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Fall and Winter Habitat Use and Movement by Columbia River Redband Trout in a Small Stream in Montana

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Abstract.—We used radiotelemetry to quantify the movements and habitat use of resident adult Columbia River redband trout *Oncorhynchus mykiss gairdneri* (hereafter, redband trout) from October to December 1997 in South Fork Callahan Creek, a third-order tributary to Callahan Creek in the Kootenai River drainage in northwestern Montana. All redband trout ($N = 23$) were consistently relocated in a stream reach with moderate gradient (2.3%) near the site of original capture. Some fish ($N = 13$) displayed sedentary behavior, whereas others were mobile ($N = 10$). The mean total distance moved during the study for all fish combined was 64 m (SD = 105 m; range, 0–362 m), and the mean home range from October through December was 67 m (SD = 99 m; range, 5–377 m). Thirteen redband trout made short upstream and downstream movements (mean total movement = 134 m; range, 8–362 m) that were related to habitat use. Mobile fish commonly migrated to complex pools that spanned the entire channel width (primary pools). Eight of 10 fish that did not change habitat location occupied primary pools, whereas the remaining 2 fish occupied lateral pools. Fish commonly overwintered in primary pools dominated by cobble and boulder substrates that contained large woody debris. As water temperatures decreased from 3.2–6.3°C in October to 0–3.8°C in November and December, we found a 29% average increase (46–75%) in the proportional use of primary pool habitats. The lack of extensive movement and small home ranges indicate that adult redband trout found suitable overwintering habitat in deep pools with extensive amounts of cover within a third-order mountain stream. Resource managers who wish to protect overwintering habitat features preferred by redband trout throughout their limited range in streams affected by land management practices could apply strategies that protect and enhance pool habitat and stream complexity.

Winter conditions can limit salmonid populations in mountain streams (Chisholm et al. 1987). Adequate overwintering refuge habitat from inclement stream conditions may govern salmonid production (Bustard and Narver 1975). Despite these theories, few studies have quantified the habitat use and movement of stream-dwelling resident salmonids during fall and winter in northern Rocky Mountain streams.

Several studies have examined the movements of stream salmonids, although results are variable and sometimes contradictory (Fausch and Young 1995). Temperature declines in the fall can induce salmonids to make extensive movements from tributaries to deep pools and coarse substrates in larger stream systems where conditions are more hospitable for overwintering (Bjornn and Mallet 1964; Bjornn 1971; Cunjak and Power 1986; Clapp et al. 1990; Brown and Mackay 1995). Bjornn and Mallet (1964) reported extensive downstream movements by westslope cutthroat trout *O. clarki lewisi* (up to 101 km) to overwintering areas. Brown and Mackay (1995) reported that cutthroat trout moved (up to 7.6 km) to deep, ice-covered pools where water temperatures were warmer than in the rest of the stream during winter. Conversely, salmonids may remain in suitable habitat areas within a small stream section throughout the year if population numbers do not exceed the winter cover capacity of the stream (Bjornn 1971). Using radiotelemetry, Young (1998) found that Colorado River cutthroat trout *O. clarki pleuriticus* used the same habitat location from early July to late October in a southcentral Wyoming stream. Similarly, in a Wyoming stream, Chisholm et al. (1987) found that brook trout *Salvelinus fontinalis* moved less than 350 m to low-gradient stream

