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RE: Yellowstone bison 12 month status review (FWS/R6/080098)

Examining climate change together with other factors threatening the persistence of Yellowstone bison

Dear Regional Director Matthew Hogan,

On behalf of Buffalo Field Campaign, I am attaching the following publication for your consideration which speaks for itself:

John A.F. Wendt et al., *Large-scale climatic drivers of bison distribution and abundance in North America since the Last Glacial Maximum*, Quaternary Science Reviews 284: 107472 (April 16, 2022).

While bison have demonstrated a remarkable capacity to adapt to shifting stressors and persist in the past, the U.S. Fish & Wildlife Service must examine factors threatening Yellowstone bison's capacity to adapt and persist as a self-sustaining population in the wild for the foreseeable future.

In forecasting the future, examine the past knowing that the determining factors enabling bison to survive, such as a hospitable climate, corridors, connectivity to habitat, and natural interchange with other wild populations, may no longer be present or may not exist in the future.

> Hence, as temperatures rose, bison distributions shifted to higher latitudes and elevations (Fig. 6). These trends suggest that thermal stress applied considerable selective pressure, resulting in shifts in the distribution of late Quaternary bison populations.
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> Bison body mass has declined substantially since the LGM (Hill et al., 2008; Lyman, 2004; Martin et al., 2018). The most rapid body size loss occurred during the Pleistocene-Holocene transition when body size dropped by 26% over 3000 years (Martin et al., 2018).
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The negative relationship between temperature and body size indicates that long-term diminution may be an evolutionary response to selective pressure exerted by rising temperatures throughout the late Pleistocene and early Holocene.

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Hence, warming temperatures, especially at the Pleistocene-Holocene transition, may have selected for smaller-bodied bison. We note that rapid bison diminution between 16 and 8 ka (Hill et al., 2008; Martin et al., 2018) coincides with the highest simulated summer temperatures within the bison distribution (Fig. 5).

Millennial-scale changes in bison abundance and distribution were also strongly influenced by hydroclimate dynamics. Elevated summer insolation drove pervasive drought conditions in mid-continent North America during the early to mid-Holocene (Shuman and Marsicek, 2016; Williams et al., 2010).

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Between 12 and 6 ka, bison experienced multiple waves of abundance declines throughout much of their geographic distribution as reconstructed continental aridity intensified (Figs. 1–3). Subsequently, increasing moisture availability throughout midcontinent North America after 5 ka coincided with rising bison abundances throughout in the Great Plains and Intermountain West (Fig. 2). The observed relationship between hydroclimatic conditions favorable for increased abundance and availability of forage and growing bison populations aligns with archaeological records that show an increased investment into the pursuit and procurement of bison and trade of bison products by Indigenous populations in the late Holocene (Cooper, 2008; Roos et al., 2018; Zedeno et al., 2014).

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From our distribution maps, modeled climate envelopes, and prior knowledge of past regional biome shifts, we conclude that bison populations persisted throughout a broad geographic range of NA [North America] since the LGM [Last Glacial Maximum], and that the highest bison abundances were found in open temperate rangelands. Although historical distributions of biomes throughout most of western North America are poorly constrained, bison distribution shifts correspond to documented expansions and contractions of grassland and shrubland biomes, including, for example, the northward expansion of open rangelands into the previously glaciated ice-free corridor at 13-12 ka (bison range expansion), the aridification of the southwest through the early to mid-Holocene (bison range contraction), and the retreat of arboreal taxa at the forest-prairie ecotone along the northern and eastern margins of the Great Plains beginning at ca. 10 ka (bison range expansion). Additionally, hydroclimatic conditions appear to act as a strong control on bison abundance in open rangelands. While bison can incorporate woody vegetation into their diet and even subsist on browse, grassy habitats support the greatest bison populations and potential population growth. Perhaps the most striking evidence of bison abundance responding to climate-driven changes in forage production is found in the widespread increases in bison abundance throughout the rangelands of the Great Plains and Intermountain West during the relatively wet late Holocene. This underscores the important influence of climate and climate-vegetation feedbacks on bison distributions at large spatiotemporal scales.

Over the past 20 thousand years, bison experienced dramatic environmental changes that shaped their distribution, morphology, behavior, and population dynamics. During the early deglacial period, bison were geographically widespread, yet fragmented into regional glacial refugia. Though large populations of most North American megafauna did not persist beyond the YD [Younger Dryas], bison survived and exhibited remarkable stability. As temperatures warmed and precipitation declined at the Pleistocene-Holocene transition, bison abundances declined in southern and low-lying regions, and populations shifted northward and upslope. With easing drought conditions in the late Holocene, increased forage production supported increasing bison populations throughout the continental interior. Late Holocene bison populations continued to increase until just recently, when 19th century market hunting led to the near extinction of bison from North America (Isenberg, 2001).

Our distribution modeling approach demonstrates that bison continuously inhabited significant portions of the Great Plains and Intermountain West since the LGM. Bison populations advanced and contracted in response to climate warming and cooling and changes in hydroclimatic conditions that influenced the quality and availability of forage. Our results highlight the remarkable adaptability of bison to a wide range of climatic and ecosystem conditions and support the premise that modern bison are unique in some ways from their Pleistocene ancestors. The climate envelope occupied by Pleistocene bison was different from the climate experienced by anatomically modern bison during the late Holocene.

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Today, bison face risks from constrained mobility, geographic isolation of herds, habitat loss, artificial selection for nonadaptive traits, inbreeding depression, reduced fitness from cattle introgression, competition with other herbivores, and other sources (Halbert and Derr, 2007; Hedrick, 2009; Martin et al., 2021). These risk factors may reduce bison capacity to adapt to rapid environmental changes in the future. Because the current distribution of bison has been greatly reduced from its historic extent and is highly influenced by human interventions, conservation planning for the establishment of new protected areas or identification of at-risk populations can leverage distribution models trained on bison occurrences in archaeological and paleontological records.

Wendt et al. 2022 at 12–14.

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