

Bison Biogeography in Late Quaternary North America: Abundance, Distribution, and Climate

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Time: 20,000 to 0 years before present

Place: North America

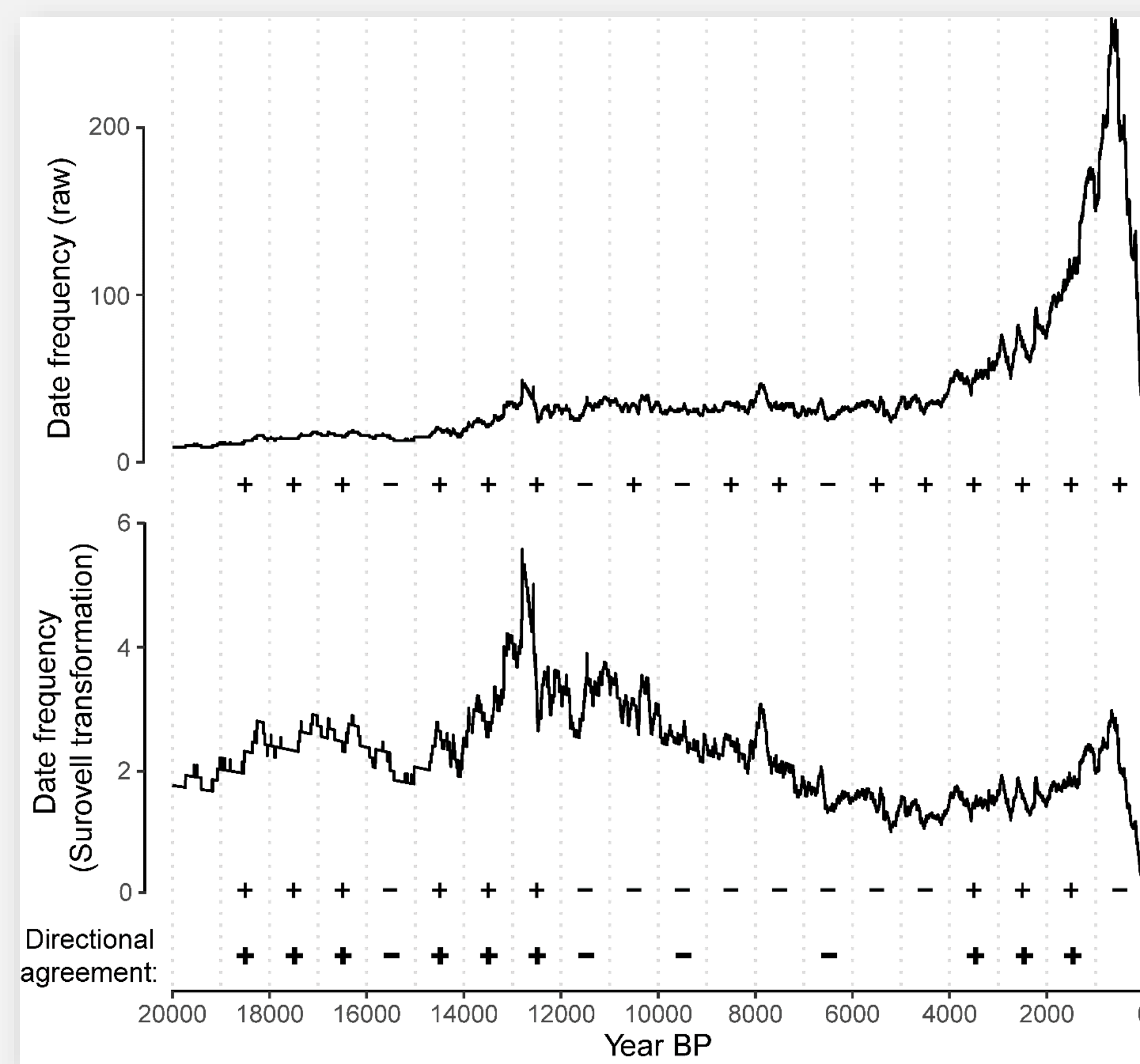
Bison observations: Archaeological and paleontological sites: Neotoma (731), CARD (1828), and primary sources (141)