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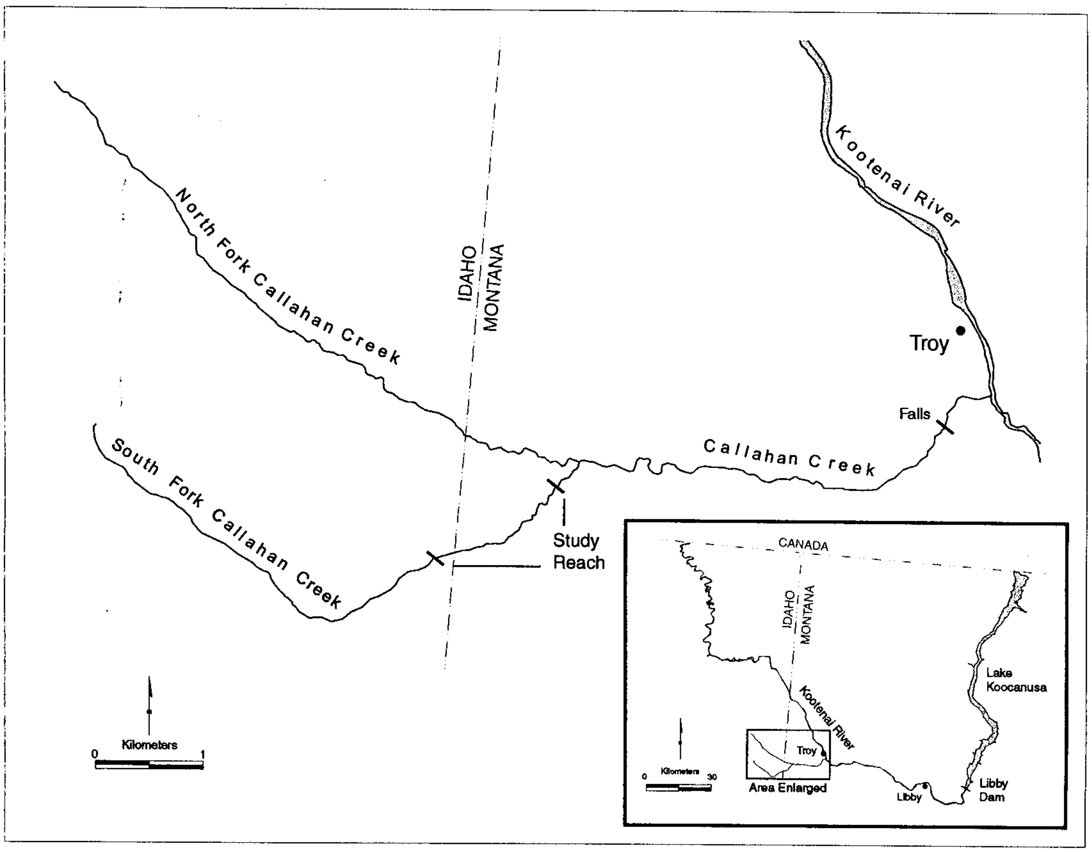

FIGURE 1.—Study reach in South Fork Callahan Creek in Montana.

reaches during late fall. Rainbow trout *O. mykiss* move into deep, low-velocity areas with extensive amounts of cover as winter approaches (Lewis 1969; Baltz et al. 1991). Lewis (1969) reported that adult rainbow trout tended to move into deep pools during winter in a Montana stream.

Populations of Columbia River redband trout *O. mykiss gairdneri* (hereafter termed redband trout), a subspecies of rainbow trout, have declined due to a complex combination of land and water practices (logging, mining, agriculture, grazing, and dams), hybridization, and competition with nonnative fishes (Williams et al. 1989; Behnke 1992). No known studies have focused on fall and winter habitat use and movement by redband trout in the upper Columbia River basin. Relatively small and fragmented populations of genetically pure redband trout persist above barrier falls in the Kootenai River drainage in Montana (Allendorf et al. 1980). These remnant populations represent the only known sources capable of refounding the historic distribution of pure redband trout in Montana. If winter habitat conditions limit redband trout production, identification of winter habitat selection is crucial for fisheries managers to develop effective conservation and management programs that will protect and enhance critical overwintering habitat. Our objective was to identify overwintering habitat and to describe the movements of adult redband trout by use of radiotelemetry in a small stream in the Kootenai River drainage in Montana.

Study Area

Our study was conducted in South Fork Callahan Creek, a third-order, 5,600-ha watershed located in the Kootenai River basin of northwestern Montana in the Kootenai National Forest (Figure 1). Callahan Creek originates along the eastern slopes of the Cabinet Mountains in Idaho (Idaho Panhandle National Forest) and flows approximately 20.8 km east through steep topography to its confluence with the Kootenai River. Elevations in the South Fork Callahan Creek range from 825 to 2,252 m.

