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Novel physical evidence that beaver historically were native to the Sierra Nevada

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North American beaver (*Castor canadensis*) have been considered native to northern California's Klamath and Pit River watersheds and the Central Valley, but not the Sierra Nevada (Zeiner et al. 1990). Current wildlife management policies in California and Nevada continue to cite early twentieth century zoologists Joseph Grinnell (Grinnell et al. 1937:636) and Donald Tappe (1942), who concluded that beaver were not historically extant at elevations above 305 meters (1,000 feet) on the western slope, nor on the eastern slope, of the Sierra Nevada.

There is no obvious biogeographical barrier that would have prevented beaver from migrating from their historic ranges on the Pit River watershed in the southern Cascades into the northern Sierra Nevada, which it borders, nor up the tributaries of the Sacramento and San Joaquin rivers into the many low gradient streams of the western slope of the that range. Beaver have occurred historically in every other North American mountain range from the Arctic Circle to northern Mexico (Naiman et al. 1988). Preferred food sources for beaver are widely available in the Sierra Nevada, as aspen (*Populus tremuloides*), cottonwood (*P. trichocarpa*), willow (*Salix* spp.), and mountain alder (*Alnus incana*) are plentiful (Beier and Barrett 1989). These facts raise questions as to why beaver would not have been historically extant in the Sierra Nevada. In addition, the widespread presence of incised, rapidly eroding streams in Sierran montane meadows, which were historically low gradient and meandering, raises the question as to whether beaver might have stabilized these streams in the past (Wilcox 2007). The discovery of several re-exposed beaver dams on these same incised channels presented a novel opportunity to assess their age via radiocarbon dating of the wood used in their construction.

In 1988, several previously buried beaver dams were discovered on the incised channel of Red Clover Creek in eastern Plumas County, about 60 miles north of Truckee, California and east of the Sierra Crest (Wilcox 2007). This creek is tributary to Indian Creek (via Last Chance Creek), part of the East Branch North Fork Feather River watershed that

drains ultimately to the Sacramento River. In 1989, two dams were examined, and one was relatively well-preserved prior to its exposure in the stream banks with wood suitable for ^{14}C sampling. Located at 39° 58' N, 120° 32' W, at an elevation of 1,637 m, these structures exhibited characteristics of a contemporary beaver dam with interlaced wood, and numerous beaver cut-marks visible. The dam had been buried under 1.2 m of soil and was situated at a right angle to Red Clover Creek. The middle section would have been in the creek bed, but was presumably washed away sometime in the past. In all probability, this beaver dam was exposed in 1986, the result of an erosional episode during the extensive floods that year in Plumas County.

Wood samples exhibiting evidence of beaver activity (beaver cut-marks) were removed for radiocarbon dating from three locations on the left bank side of the dam: the bottom, above the midline, and in an area of prior dam repair near the upper part of the dam. The removal of these samples followed strict protocols to avoid contamination, including avoidance of direct skin contact, removal with a clean trowel with a minimum of handling, followed by wrapping in aluminum foil. Smoking did not occur in the vicinity of the collection area, nor were samples exposed to paper or plastic bags. Once moved to the laboratory, the foil was opened in a dust-free environment, allowed to dry, and resealed in foil. The specimens were then sent to Beta Analytic (Miami, FL 33155) for analysis utilizing accelerator mass spectrometry of carbon oxidized to CO_2 and converted to graphite (Beta Analytics 2012), and results reported in accordance with standard methods and controls (Stuiver and Polach 1977). Wood samples suitable for dendrochronological dating (i.e., conifer branches of adequate diameter) were not available.

Radiocarbon dates from the different portions of the remnant beaver dam were AD 580 ± 60, AD 1730 ± 70, and AD 1850 ± 70 years. Interpretation of the dates and soil profiles indicated that the dam was first constructed around AD 580. The dam was reused, or continued to be used and repaired, around 1730. Finally, repair of a significant breach occurred at or around 1850. Sometime after that the dam apparently was abandoned and buried beneath sediment. The last date is within a decade of settlement in Red Clover Valley for ranching purposes (Hughes 1934). In the early 1930s, stone-filled erosion control structures were placed in the creeks of this area, suggesting that channel incision related to overgrazing of riparian vegetation was a twentieth century phenomenon (Hughes 1934). A remnant of one of these structures is located about 6 m from the bank near this beaver dam, an indication of the amount of sidewall erosion that has occurred since its placement.

In 2011, another buried beaver dam exposed by erosion was discovered in Red Clover Creek, located 16 km upstream from the 1989 dams at an elevation of 1,671 m (39° 56' N, 120° 25' W). A small willow branch from this dam (again not suitable for dendrochronological study) was also sent to Beta Analytic for radiocarbon analysis, and it was determined to date to AD 1820 ± 30 years (M. Kossow and J. Wilcox, Plumas Corporation, personal communication 2012).

The novel findings of ancient beaver dams periodically inhabited for over a millennium until ~1850 represents, to the best of our knowledge, the first direct physical evidence of beaver at higher elevations of the Sierra Nevada. The 1820 date of a second dam 16 km upstream suggests widespread colonization of the Red Clover Creek valley by beaver through the early nineteenth century. Since these discoveries, additional remnant beaver dams (Figure 1) have been exposed in eroding, incised channels in other Feather River watershed montane meadows, as well as in the upper Mokelumne River and Carson River watersheds. Sample analysis of these additional sites with radiocarbon dating and

Figure 1.—Photograph of a remnant ancient beaver dam with multiple sticks, and a 12 ounce juice bottle for scale. The acute angle cuts on the stick ends are characteristic of beaver. The beaver dam is 1.5 m below the surface of a montane meadow on the wall of an incised channel on Clarks Creek, approximately 8 km southeast of Antelope Lake, Plumas County, California. The elevation of the meadow is 1,707 m (5,600 feet) and located at approximately 40° 08' N, 120° 30" W. Reprinted with permission of J. Wilcox, Plumas Corporation, 2011.

dendrochronology is recommended in order to confirm our results, and to provide additional physical evidence of the historical distribution of beaver in other Sierra Nevada watersheds. Additional buried beaver dams could also be located using ground penetrating radar, as has been recently demonstrated in Colorado (Kramer et al. 2012).

The most recent radiocarbon date for the ancient beaver dam corresponds to the peak in mid-nineteenth century beaver trapping in the Central Valley of California. This continental "California fur rush" began with the arrival of the Hudson's Bay Company "fur brigades" that tried to extirpate beaver and other fur-bearing mammals south of the Columbia River to create a "fur desert" and discourage incursions into California by American mountain men (Wikipedia Contributors 2011). Although the Hudson's Bay Company decimated beaver populations, they failed to prevent early American exploration and colonization of inland California, which was driven largely by the pursuit of beaver until the California gold rush began (Dolin 2011:292).

The discovery of the physical evidence reported herein prompted a contemporary review of occurrence records and other indirect evidence that beaver historically were present in the Sierra Nevada (Lanman et al. 2012).

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