Climate data: TraCE-21ka simulation with CCSM3

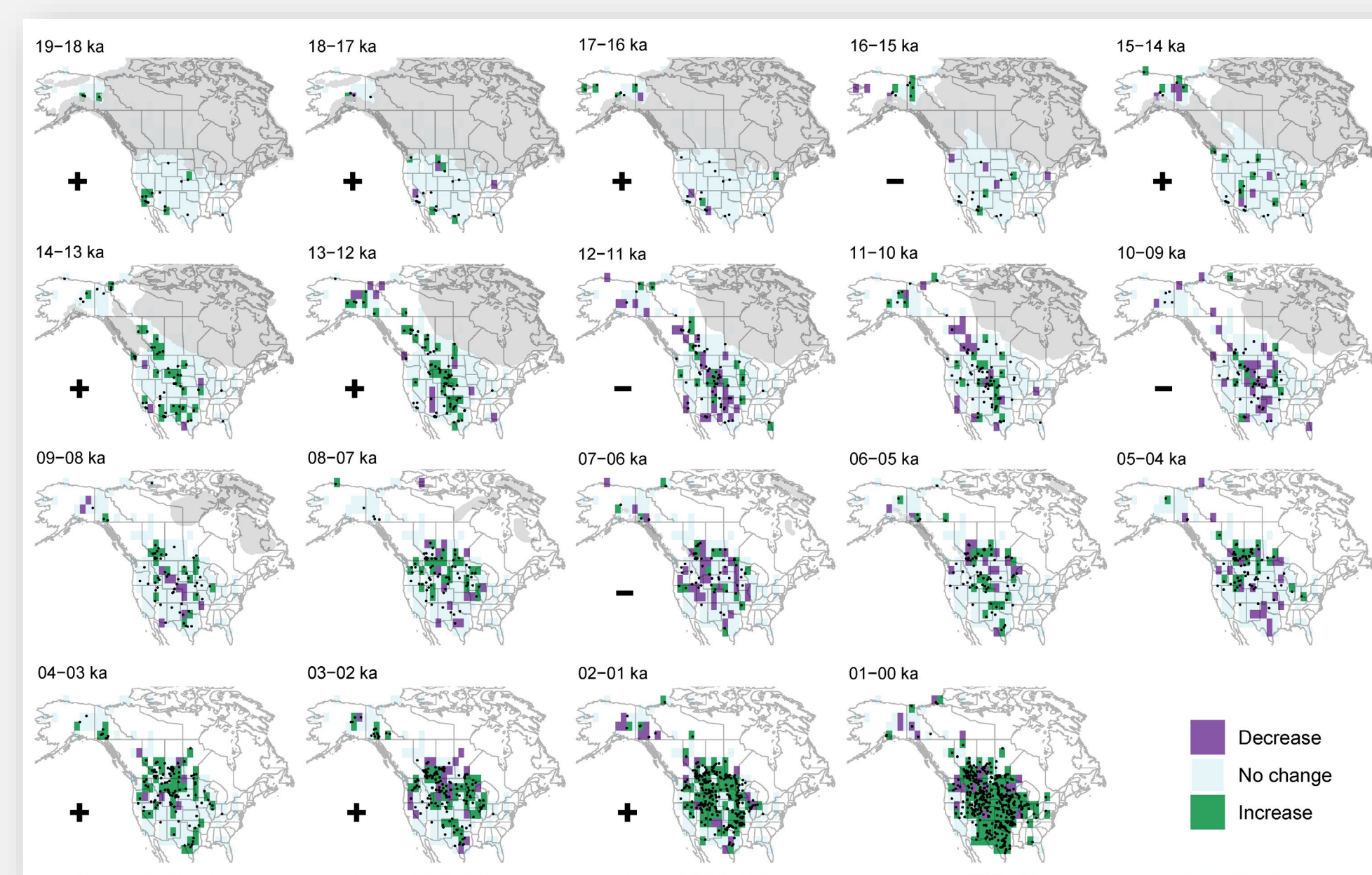
Distribution model: MaxEnt

ABUNDANCE

- Bison abundance was influenced by hydroclimatic shifts that affected the quality and availability of forage.
- Abundances decreased through the dry early Holocene and increased when moisture availability improved in the late Holocene.