The study section of the stream flows approximately 4,085 m through a moderately confined valley bottom type characterized by cobble and large gravel substrates (Muhlfeld et al., this issue). The average reach gradient is 2.3%. The underlying bedrock is mostly from the Precambrian sediments of the Belt Supergroup; soil material is derived from alpine and continental glaciation, glaciofluvial deposits, and residual material (U.S. Forest Service, Three Rivers Ranger District, Troy, Montana, unpublished data). During a stream habitat inventory conducted in August 1997, the mean low-flow wetted width was 7.3 m, and the mean depth was 0.22 m (Muhlfeld et al., this issue). Pool habitats that span the entire channel width encompassed 6% of the total available habitat and had a mean depth of 0.52 m (SD = 0.17 m). Annual precipitation ranges from 63.5 to 274 cm (U.S. Forest Service, Three Rivers Ranger District, Troy, Montana, unpublished data). Runoff patterns are typical of the northern Rocky Mountains; high flows occur in the spring, and base flow conditions are experienced in the late summer. This hydrophysiographic region is highly susceptible to rain-on-snow events that result in an increase in the frequency, magnitude, and timing of channel-forming discharges (peak flows).

The watershed has been intensively managed for timber production and mining since the early 1920s. Riparian vegetation consists of European alder *Alnus glutinosa*, willow *Salix* spp., and western red cedar *Thuja plicata* communities. Upland vegetation is dominated by western larch *Larix decidua*, Douglas fir *Pseudotsuga menziesa*, and subalpine fir *Abies lasiocarpa*.

Callahan Creek is the only known watershed in Montana that supports both native inland redband trout and bull trout *Salvelinus confluentus.* A barrier falls is located approximately 3.2 km upstream from the confluence of the Kootenai River and is suspected to be the isolating mechanism impeding genetic introgression of coastal rainbow trout from the Kootenai River (Marotz and Fraley 1986).

Methods

We used radiotelemetry to monitor the habitat use and movement of redband trout from 6 October to 14 December 1997. Twenty-six adult fish (196–255 mm in total length [TL]) were captured by angling, surgically implanted with radio transmitters, and released in close proximity to their capture location (Table 1). Fish were captured in fast (e.g., riffles) and slow (e.g., pools) habitat types throughout the reach to obtain a representative sample of fish from available habitat types.

We first implanted and released 10 redband trout (mean total length = 231 mm; range, 206–255 mm) on 5–6 October and then an additional 5 on 11–12 October (mean total length = 222 mm; range, 214–237 mm), hereafter referred to as group 1. As these tags reached the end of their expected 30-d battery life, we implanted 11 additional fish on 1–2 November (mean total length = 209 mm; range, 196–246 mm), hereafter referred to as group 2. Fish were anesthetized with a solution of 60 mg of tricaine methanesulfonate (MS-222)/L, and transmitters were surgically implanted into the body cavity. Each anesthetized fish was placed in a padded V-shaped trough, and gills were irrigated with a solution of 30 mg of MS-222/L during surgery. We made a 10-mm incision immediately anterior of the pelvic girdle and 3 mm to the side of the midventral line (Young 1995). A sterilized transmitter was placed in the body cavity, and the antenna was extended through the body wall. Each incision was closed with two to three synthetic absorbable sutures. Fish were placed in live traps along the stream margin for approximately 12 h after surgery to ensure proper recovery before release. Transmitters weighed 2.0 g in air, and each emitted a unique frequency (40 pulses/min) in the range of 49.380–49.920 MHz; a 36-h-on, 132-h-off cycle maximized the battery life (model 377, Advanced Telemetry Systems [ATS], Isante, Minnesota). Large redband trout (>100 g) were difficult to capture during October and November. Consequently, some transmitters exceeded the recommended 2% transmitter-to-body weight ratio (mean = 2.28%, SD = 0.45%) that was suggested by Winter (1983). However, recent information suggests that the ‘‘2% rule’’ should be replaced by an index with a more scientific basis (Brown et al. 1999). For example, the swimming performance of intraperitoneally implanted juvenile rainbow trout was not substantially altered by the presence of the tag or the effects of the operation even though the transmitter comprised 6–12% of the fish’s weight (Brown et al. 1999).

Fish were tracked twice a week during the daytime with a Lotek (model SRX 400) scanning receiver equipped with an ATS loop antenna from vehicle access points along the stream. Also, fixed-wing aerial telemetry was used to survey remote and inaccessible areas throughout the Callahan Creek drainage and the Kootenai River system on three different occasions during the study to iden-

TABLE 1.—Summary of radio-tagged adult Columbia River redband trout and habitat used in the South Fork Callahan Creek, Montana, during fall and winter 1997.

