# Discussion

## A 5,500-Year Model of Changing Crop Niches on the Tibetan Plateau

### A Comment

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This paper was submitted 16 II 17 and accepted 13 III 17.

The article under review, by Jade d'Alpoim Guedes, Sturt W. Manning, and R. Kyle Bocinsky (2016), presents an agricultural thermal niche model that predicts the altitudinal distribution of staple grains on the Tibetan Plateau over the last 5,500 years. The authors demonstrate that cultivation of barley and wheat permitted agriculture to thrive on the Tibetan Plateau when the growing of millets was no longer feasible because of a cooling climate around 3500 BP. They review archaeological data illustrating how for 2,000 years foxtail and broomcorn millets were the primary cultivars in eastern Tibet before being replaced around 3500 BP by two newly introduced domesticates, wheat and barley. The authors' figure 2 charts the probability of millet cultivation between 3000 and 4200 BP, showing a downward altitudinal trend from 3,000 to 2,000 m, in a period corresponding with increasing cold and a reduction in East Asian summer monsoon intensity.

The agricultural thermal niche model devised by d'Alpoim Guedes, Manning, and Bocinsky (2016) presupposes that climatic conditions on the Tibetan Plateau from 5500 BP until the present favored river valleys <4,000 m asl. The authors state that 99.98% of contemporary cropland in Tibet is found below 4,000 m. One factor explaining why an exceedingly small percentage of agriculture is computed to be above 4,000 m is that the lower margin of the Tibetan Plateau was set by the authors at just 1,500 m asl, geographically extending it into the Tsaidam Basin and Loess valleys of the upper Yellow River Basin. Nevertheless, data used by the authors to determine that only .02% of agriculture occurs above 4,000 m appears to be of insufficient precision.

The sources of this statistic are given in supplementary materials attached to the authors' article. In order to model the geographical and altitudinal distribution of agriculture on the Tibetan Plateau, they relied on the Global Land Cover–SHARE Cropland database, version 1.0 (GLC-SHARE), created by the Food and Agriculture Organization. The GLC-SHARE database is purported to provide a picture of cropland on the Tibetan Plateau down to a 30″ (approximately 1 km) spatial resolution. However, too little cropland cover (appears as raster cells on map) is designated in central Tibet and western Tibet (see their fig. A1). My findings, based on extensive but anecdotal field observations and reference to topographical maps, contradict the claim in d'Alpoim Guedes, Manning, and Bocinsky (2016) that cropland in Tibet (except for .02% of the total) does not exceed 4,000 m asl.

In central Tibet (U-Tsang) and western Tibet (Changthang and Tö) cultivation of barley consistently occurs above 4,000 m. I estimate that 15%–20% of cropland in east central Tibet (U), 20%–25% in west central Tibet (Tsang), and 25%–30% in western Tibet (Tö) occur at elevations exceeding 4,000 m. Moreover, in Spiti (India), on the western fringe of the Tibetan Plateau, barley is cultivated up to 4,400 m asl. The highest-altitude barley-growing enclave in Tibet is located on the east shore of Lake Dangra, in the middle of the interminable plains of the Changthang. Here barley thrives in a string of villages high above the lake at 4,580 to 4,740 m asl. I estimate that 70%–80% of present-day cropland in central Tibet and western Tibet is situated above 3,300 m elevation.

Eastern, central, and western Tibet possess varying degrees of continentality or removal from oceanic effects moderating climate. The increased level of continentality, as defined by a greater mean annual temperature range from east to west, on the Tibetan Plateau has a positive correlation with altitudinal limits to barley cultivation. On the Tibetan Plateau, greater continentality results in higher warm-season temperatures and longer growing seasons above 4,000 m in the central and western regions. Central Tibet is more continental than eastern Tibet because of the Himalayan barrier, which blocks most atmospheric moisture generated by the Indian Ocean. Continentality is even more pronounced in western (upper) Tibet, with its multiple rain-shadow effect created by the Himalayan and Karakorum ranges. This is the most arid portion of the Tibetan Plateau and the one with the greatest seasonal temperature variability. Latitudinal range of most agricultural regions on the Tibetan Plateau is the same (27.5° to 34°N lat) and does not appear to be a pivotal factor in determining altitudinal constraints to cropland from east to west, except the northeastern portion (34° to 37.5°N lat).

In addition to significant biogeographical differences and variations in continentality from east to west, other major geographic factors potentially influencing the limits of barley cultivation on the Tibetan Plateau are mountain-mass effect (temperature-related phenomenon of higher snow lines and tree lines in the interior portion of mountain ranges) and aspect (physical and biotic effects caused by the direction a slope faces). D'Alpoim Guedes, Manning, and Bocinsky (2016) acknowledge that temperature inversions and cold-air flows down valleys might affect cropland distribution; however, they do not attempt to factor these microclimatic effects into their model because of insufficient meteorological data for the Tibetan Plateau. A study by Dong et al. (2015) suggests that genetic vari-

 0011-3204/2017/5804-0007$10.00. DOI: 10.1086/692995

ability and agricultural practice may possibly account for barley cultivation above 4,000 m asl. Nevertheless, it appears that continentality and its pronounced effects in middle latitudes is the crucial factor in determining altitudinal limits to barley cultivation in the eastern, central, and western portions of the Tibetan Plateau.

Only by pursuing quantitative approaches that take into consideration both continentality and altitude and the full purview of other contributing factors can an agricultural thermal niche model be developed that accurately and consistently predicts upward limits to agriculture and barley cultivation across the Tibetan Plateau over time. For the contemporary period, empirical validation is crucial. Thus, the agricultural thermal niche model employed by d'Alpoim Guedes, Manning, and Bocinsky (2016) should be amended to include data from agronomic surveys of barley cultivation on the Tibetan Plateau as well as a more encompassing cultural and geographic perspective on the region.

## References Cited

d'Alpoim Guedes, Jade, Sturt W. Manning, and R. Kyle Bocinsky. 2016. A 5,500-year model of changing crop niches on the Tibetan Plateau. *Current Anthropology* 57(4):517–522.

Dong, Guanghui, Dongju Zhang, Xinyi Liu, Fengwen Liu, Fahu Chen, and Martin Jones. 2015. Response to comment on "Agriculture facilitated permanent human occupation of the Tibetan Plateau after 3600 B.P." *Science* 348(6237):872c.