**Supplemental Discussion**

*Evaluating the Bison Mobility Hypothesis: Could a bison have migrated from northern Arizona or central Colorado quickly enough to retain the high δ13C value measured in Promontory FS-305 ankle wrap?*

Here, we provide details of our inferences regarding isotopic turnover and bison mobility, as summarized in the ‘Wandering Bison?’ section of our paper. Based on Cotton et al.’s (2016) grass carbon isoscapes model (which is itself partially based on bison δ13C values), we identified areas in northern Arizona and central Colorado in which bison are known to have δ13C values consistent with that of the FS-305 moccasin.

If a bison migrated from central Colorado or northern Arizona to Promontory, it probably would not travel a linear straight-line path. Using a least cost path (LCP) analysis approach (Supplemental Methods), we estimate more realistic travel distances of about 841 km from northern Arizona and 1407 km from Franktown Cave (Figure 1). Given that the LCP distances do not take into account circuitous movements that undoubtedly would have occurred, these seem like reasonable approximations for a thought experiment. The question is, is it feasible for a bison to have walked from either of these locations to Promontory in the amount of time required to retain a C4 signal in its hide, given that skin is constantly being replaced? To answer this question, we use skin turnover rates derived from a ‘diet switch’ experiment with a starting value similar to that inferred for the potential locations-of-origin and an end value similar to that measured around the Promontory Caves. We then use modern ecological information about bison to evaluate whether the necessary migration rate was feasible.

To our knowledge, there are no published studies of terrestrial herbivore skin carbon isotope turnover rates. However, Alves-Stanley and Worthy (2009) modelled the skin turnover of manatee skin, which is a reasonably good approximation for bison skin given that both species are large bodied mammalian herbivores. Metabolic rates (which scale with body size) are primary predictors of isotopic turnover rates (Vander Zanden, et al. 2015). Manatees have been noted to have a slower-than-expected metabolism for their body size (Irvine 1983), which implies that this equation might overestimate the ‘allowable time’ for bison migration if bison skin actually has a faster turnover rate. In other words, use of this equation will result in a minimum travel rate for bison and the rate would have had to be faster if bison skin turnover is more rapid. Alves-Stanley and Worthy’s (2009) manatee 0334 had an initial skin *δ*13C of about –16 ‰ and an expected fully-equilibrated final value of –24.4 ‰. The change in its skin *δ*13C is described by the following equation:

y = –24.6 + 8.2 e -0.00963 t , where y is the isotope value of the skin at time t.

The start value is similar to what we would expect for bison diet *δ*13C values at the potential locations-of-origin described above and the end value is virtually identical to the mean diet *δ*13C values measured from various Promontory bison tissues, making this equation an appropriate model for a ‘diet switch’ between these two regions. Using this equation assumes that the migrating bison would have consumed only C3 plants on its journey to Promontory, which is not unreasonable given the low *δ*13C values of most grasses throughout Utah, Wyoming, and western Colorado (Figure 7). We note that the Alves-Stanley equation was created to model skin values rather than inferred diets, but given our linear transformation from skin to diet *δ*13C and the match between diet endpoint values, a substitution of diet values into the equation is appropriate for this application.

 Solving Equation 5 for the FS-305 diet *δ*13C value of –17.4 ‰ gives an estimate of 13.5 days for travel from a source area with a mean grass *δ*13C of –16 ‰ to the Promontory Caves. If the animal was travelling the 841 km LCP from northern Arizona, it would have had to travel at a rate of 62 km/day for 2 weeks to arrive at Promontory with the measured skin value. If the animal was travelling the LCP from Franktown Cave, it would have had to travel 104 km/day every day for 2 weeks, unless it chose to traverse the mountains (which is possible but might not significantly cut down on travel time). If we use linear straight-line distances rather than LCPs, the travel rates are 37 km/day and 52 km/day, respectively.

Would it have been feasible for a bison to have travelled these distances so quickly? We sought analogies from modern bison in Alaska and Wood Buffalo National Park. The Alaska Department of Fish and Game reported on the movements of the wood bison released into the wild in 2015 (www.adfg.alaska.gov). The majority of bison remained within 50 miles (80 km) of their release point for several years, but two individuals travelled much longer distances. Bull 161 (the Galena bull) made two long journeys: the first was a distance of about 320 km in 6 months, and the second was about 480 km in 4 months (Tom Seaton, personal communication, Feb 7, 2019). Another migrating young wood bison, Cow 124, made a journey of 1550 km in 21 months, with a maximum straight-line distance of about 80 km in 1 month (Tom Seaton, personal communication, Feb. 12, 2019). To our knowledge, the fastest documented journey for bison is from Wood Buffalo National Park, where an entire herd travelled 82 km in 24 hours in response to wolf predation (Carbyn 1997). Although these examples demonstrate the ability of bison to travel long distances quite rapidly, no documented reports come close to the sustained rate of travel necessary for a migrant bison to arrive at the Promontory Caves from the above locations retaining a strong C4 signal in its skin.

Furthermore, if such an extraordinary journey were to occur it would most likely be undertaken by an adult male, since females generally remain with large herds that include calves. However, our ancient DNA-based sex-identification analyses indicate that the leather came from a female bison. Our alignment to the cattle genome resulted in a similar number of reads mapping to chromosomes X and 12-15, as expected for a female bison. 7945 reads aligned to chromosome 12, 8163 aligned to chromosome 13, 8032 aligned to chromosome 14, 7727 aligned to chromosome 15, and 8795 aligned to chromosome X. After normalizing the number of reads aligned to each scaffold by scaffold size, we observed a ratio of X:autosome aligned reads of 1.06:1 (chromosome 12), 1.05:1 (chromosome 13), 1.01:1 (chromosome 14), and 1.05:1 (chromosome 15). As the expected X:autosome ratio for a female is 1:1 and for a male is 0.5:1, these ratios provide strong evidence that the FS-305 ankle wrap leather was from a female. This genetic evidence further reduces the likelihood that the FS-305 leather came from a bison that travelled on its own four legs to the Promontory Caves. All together, it appears unlikely that the outlying FS-305 ankle wrap *δ*13C value came from a wandering bison.

**References**

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