Transmitter frequency (MHz)	Length (mm)	Weight (g)	Release date	Home range (m)	Total distance moved (m)	Number of relocations	Number of movements	Habitat type used (%)					
								Primary pool	Riffle	Run	Lateral pool	Pocket water	Channel braid
49.341	216	80	6 Oct	21	0	4	0	0	0	100	0	0	0
49.352	220	90	6 Oct	59	59	5	2	40	0	0	60	0	0
49.361	255	142	6 Oct	377	362	10	4	60	0	0	0	0	40
49.371	206	80	6 Oct	188	263	6	3	40	0	0	0	60	0
49.382	250	113	6 Oct			0							
49.401	223	92	6 Oct	71	71	3	1	0	0	0	100	0	0
49.421	230	101	6 Oct	71	136	6	2	0	0	83	17	0	0
49.431	233	113	6 Oct			0							
49.442	225	94	6 Oct	24	0	1	0	0	0	0	100	0	0
49.452	248	130	6 Oct	13	0	5	0	100	0	0	0	0	0
49.390	237	112	12 Oct	10	0	2	0	100	0	0	0	0	0
49.412	226	102	12 Oct			0							
49.471	214	91	12 Oct	13	0	6	0	100	0	0	0	0	0
49.491	215	85	12 Oct	105	118	12	2	83	0	0	17	0	0
49.510	219	89	12 Oct	8	0	4	0	100	0	0	0	0	0
49.820	210	74	3 Nov	73	56	10	2	20	0	0	80	0	0
49.830	202	72	3 Nov	8	0	10	0	100	0	0	0	0	0
49.840	196	72	3 Nov	65	65	6	1	33	0	0	0	67	0
49.850	246	120	3 Nov	8	0	2	0	100	0	0	0	0	0
49.860	218	90	3 Nov	316	292	9	1	100	0	0	0	0	0
49.870	202	70	3 Nov	70	63	4	1	50	0	0	50	0	0
49.880	202	68	3 Nov	10	0	4	0	100	0	0	0	0	0
49.890	196	70	3 Nov	24	8	3	1	100	0	0	0	0	0
49.900	220	96	3 Nov	9	0	6	0	100	0	0	0	0	0
49.910	197	64	3 Nov	13	0	3	0	100	0	0	0	0	0
49.920	209	76	3 Nov	14	0	3	0	100	0	0	0	0	0

tify whether missing fish migrated from the study area. Observers walked along the stream bank and used a stripped coaxial cable antenna to obtain a more accurate location after a signal was detected. Pilot tests suggested that location accuracy was within 1 m of the transmitter. Therefore, we assumed a 1-m^2 area at the location to be the current habitat used.

Primary habitat data (i.e., habitat units that spanned the entire channel) were obtained at each fish location and classified as either a pool, riffle, run, or channel braid on the basis of channel characteristics and stream flow (Bisson et al. 1982). Secondary habitat units within riffles were classified either as lateral pools or pocket waters. Lateral pools were pools located on the side of the channel (e.g., pools that did not span the wetted channel width) that had reduced velocities compared with the surrounding habitat and were produced by a boulder or large-woody-debris bank structure. Pocket waters were deep areas located in riffles that had reduced velocities created by small and large boulders.

At least once during the study, we measured habitat unit characteristics for each location that included thalweg length, mean width, mean depth, substrate score, and percent cover. Three point locations were established along transects perpendicular to the stream flow. Wetted stream width was measured (0.1 m) at each transect, and mean width was calculated. Water depth (0.1 m) was measured at each point interval with a calibrated rod, and mean water depth was calculated by adding the nine depth measurements and dividing the sum by 12 to account for zero depths at the shoreline (Platts et al. 1983). Percent composition of substrate was visually estimated and ranked as sand–silt (<0.2 cm; rank = 1), pea gravel (0.2–0.6 cm; rank = 2), gravel (0.6–7.5 cm; rank = 3), rubble (7.5–15.0 cm; rank = 4), cobble (15.0–30.0 cm; rank = 5), boulder (>30 cm; rank = 6), or bedrock (rank = 7; Overton et al. 1995) and weighted by proportional area to obtain a single variable for each unit (Baltz et al. 1991). Percent cover was visually estimated as either woody debris, boulder, undercut bank, overhead vegetation (within 0.5 m of the water surface), or surface turbulence. Hourly water temperatures were monitored with an Orion Hobo temperature data logger deployed at the downstream limit of the study reach.

