was greatest during this time, and the fish moved in less tightly structured groups. Feeding-related activity accounted for a majority of the 81.3 hours of activity observed: 74.6% for solitary suckers, 54.2% for the 5-sucker group, and 62.5% for the 6-sucker group.

Extensive Collections and Historical Comparisons

The Little Truckee River, Sagehen Creek, Prosser Creek, and Martin Creek differed significantly (chi square p < .05 [Steel and Torrie 1960]) in relative abundance of Tahoe and mountain suckers from early surveys (Table 3). Tahoe suckers were previously estimated to be more abundant than mountain suckers only at the Little Truckee River site (47% Tahoe, 44% mountain, and 9% hybrids in 1942 [Hubbs et al. 1943]); but in 1983, Tahoe
Table 3. Long-term changes in relative abundance of Tahoe and mountain suckers at seven Lahontan Basin locations. Sources are HHJ: Hubbs et al. (1943); LMD: Lynn M. Decker, unpublished field notes; GAF: Flittner (1953); DCE: Don C. Erman, University of California, Berkeley, unpublished data; PBM: Peter B. Moyle, University of California, Davis, unpublished data; AJC: Alex J. Calhoun, field collection provided by California Academy of Sciences, San Francisco. Collection methods are S = seine, E = electrofisher, P&D = pump and drain.

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>Tahoe sucker</th>
<th>Mountain sucker</th>
<th>Hybrids</th>
<th>Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>Little Truckee</td>
<td>VIII-15-1942</td>
<td>47</td>
<td>33</td>
<td>44</td>
<td>31</td>
</tr>
<tr>
<td>River</td>
<td>VII-22-1982</td>
<td>50</td>
<td>4</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>VII-20-1983</td>
<td>100</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sagehen Creek</td>
<td>VIII-17-1951</td>
<td>44</td>
<td>38</td>
<td>48</td>
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suckers were relatively more abundant at all four California sites. In 1983 collections, Tahoe suckers comprised 100% of the suckers in the Little Truckee River, 87.5% in Sagehen Creek, 100% in Prosser Creek, and 95% in Martis Creek. This result was a reversal of the relative abundance in early surveys when mountain suckers were 48–52% of the sucker population in Sagehen Creek (Flittner 1953), 80% in Prosser Creek (Hubbs et al. 1943), and 97% in Martis Creek (Alex J. Calhoun, California Academy of Sciences, San Francisco, unpublished data).

In the tributary to the Carson River, Hot Creek, and North Fork of the Humboldt River in Nevada, the relative abundance of mountain and Tahoe suckers was not significantly different (p > .05) from early surveys (Table 3). In the tributary to the Carson River, equal proportions of mountain and Tahoe suckers were observed in 1942 (49% mountain, 50% Tahoe, and 1% hybrids) as compared to 1983 (45% mountain, 45% Tahoe, and 10% hybrids). In Hot Creek and the North Fork of the Humboldt River, the mountain sucker remained relatively more abundant. In Hot Creek it represented 87% of the sucker sample in 1938 and 82% in 1983; and in the North Fork of the Humboldt River, the mountain sucker represented 78% of the sucker population in 1942 and 70% in 1983.

Of the sites visited, only the Hot Creek, Nevada, site appeared unchanged from earlier descriptions. Evidence of recent human or livestock disturbance was present at all other sites. The site on the North Fork of the Humboldt River had extensive bank slumping, probably caused by cattle and horses, but it is not known if subsidence was evident in 1942. The tributary to the Carson River is
controlled by a diversion structure upstream and during most irrigation seasons may remain dry continuously for several weeks (Jim Curran, Nevada Dept. of Wildlife, Fallon, personal communication).

The California streams surveyed had one change in common—reservoirs had been constructed. Sagehen Creek and Little Truckee River now flow into Stampede Reservoir (filled in 1969), Prosser Creek flows into Prosser Reservoir (filled in 1963), and Martis Creek has been bisected by Martis Reservoir (filled in 1971). Martis Creek and the Prosser Creek system were also subject to California Department of Fish and Game stream poisoning operations. Martis Creek was poisoned last in 1977 (Peter B. Moyle, University of California, Davis, personal communication), and Prosser Creek was poisoned last in 1984 (Lynn M. Decker, personal observation). Sagehen Creek has undergone little physical change upstream from the reservoir (Erman 1973), while some channelization and bank restructuring took place in 1982 at the Little Truckee site. Livestock grazing has been common at all sites.

**Discussion**

Marked changes in the observed distribution and abundance of suckers in Sagehen Creek have occurred since Stampede Reservoir was filled in 1969 (Erman 1973). By 1975 some Tahoe sucker individuals had colonized upstream areas far above their original range. The species is now apparently a permanent inhabitant of areas above the range determined from 1952 to 1969 (Gard and Flittner 1974) and above the range of the mountain sucker. In contrast, mountain suckers occur no further upstream than they did in 1951 (Flittner 1953) and are consequently now confined to only 12% of their historical longitudinal distribution in Sagehen Creek.

