BUFFALO FIELD CAMPAIGN

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April 19, 2024

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

Extirpated range must be examined in establishing a baseline of cumulative effects for investigating factors threatening Yellowstone's distinct bison herds

Dear Regional Director Matthew Hogan,

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

Brice B. Hanberry, *A solution for perfect bioclimate envelopes that are imperfect for extirpated species*, Environmental Research Ecology 2: 025005 (July 7, 2023).

In examining threats to Yellowstone bison, loss of range and habitat, and loss of connectivity to range and habitat is exacerbated by government actions confining the wild herd's migrations to "zones" that decrease the isolated population's ability to adapt to a rapidly changing ecosystem.

The U.S. Fish & Wildlife Service must examine the effects of extirpated range as part of its' cumulative effects investigation into factors threatening or endangering Yellowstone's distinct bison herds including, for example, rapid climate change forecast over the next century.

The effects of extirpated range must be examined in the context of whether the government's restricted range for Yellowstone bison can sustain intact herds in the wild, or not, in the face of a rapidly changing climate, shifts in suitable habitat outside "protected areas" and "zones" imposed by the government, continuously rising temperatures, increased drought frequency and intensity, loss in the availability and nutritional value of grass and sedge species, among other evident factors.

If suitable habitat shifts North, based on the Yellowstone bison population's distinct migratory patterns, both herds would be subject to more frequent and intense government management actions in Gardiner Basin. The absence and lack of measures in place protecting the Yellowstone bison population within a remnant of the wild herd's indigenous habitat and range, heightens the risk of extinction for the foreseeable future.

Hanberry's work may provide a useful approach in examining "effects of range contractions on modeling of species to determine suitable space under climate change," excerpted here:

> Present-day species distributions modeled with climate variables cannot provide potential future climate space for species that have contracted in range due to extirpations, regardless of abundant sample sizes within current ranges. My objective was to examine effects of range contractions on modeling of species to determine suitable space under climate change, exploring different approaches to modeling based on historical range maps. As examples of this issue, I estimated the current and future bioclimate envelopes of American bison (*Bison bison*) and elk (*Cervus elaphus*) from their current reduced ranges in the western United States compared to historical ranges immediately before extirpation. One solution for bioclimate envelope modeling is to generate presence samples from the historical range and pseudoabsence samples from outside of the historical range. By using the fullest climate space, the models identified areas of future suitable climate space that otherwise would be underpredicted (10%-27% of climate space, for these two examples) based on current ranges of species that have been extirpated from their historical range. Range contraction substantially reduced predictions of suitable climatic space under climate change. Therefore, species need to be evaluated for range extirpation before determining potential impacts of climate change on biodiversity conservation.
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> Species that are declining may contract in range, resulting in local extinction, or extirpation from geographic extents (Lomolino and Channell 1998). Land use can result in habitat loss and fragmentation, constraining species to only a portion of historical ranges. Overexploitation directly can remove species from some part of the range. Around 25% of assessed animal and plant species are threatened with extinction, primarily due to land use and overexploitation (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES] 2019).
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> Bioclimate envelope models (i.e. bioclimatic models, climate envelope models) are distribution models based on correlations between species occurrences and climate variables. Bioclimate envelopes models are a relatively accessible and fruitful line of research, encompassing tens of thousands of publications. . . .
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> Modeling of species to determine suitable space under climate change is one specific objective of bioclimate envelope modeling (Jeliazkov *et al* 2022). However, to produce a reliable model of climate space for a species, occurrence samples need to cover the full climate range of the species, regardless of sample size (Martínez-Freiría *et al* 2016). . . .
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> Two examples of species that have been extirpated from their historical ranges in North America, following Euro-American settlement, are American bison (*Bison bison*) and elk (*Cervus elaphus canadensis*). . . . The diets of both species are principally graminoids for most of the year, although bison favor sedges if available while elk favor grasses, and overlap continues into the summer, when elk consume more forbs and woody plants than bison (Gates et al 2010). Greatest competition for

forage is from domestic cattle, due to presence of 30 million beef cows, seasonally with calves, in the United States (USDA NASS 2023).

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The trait of large body size (>44 kg), or slow reproduction rates, may make species extremely vulnerable to extinction, regardless of historical range extent or abundance (González-Suárez *et al* 2012). . . .

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The ranges of bison and elk have contracted from nearly the full width of North America, albeit not filling the entire extent, to limited ranges in western central North America, within public lands or in mountainous private lands where land use is not intensive. Bison are highly managed, and wild Plains bison only range freely within the confines of limited public lands, particularly Yellowstone, Theodore Roosevelt, and Wind Cave National Parks and Custer State Park. Elk and bison have been re-introduced into a few public lands in the eastern U.S. (Gates *et al* 2010, Popp *et al* 2014). Due to their large size and impact on infrastructure, bison and elk usually are unwelcome on private lands and individuals that attempt to expand are removed (Fricke *et al* 2008).