Raw (top) and transformed (middle) frequency distributions of bison observations in North America 20-0 ka. Signs indicate whether mean frequencies increased (+) or decreased (-) relative to the prior 1000-year interval (top and middle) and whether there is directional agreement between raw and corrected frequency datasets (bottom).



Relative change in bison abundance based on raw bison site counts.

SELECTED REFERENCES

Fordham, D.A., Saltré, F., Haythorne, S., Wigley, T.M.L., Otto-Bliessner, B.L., Chan, K.C., Brook, B.W., 2017. PaleoView: a tool for generating continuous climate projections spanning the last 21 000 years at regional and global scales. *Ecography* 40, 1348–1358.

Goring, S., Dawson, A., Simpson, G., Ram, K., Graham, R., Grimm, E., Williams, J., 2015. neotoma: A Programmatic Interface to the Neotoma Paleocological Database. *Open Quaternary* 1, Art. 2.

Martindale, A., Morlan, R., Betts, M., Blake, M., Gajewski, K., Chaput, M., Mason, A., Vermeersch, P., 2015. Canadian Archaeological Radiocarbon Database.

Phillips, S.J., Dudík, M., Schapire, R.E., 2016. Maxent software for modeling species niches and distributions.

Surovell, T.A., Byrd Finley, J., Smith, G.M., Brantingham, P.J., Kelly, R., 2009. Correcting temporal frequency distributions for taphonomic bias. *Journal of Archaeological Science* 36, 1715–1724.

Hypothesis 1:

