Appendix B: Processing of remote-sensing data.

Our remote sensing methodology follows that of Hirota et al. (2011) and Staver et al. (2011). Tropical Rainfall Measuring Mission (TRMM) 3B43 monthly precipitation estimates (0.25 degree grid spacing) were used to calculate mean annual rainfall R (mm yr^{-1}) over the period 2000 to 2010 inclusive (Nicholson et al. 2003). Tree cover estimates for the period November 2000 to November 2001 were taken from MOD44B collection 3 (Vegetation Continuous Fields (VCF) at 500 m resolution) (Hansen et al. 2003). Grass cover was estimated (as discussed below) from monthly Normalised Difference Vegetation Index (NDVI) data over the same period (MOD13A3 Vegetation Indices at 1 km resolution). Mean annual evapotranspiration (ET) E was calculated from MOD16A3 annual ET estimates over the period 2000 to 2010 (1 km resolution) (Mu et al. 2011). The latter three datasets are derived from Moderate Resolution Imaging Spectroradiometer (MODIS) measurements. Data was extracted at 1 km resolution (higher resolution layers were averaged), to avoid averaging over important environmental gradients and tree-cover inhomogeneities. The geographical region was most of Africa, South America and Australia between 30 degrees south and 20 degrees north, filtering out areas with high (> 1200 m) elevation (Staver et al. 2011) using the GTOPO30 elevation layer, as well as flooded land, shrubland or agricultural areas using the GLC2000 land use layer (codes $7, 8, 11, 12, 15-18, 20-22$)(Bartholomé and Belward 2005). The western part of the Gran Chaco region (between 60 and 66 degrees west and 18.5 and 30 degrees south) was excluded from the analysis as it contains large areas of dry forest with a dense shrub subcanopy rather than grasses as our savanna model requires. Many samples from this region show up as a separate cluster of abnormally high tree cover at low E, although the majority fit well with the continental patterns shown in the text. The final dataset included 500000 sites from Africa and South America (each), and 400000 in Australia, randomly sampled.

MOD44B VCF estimates peak tree cover (defined as woody vegetation over 5 metres tall). VCF tree cover does not include the gaps within a tree crown and corresponds to approximately 80% of the projected tree crown cover fraction (Hansen et al. 2003). Although tropical savanna tree cover may have some seasonal variation, it is much smaller than for the herbaceous layer (see text). Thus, f_t in a pixel was estimated as VCF divided by 0.8, or set to 1, whichever was smaller. Seasonally-averaged grass cover (f_g) was estimated as follows. The seasonally-averaged total projected vegetation fraction $f_t + f_g$ was estimated using a simple NDVI linear mixture model (Zeng et al. 2000), $f_t + f_g = (N_{\text{avg}} - N_s)/(N_v - N_s)$ where N_{avg} is seasonally averaged NDVI in a given pixel, N_s is the NDVI of bare soil, and N_v is the NDVI of dense vegetation. We set $N_s = 0.1$ which is the NDVI of a prominent, seasonally-invariant spike in the African NDVI histogram corresponding geographically to the southern reaches of the Sahara, north of the Sahel. Our dense vegetation estimate $N_v = 0.82$ was chosen such that the number of sites assigned a total vegetation fraction of 1 was comparable to the number of sites with VCF tree cover greater than 0.8. Grass cover was then estimated as the difference between total vegetation and f_t, or set to 0, whichever was larger. The resulting fractional cover estimates were sufficient for discerning the broad continental patterns in fractional cover.

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