Individual fish movements were quantified by measuring with a tape the distance from the previous location to the new location along the stream bank. Individual movement was considered the linear distance moved between locations, and total movement was the sum of all movements for the duration of the study. The study home range was defined as the linear distance between the fish's most upstream and downstream locations (Young 1996, 1998) or, if the fish did not change habitat location, the habitat unit (primary or secondary) it occupied during the study.

Results

A total of 124 relocations (mean per fish = 5.4; range, 1–12) were obtained on 23 of the 26 radio-tagged redband trout from 11 October to 14 December (Table 1). Ground and aerial surveys revealed that all study fish were consistently relocated within the same study reach throughout the duration of the study (Figure 1). Three fish were never relocated after release, and eight fish were not found after 3 weeks of ground and aerial tracking. These fish apparently carried faulty transmitters that failed prematurely because of sensitivities to low stream temperatures found in South Fork Callahan Creek (D. Riechle, ATS, personal communication).

Redband trout displayed both sedentary and mobile behavior during fall and winter. Considering all study fish together, 13 fish (57%) did not change habitat location (e.g., were sedentary), and 10 fish (43%) migrated to other habitat units (mean total movement per fish = 134 m; range, 8,362 m). The mean total distance moved for all fish was 64 m (SD = 105 m; range, 0–362 m), and the mean study period home range was 67 m (SD = 99 m; range, 5–377 m).

No pattern of upstream or downstream movement was found; six fish moved upstream, three moved downstream, and one fish moved upstream from a run to a side pool and then back to the original run a week later. However, fish that moved primarily went to deeper, slower habitats than those previously occupied after release; 7 of the 10 mobile fish were last located in primary pools. Of these, four moved from runs, two were from lateral pools, and one was from a pocket water in a riffle. Of the three remaining mobile fish, two were last located in lateral pools, and one was in a run.

Sedentary fish commonly remained in primary pool habitats during their respective monitoring periods. For group 1, seven fish did not leave the habitat units where they were tagged and released. Four of these sedentary fish were located in primary pool habitats through 26 October, and one fish remained through 19 October. One fish was located in a deep run from 19 October to 16 November, and one fish was located in a side pool through 11 and 26 October. For group 2, all six sedentary fish remained in the primary pool in which they were tagged.

We found that both study groups used primary pools more than other habitat types; however, use of pools intensified during November and December as water temperature declined sharply (Table 1). Mean daily stream temperatures declined from 3.2–6.3°C during 11–26 October to 0–3.8°C during 7 November–14 December. Surface and fringe ice formation was first observed in late November. Snow and ice bridging and anchor ice formation were observed in some areas of the stream on 14 December. From 11 to 26 October, 46% ($N = 19$) of locations were in primary pools, 24% ($N = 10$) were in side pools, 7% ($N = 3$) were in pocket waters, 12% ($N = 5$) were in runs, and 10% ($N = 4$) were in braided channels. From 8 November to 14 December, 75% ($N = 62$) of locations were in primary pools, 14% ($N = 12$) were in side pools, 6% ($N = 5$) were in pocket waters, 5% ($N = 4$) were in runs, and none were in braided channels. Thus, as stream temperatures declined from fall to winter, redband trout showed a 29% increase in the proportional use of primary pools.

Primary pools were relatively deep and contained extensive amounts of cover. Average pool depth was 0.59 m (range, 0.43–0.70 m), and mean total area was 102 m^2 (58–185 m^2). Mean percent total cover (all cover categories combined) was 60% (30–100%). Large woody debris covered an average of 27% (0–70%) of the total pool area. Primary pools were dominated by cobble-sized substrates (mean score = 4.54, SD = 0.75).