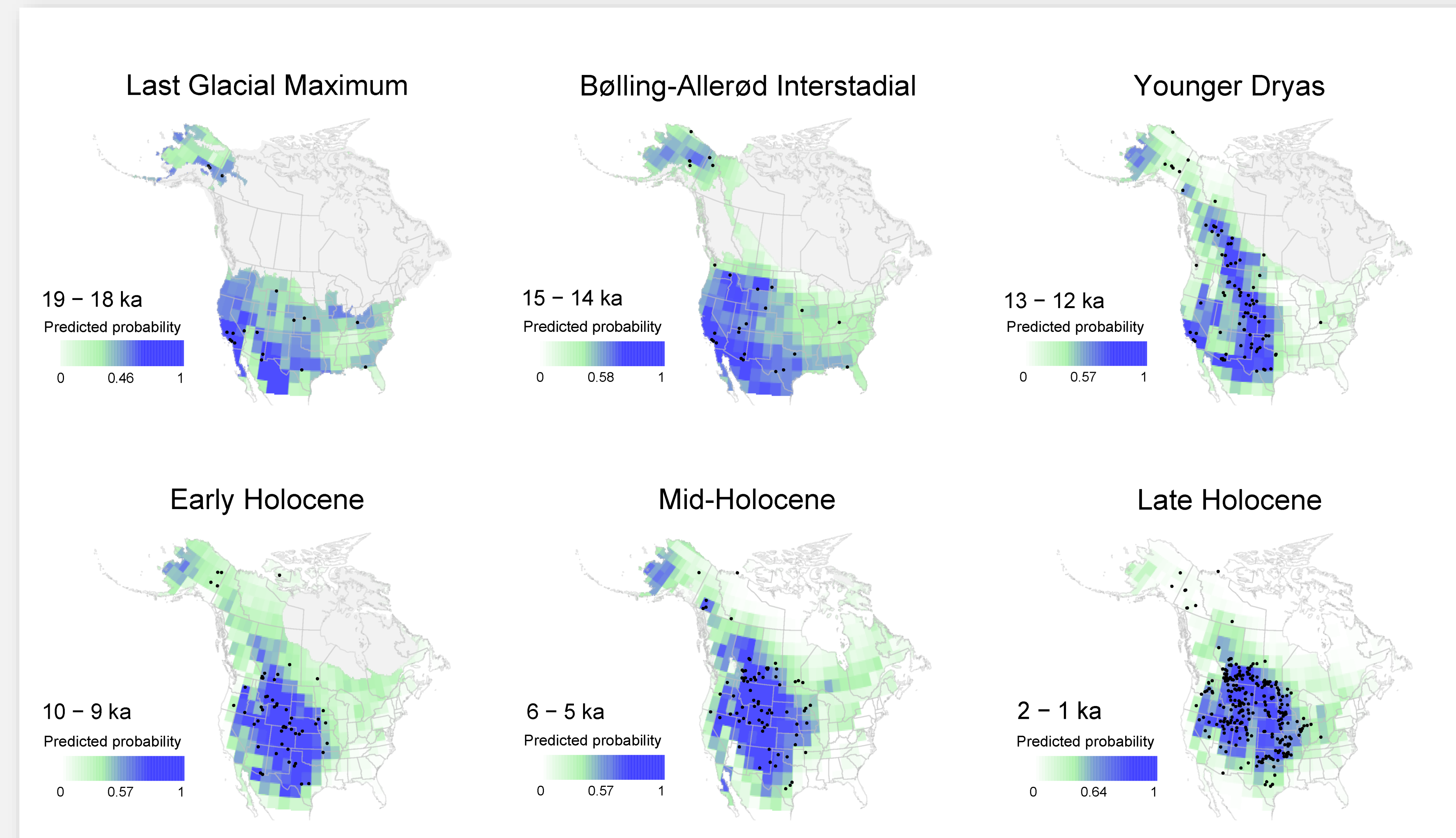
In open habitats, bison abundance will be positively correlated with moisture availability that indirectly influences the quantity and availability of grassland forage.

Hypothesis 2:

The geographic distribution of bison will respond to long-term changes in temperatures and associated hydrothermal stress.