Bioclimate envelope modeling requires completeness of species distributions to represent climate tolerances. While others have modeled North American mammal distributions (e.g. Deb *et al* 2020), and some with recognition that contracted ranges affect future predictions of climate space (Lima-Ribeiro *et al* 2017, Faurby and Araujo 2018, Sales *et al* 2022), fossil records rather than historical range maps immediately before extirpation have been applied and different modeling approaches for historical ranges have not been examined. Therefore, research questions remain about (1) how bioclimate envelope models from species observations of reduced ranges fill the climate space of overexploited, extirpated species compared to historical ranges before exploitation and (2) what are different options to find the missing climate envelope for historical ranges? . . . Because general historical ranges are known for bison and elk, as examples of species with abundant samples but within a limited range, I explored different solutions for filling the lost climate space for these species. One solution was continuing to use current occurrence samples and simply avoiding sampling (pseudo)absence points from the historical range. The second solution was generating presence samples from historical ranges with background (pseudo)absence points. A third solution was a combination of presence samples from the historical range while avoiding the historical range for (pseudo)absence points. To detect any historical climate change effects on ranges, I also hindcasted to the 1900s, 1800s, and 1700s. This research will help improve evaluation of future distributions for species with contracted ranges, by demonstrating potential missing climate envelopes in models based on current observations for species that have range reductions and potential model improvement by using historic ranges to better predict future distribution of species that have extirpations across large parts of their historic distributions.

Hanberry 2023 at 1–3.

Due to human activities during past centuries, many species ranges have contracted into a reduced climate space, which may result in underestimation of climate tolerances and distributions under future climate change. To examine effects of range contractions on modeling of species to determine suitable space under climate change, I explored solutions for modeling bioclimate envelopes from historical ranges before extirpation. For two example species of bison and elk, which have abundant sample sizes, bioclimate envelopes from current observations had near perfect accuracy, despite the challenge of matching climate to limited reintroductions of extirpated species in the eastern U.S. Nevertheless, the perfect matches missed the historical ranges of bison and elk based on historical maps, similar to results from fossil records (Lima-Ribeiro *et al* 2017, Faurby and Araujo 2018, Sales *et al* 2022). Therefore, a successful solution to filling the missing envelopes was to reproduce the historical ranges and generate well-distributed presence samples from the historical range and pseudoabsence samples from outside of the historical range.

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The approaches to bioclimate envelopes produce different current and future extents, which is extremely relevant to consider for species with known extirpations. Models of current reduced ranges will predict smaller extents for the future under climate change than models of the historical ranges, whether based on fossil records or historical range maps (Lima-Ribeiro *et al* 2017, Faurby and Araujo 2018, Sales *et al* 2022). Relatively recent range contractions also will reduce suitable areas predicted for the future (Martínez-Freiría *et al* 2016). For these two species, future predicted extents based on current observations were 10%–27% of future predicted extents based on historical ranges. While the future predicted extents may seem sufficient to meet the needs of species, species require more than just climate for habitat, which will consequently reduce the extent (Deb *et al* 2020, Sales *et al* 2022). Furthermore, if suitable habitat shifts and decreases, connectivity issues develop, which would appear very possible for free-ranging elk according to the future bioclimate envelope modeled only from current observations. Similarly, current concentrated locations of managed bison populations become partly unsuitable under the future bioclimate envelope modeled from current observations. In contrast, changing climate is a limited issue for the climate space of elk under the future bioclimate envelope modeled from the historical range. For bison, most of their historical stronghold of the Great Plains grasslands will no longer have optimal climate based on the future bioclimate envelope modeled from the historical range. Nonetheless, bison have limited presence in the Great Plains currently due to private lands and crop fields.

For some species, current distributions are unknown, much less historical distributions before land use change and overexploitation. Historical ranges maps for elk and bison matched well with the ranges generated in the PHYLACINE [The Phylogenetic Atlas of Mammal Macroecology] dataset for 146 extant terrestrial large-bodied (>44 kg) mammals developed from climate suitability modeling and historical and paleoecological occurrence records (Faurby *et al* 2018). Therefore, the PHYLACINE dataset may be a potential source of historical ranges, particularly if historical range maps are inaccessible. However, evaluation is critical because current distributions of bison in public lands did not match well with the

> PHYLACINE current ranges, whereas the GBIF [Global Biodiversity Information Facility] occurrences, used here to model current distributions, aligned with locations of bison in public lands.
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> Species range contractions due to human influences may lead to underestimation of future potential species distributions under climate change. Here, I explored different options for modeling overexploited species with contracted ranges through use of historical ranges. To more accurately model future climate space, historical ranges are necessary, and one solution for bioclimate envelope modeling is to generate presence samples from the historical range and pseudoabsence samples from outside of the historical range. The current ranges of species that have been extirpated from their historical range will generate a conflicting outcome about the impact of climate change compared with the historical ranges, if species maintain historical climate tolerances. The current range models forecasted areas that were 10%-27% of the areas forecasted by historical ranges. Species need to be assessed for range extirpation before establishing potential effects of climate change on species distributions.

Hanberry 2023 at 5–8.

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