Discussion

As temperatures decreased from fall to winter, the use of primary pools by redband trout intensified near the site of original capture and release. Redband trout exhibited a use of pools similar to that of other species of salmonids during fall and winter (Cunjak and Power 1986; Hearn and Kynard 1986; Chisholm et al. 1987; Brown and Mackay 1995; Young 1998). Similarly, Muhlfeld et al. (this issue) found that adult redband trout selected primary pools during summer throughout the Callahan Creek drainage in Montana. Water temperatures below 4–6°C stimulate winter concealment by some salmonid species (Chapman and Bjornn 1969; Bjornn 1971) because as water temperatures approach freezing temperatures, metabolic rates of fish are reduced, food requirements are lowered, and less energy is available for activity. Hence, during relatively inactive periods, salmonids require deep, low-velocity areas that maximize energy conservation (Fausch 1984). Pools also provide areas of protection from inhospitable conditions such as anchor and frazil ice formation (Brown and Mackay 1995) and from potential predators (Chapman and Bjornn 1969). Our results demonstrate that adult redband trout occupied pools dominated by cobble-sized substrates. Other studies have shown that as temperatures decline in the fall, salmonids will shift microhabitat use from small- to larger-sized substrate for overwintering cover (Bjornn 1971; Johnson and Kucera 1985). Therefore, pools appear to have a combination of greater depth and lower velocity with extensive cover and interstitial spaces that provides the most optimal winter habitat for adult resident redband trout.

Although some authors have reported long downstream movements during the fall and winter period (Bjornn and Mallet 1964; Bjornn 1971; Mejers et al. 1992), relatively sedentary behavior by salmonids has been observed in other Rocky Mountain stream systems with adequate overwintering habitat (Chisholm et al. 1987; Jakober et al. 1998; Young 1998). The amount of suitable winter cover in streams with water temperatures below 4–6°C plays a major role in regulating the number of fish that survive over winter (Bjornn 1971). Low stream temperatures (4–10°C) often trigger fall migrations of salmonid species (Bjornn 1971). If redband trout were unable to locate suitable overwintering habitat as temperatures declined and if populations exceeded the winter capacity of the stream, we would have expected fish to migrate downstream to deep pools. Thus, redband trout may not have been forced to migrate with the onset of winter conditions because adequate winter habitat, in the form of deep, slow pools with extensive cover, was locally available in the study reach. Failure of redband trout to leave the stream reach may reflect an ability to persist in this small stream system throughout the fall and winter due to their small body size (range, 196–255 mm TL), which allowed them to be concealed in interstitial spaces in available cobble and boulder substrates (Jakober et al. 1998; Young 1998). Also, downstream movements may have occurred in the spring before our study (Shepard et al. 1984). Perhaps the sedentary behavior we observed reflects selective pressures of the downstream barrier falls.

Small total movements exhibited by redband trout in our study (<350 m) are consistent with those observed for radio-tagged brook trout and cutthroat trout during the fall and winter. Using radiotelemetry, Young (1998) found that cutthroat trout in a small stream in Wyoming occupied mean home ranges of 38 m (range, 3–152 m), nearly half of our reported mean home ranges. He speculated that cutthroat trout failed to move and change habitat from summer to autumn due to the availability of coarse substrates for concealment and year-round low water temperatures in the study stream where the fish were monitored. Similarly, Chisholm et al. (1987) reported that brook trout moved into low-gradient stream reaches with the onset of winter, less than 350 m from where they were radio-tagged and released in a Wyoming stream. However, redband trout possibly could have altered this relatively sedentary behavior if stream temperatures continued to remain less than or equal to 1°C for an extended period of time and harsher weather conditions created unfavorable overwintering habitat. Formation of anchor ice can dam rivers and exclude fish from overwintering areas (Brown and Mackay 1995), and frazil ice development may cause winter mortality because ice crystals can plug the gills and mouths of salmonids (Tack 1938). Thus, if faced with harsher overwintering conditions, redband trout may be forced to find more suitable habitat in other areas of the stream or watershed.

Our results suggest that deep pools with complex cover are important to overwintering adult redband trout. Maintaining pools with adequate depth and cover throughout their limited range is probably critical for the conservation of redband trout. Minimizing impacts from land-use practices (e.g., logging and associated road construction) that can reduce cover and depth of pools (Burns 1972; Hartman et al. 1996) would maintain suitable overwintering habitat and probably enhance the winter survival of redband trout populations throughout their limited range in the upper Columbia River basin.

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