DISTRIBUTION

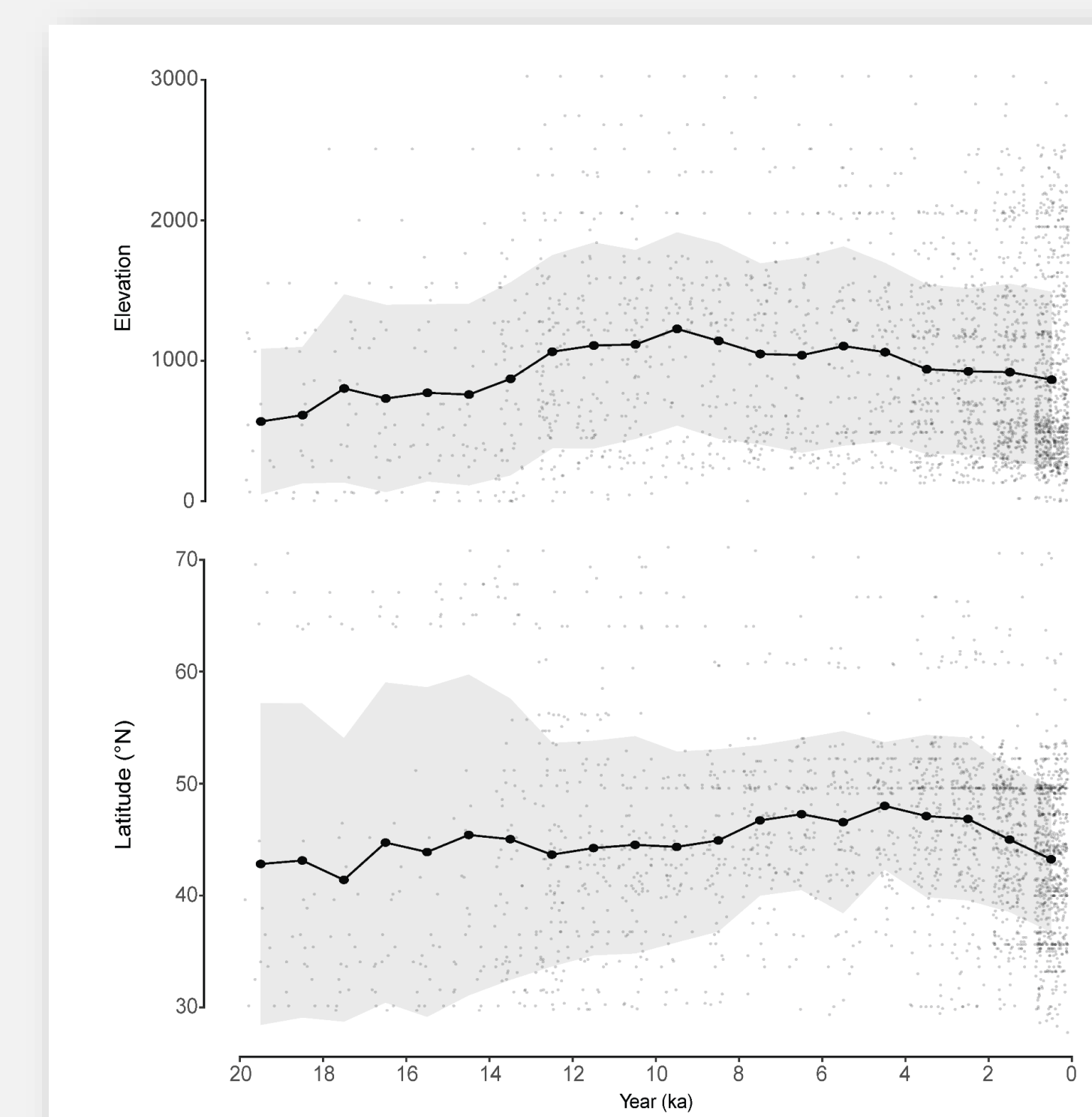
- Populations retracted from disjunct Pleistocene refugia and congregated in midcontinent rangelands.
- Bison persisted throughout much of the Intermountain West and Great Plains.
- Bison expanded into the ice-free corridor by 13.5 ka.
- Bison distribution tracked the expansion of prairie assemblages at the grassland-forest ecotone.