Gard and Flittner (1974) speculated that the upstream limits of both species were influenced by gradient and substrate, but recent upstream movements of Tahoe suckers tend to discount this hypothesis. If the Tahoe sucker is not limited by these factors, then it is unlikely that the mountain sucker would be so limited. It is possible but unlikely that the long complex (approximately 2 km) of beaver dams and ponds above the study reach deter upstream migration of the mountain sucker but not the Tahoe sucker. Unlike Tahoe suckers, which survive very well in lakes and reservoirs (Willsrud 1966, Vigg 1978, Marrin et al. 1984), mountain suckers are thought to prefer moving water and have rarely been reported from lacustrine environments even when they inhabit tributary systems (Snyder 1983). However, my results in Sagehen Creek showed that mountain suckers leave the stream and presumably enter the reservoir in late summer, as do Tahoe suckers. Upstream migration in early summer is probably coincident with spawning, and the few adults apparently found sufficient spawning habitat below the pond sequence.

Expanded upstream movement of the Tahoe sucker may result from interaction between density-dependent factors and the availability of suitable stream habitat. It appeared that seasonal abundance of Tahoe suckers increased in the reach, their upstream distribution also increased. Tahoe sucker abundance (Erman 1973, Don C. Erman, University of California, Berkeley, unpublished data) and size (Marrin et al. 1984) increased after filling of the reservoir. Density-dependent intraspecific interactions when population levels were high may have caused the Tahoe sucker to expand its distribution upstream where it remained once suitable habitat areas were reached (Don C. Erman, University of California, Berkeley, personal communication). Mountain suckers have decreased in abundance and now remain only in the remnants of their former habitat.

Flittner (1953) estimated the population of suckers in Sagehen Creek (1951–52) at 3,308 individuals, 49% of which were mountain suckers, 35% Tahoe suckers, and 13% considered hybrids. In 1983 the estimated maximum population in the sampled reach of Sagehen Creek was 280 suckers; 40 (14%) mountain suckers (adults) and 240 (86%) Tahoe suckers (155 adults and 75 juveniles). Because suckers migrated in and out of the stream, the relative abundance of sucker species changed over time during the study period. Thus, an overall decline in suckers in Sagehen Creek seems to have occurred as well as a change in the relative abundance of the two species, with the mountain sucker now comprising a relatively small proportion of the population as compared to its 1951–52 levels.
In the limited distribution of the mountain sucker, habitat use almost completely overlaps that of the Tahoe sucker, and I was unable to document resource partitioning based on microhabitat preference. Although mountain suckers possess specialized morphological characteristics that seem adaptive to living and feeding in riffles and swifter current areas, they were never found in these habitats. The arrival of mountain suckers into the stream was, however, coincident with the increase in algae available on the substrate. Mountain suckers were observed feeding substantially more often than the associated Tahoe suckers. Sites with more algae were apparently selected by the mountain sucker, and this difference may reflect the presumed heavier use of diatoms and algae by the mountain sucker than by the Tahoe sucker (Hauser 1969, Marrin 1980). It seems unlikely, based on my observations, that the food resource in Sagehen Creek was limited or that one species prevented the other from feeding in an area, as both species were present at these sites and neither inter- nor intraspecific agonistic encounters were observed in the stream or stream observation tank. Resource partitioning was perhaps not evident because of the current low density of fishes and abundant algae.

The comparatively high degree of observed hybridization for the Lahontan Basin—13% reported by Flittner (1953) compared with 1% predicted by Hubbs et al. (1943)—indicated previously that isolating mechanisms may have been incomplete in Sagehen Creek. If former isolating mechanisms existed, such as segregation along a longitudinal gradient or on a microhabitat level, results of my study show that they may now be functionally nonexistent. To some extent, temporal segregation may limit the time of spatial overlap between the two suckers, as documented for other sympatric sucker species (Nelson 1968). Mountain suckers were absent when Tahoe suckers were spawning. A smaller size class (110–140 mm total length) of the Tahoe sucker, however, moved into the stream with similarly sized adult mountain suckers and was present and abundant at sites when mountain suckers appeared ready to spawn in mid-August. It is possible that the Tahoe suckers present were ripe, even though large Tahoe suckers (160–220 mm total length) had spawned earlier. The possibility also exists that the smaller Tahoe suckers moving into the stream with the mountain suckers were hybrids.

Distribution and abundance data from Sagehen Creek and three local streams show that populations of the mountain sucker are now extremely limited and suggest that species may have become vulnerable to local extinction; at best, mountain suckers are certainly rare in these areas. Similar shifts between years in relative abundance of suckers were not evident at the eastern Lahontan Basin sites in Nevada. The differences between regions are possibly due to an interaction of reduced and altered habitat and destructive management practices in the mountain sucker areas in eastern California.

In Sagehen Creek and three other nearby streams, the impoundment of reservoirs seems to have reduced the habitat area of the mountain sucker and may have eliminated former mechanisms isolating it from the Tahoe sucker. The inundation of lower Sagehen Creek may also have contributed to the Tahoe sucker overwhelming the mountain sucker in these areas, thereby increasing the probability of genetic swamping (Hubbs 1955).

The loss of a sucker species due to progressive hybridization has been documented by Andreasen (1975). Although I have not determined whether the proportion of hybrids in the Sagehen Creek population has increased since 1951, it seems doubtful that a population of 40 individuals—down from 1,630 (Flittner 1953)—can persist much longer. In two years of observation, young-of-the-year mountain suckers were absent in Sagehen Creek and in the three other local streams. Such was not the case at the eastern Lahontan Basin sites in Nevada. It also seems unlikely that the reservoirs harbor large populations of the mountain sucker, since they have yet to be noted in collections by other researchers.

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Literature Cited


