Bison as sentinels: monitoring the response to warming, drought and productivity on the Great Plains

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The journal of *Ecology and Evolution* published our article entitled "Decadal heat and drought drive body size of North American bison (*Bison bison*) along the Great Plains" (Martin & Barboza 2019). We described how bison have adapted to local climate change over the last 50 years at Wind Cave National Park (hereafter, referred to as WICA). We also compared body size of 19 bison herds with environmental conditions along the Great Plains from Saskatchewan to Texas (Figure 1). A free version of the article can be found here: DOI: 10.1002/ece3.5898.

Results |

Over the last 50 years, bison at Wind Cave National Park have decreased in mature body size by 11% for the females (equivalent to a loss of 21 lbs. per decade) and 23% for males (equivalent to a loss of 82 lbs. per decade). Body mass declines were associated with warming and with increasing drought severity. Similarly, across the entire Great Plains (Figure 1), decreases in body size of male and female bison were associated with increasing temperature and increasing drought severity (Figure 2).

Background Information |

The Great Plains (Figure 1) has been warming and becoming increasingly drought prone over the past century. More recently, since the year 2000, mean annual temperature has warmed by 0.8°C [2°F] in the northern Great Plains and by 0.4°C [1°F] in the southern Great Plains (Wuebbles et al. 2017). In the winter months, mean temperatures of the Great Plains have warmed by 2.5°C [5°F]. Daily record high temperatures have increased since the 1980s, prompting heatwaves and droughts, which are increasing in frequency and intensity, despite increasing precipitation (Wuebbles et al. 2017).

In the northern Great Plains, temperatures will rise 3–6°C [6–12°F] above current levels within the next 5–8 decades. Similarly, in the southern Great Plains, annual average temperature is projected to rise 1–2°C [2–4°F] in the near-term and 2–5°C [4–10°F] in the long-term. In south Texas, mean decadal temperature for the 2010s was 20°C [68°F], but that is expected to rise to 25°C [77°F] by 2050. Consequently, "megadroughts" that can persist for 10 30 years are becoming more likely (Cook et al. 2015). Megadroughts occurred during Medieval times (coinciding with a warmer global climate, the Medieval Warm Anomaly) that coincided with the fall of the Roman Empire (Harper 2017). The probability of drought on the Great Plains is predicted to increase from 40% to 95% with a 10 – 80% probability of a multi-decadal droughts by the late 21st century (Cook et al. 2015). Droughts compound the effects of rising temperature on both plant and animal growth to reduce productivity of the Great Plains.

Implications |

Animal body size largely determines relationships of longevity (life span), ecological interactions, energy budget (supply of forage = storage of fat + use for growth, metabolism, and maintenance), reproductive strategies (birthing rates and litters), and productivity (longevity, growth, and reproduction rates).

Life span (or longevity) of female *Bison* appear to decrease with declining body size at WICA: the 90th percentile of maximum age has declined from 21.5 years in 1970s, to 17.5 years in the 1980s, and to 16.5 years in the 1990s. However, it is unclear if this shift in age is an outcome of management — or climate change. Longevity scales with body mass of mammals, that is, as body mass decreases so does the expected lifespan across species. We are less certain of the relationship between longevity and body mass within species.

- Monitor the life span of your herd cows, it may be difficult because they live so long, but it may be a useful tool for future bison managers.

Our model predicts that under a future scenario of a MAT of 25°C [77°F] and PDSI of -5 (a forecasted scenario for the southern Great Plains), female bison will be 252 kg [555 lb]. Famoso et al., (2018) derived a threshold of 300–340 kg [660–750 lb] for all herbivorous mammals (ranging from mice to elephants), below which, mammals produce more than one offspring. For *Bison*, this shift in reproductive strategy may be indicated by simply smaller calves and/or an increased frequency of twinning. However, smaller calves from smaller mothers may be more vulnerable to harsh summers and

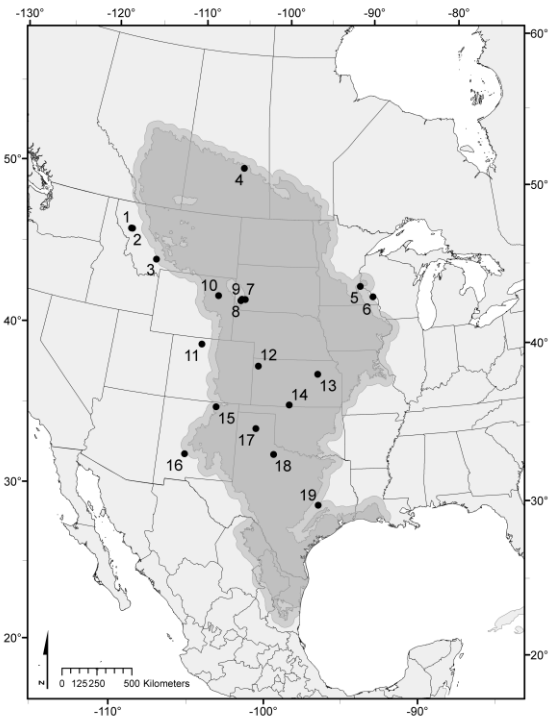

Figure 1. Map of 19 bison herds visited. Note: site #8 is Wind Cave National Park in the Black Hills of South Dakota.

winters.

- While not many producers and managers record the number of calves for each mother in a year, this might be something to monitor.

Discussion & Conclusions |

Our data suggest that growth of *Bison* is driven by temperature and drought. We predict that *Bison* body size is likely to decline over the next five decades along the Great Plains due to projected increases in temperatures and both the frequency and intensity of drought. Your *Bison* are sentinels of climate change impacts on the Great Plains and prairies of North America, in essence they are an indicator species of ecological change—let's listen.

- The bison community can monitor their herds to inform us all about the changing productivity of the Great Plains.

Our herd cows are most important assets we have.

1. As you recruit new homegrown herd cows into your herd, do not be surprised if they will not be as large as your older generations of herd cows used to be.
2. Similarly—rates of growth are likely to decline for 1.5 to 3-year-olds, whereas short-term rates of growth may appear to increase for calves to 1.5-year-olds (Figure 2).
3. Subsequently, not selecting for larger framed animals may be in your best interest; in fact, not selecting for size at all is in your best interest. Instead, select for sound posture, good legs, and conformation. Hardy animals that are able to lose less mass during winter and during drought may be most important for sustaining a herd.

Bison have changed their body size in response to climate change over the past 40,000 years (Martin et al. 2018), without management from humans. Our *Bison* will continue to adapt to climate change without our help, but we have the ability to be good stewards of bison and our lands for the next generations.

Last points to consider |

- Parasite load may increase because winter temperatures are warming,
- Monitor the frequency of twinning in your herds, shrinking herd cows through the generations may lead to more frequent twins for calves,
- Monitor the longevity (life spans) of your herd cows, smaller herd cows may lead to decreased life spans through generations.
- Lastly, if you have already started collecting this information over the past decade and are interested in sharing your data, please contact Jeff through the TBA staff.

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