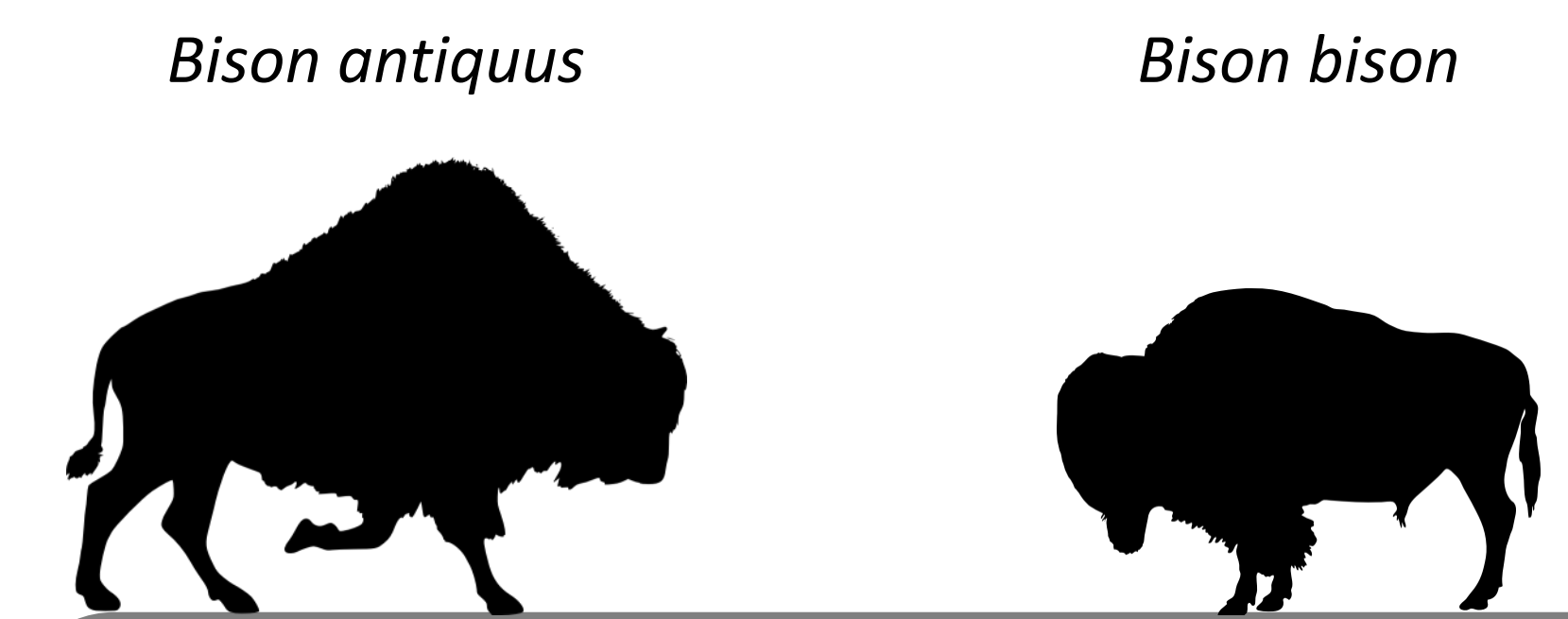
Geographic representation of modeled bison distributions at key intervals between 20-0 ka. The number on each scale identifies the predicted probability threshold for separating bison presences (blue) from absences (green and white). Observations (bison sites) shown as points (black).

Interval (ka)	AUC	Threshold (sensitivity = specificity)	Observations
20-19	0.65	0.63	11
19-18	0.81	0.47	18
18-17	0.76	0.55	20
17-16	0.76	0.61	24
16-15	0.79	0.57	23
15-14	0.74	0.58	27
14-13	0.73	0.56	58
13-12	0.84	0.54	85
12-11	0.79	0.65	70
11-10	0.80	0.54	73
10-9	0.82	0.59	55
9-8	0.86	0.57	64
8-7	0.87	0.54	78
7-6	0.87	0.54	69
6-5	0.86	0.54	78
5-4	0.91	0.39	93
4-3	0.88	0.47	160
3-2	0.89	0.55	208
2-1	0.88	0.62	360
1-0	0.87	0.63	722

Summary of area under the curve (AUC), threshold value (sensitivity = specificity), count of observations used for model training, and count of background points for evaluation across all time intervals modeled.

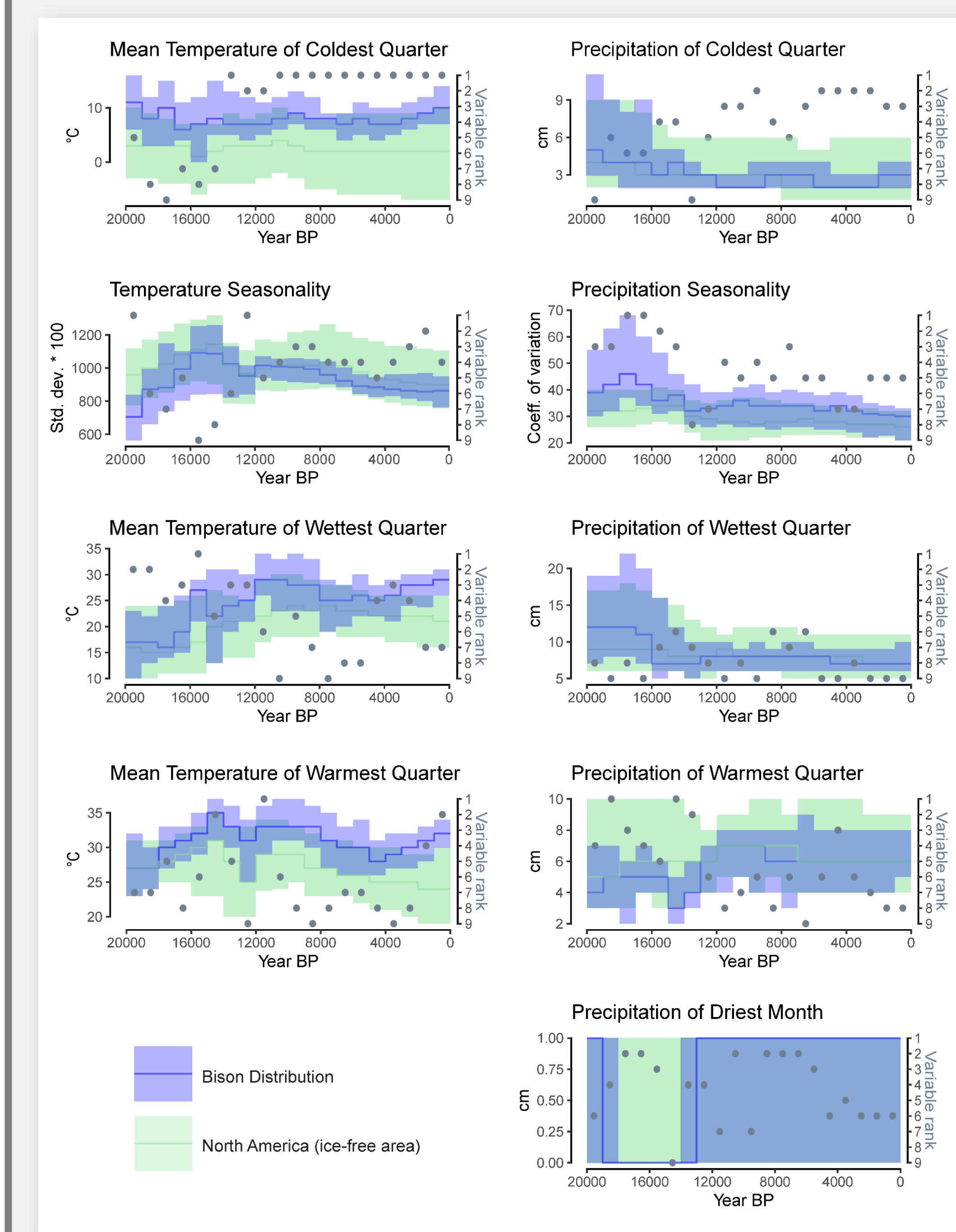


Elevation (top) and latitude (bottom) of bison observations (small dots) across 1000-year intervals between 20-0 ka. Summarized by mean (large black dots) and standard deviation (gray shading).



CLIMATE

- Distribution primarily defined by winter temperature since 14 ka.
- Bison experienced rapidly warming summer temperatures through the Pleistocene-Holocene transition.
- The climate space occupied by bison generally narrowed over time.



Simulated evolution of climate conditions and variable rank for each 1000-year interval since 20 ka. The distributions of climate variables within the model-defined distribution of bison (blue) and North America minus ice-covered areas (green) are summarized with the median (line) and 1st and 3rd quartiles (IQR; shading). Variable rank (dots) reflects the ranking of the percent contribution score relative to the other climate variables (right axis) within a given interval.

PUBLICATION

Wendt, J.A.F., McWethy, D.B., Widga, C., Shuman, B.N. *In press*. Large-scale climatic drivers of bison distribution and abundance in North America since the Last Glacial Maximum. *Quaternary Science Reviews*.



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