SUPPLEMENTARY MATERIAL

ESTIMATION OF ANPP AND NSP ACROSS THE RÍO DE LA PLATA GRASSLANDS

For the estimation of beef production across the Rio de la Plata Grasslands (RPG) a two steps analysis was performed. First, based on the radiative model proposed by Monteith (1972), we estimated the aboveground net primary productivity (ANPP) as the product between the solar incoming photosynthetically active radiation (PARi), the fraction of the photosynthetically active radiation intercepted by green vegetation (fPAR) and the radiation use efficiency to convert the absorbed radiation into biomass (RUE). To do so three land use and land cover classifications of the RPG were used to identify areas in which grassland cover was located. The three land use/land cover used were: 1) Copernicus Global Land Cover Classification developed by European Space Agency (ESA) (Buchhorn et al. 2020) for the year 2019 and which present a spatial resolution of 100 m, 2) Land use land cover classification of the Rio de la Plata Grasslands for the year 2012-2013 which identify perennial forage resources at pixel MODIS scale (~250 m) (Baeza and Paruelo 2020), and 3) MapBiomas Pampa and Atlantic Forest Tinational initiatives (Souza et al. 2020; Vallejos et al. 2021; Milkovic et al. 2021) for the year 2019, which provide a land cover and land use map on a 30 m scale (https://mapbiomas.org/). Within each land-use map, and only for areas labelled as grasslands, savannas, wetlands and shrublands, information of solar incoming photosynthetically active radiation and the spectral index EVI (Enhanced Vegetation Index) were obtained monthly from 2001 to 2020 through the web platform Google Earth Engine (Gorelick et al. 2017). PARi data was obtained from ERA5-Land dataset (Muñoz Sabater 2019), which provide monthly-mean averages of surface net solar radiation at global scale from 1981 to present. A scale factor to convert units from $J.m^{-2}.day^{-1}$ to $MJ.m^{-2}.month^{-1}$ was applied. Also, we considered that the photosynthetic active radiation was 48% of the total incoming solar radiation (McCree 1972). EVI spectral index was obtained from the MODIS satellite mission. Specifically, we used the MOD13Q1 synthetic product, which provides data at a 5.3 ha spatial resolution on a 16-day frequency. EVI data was transformed to fPAR using a locally-calibrated equation: fAPAR = 1.4914 * EVI – 0.1382. Finally, the product between PARi ($MJ.m^{2}.month^{-1}$) and fPAR, the amount of energy absorbed by active vegetation (APAR), was converted into ANPP using the following equation: ANPP (g $DM.m^{-2}.month^{-1}$) = -0.1978 + APAR * 0.4227 * 10. Monthly ANPP data was integrated to the annual scale and expressed in kg $DM.ha^{-1}.yr^{-1}$ through the multiplication by 10. The fitted model to convert from EVI to ANPP was developed by the Laboratorio de Análisis Regional y Teledetección (LART)-IFEVA-CONICET belonging to the Faculty of Agronomy - University of Buenos Aires.

The second step of the analysis consisted in using the ANPP estimations to quantify the beef production across the RPG. To do so, two sources of data (Irisarri et al. 2014 and Gutierrez et al. 2020) were combined to cover the entire ANPP gradient of the RPG. Irisarri et al. (2014) included data from 113 farms arranged into 19 groups according to their mean annual precipitation and geographic location. For this study, we selected 6 groups that corresponded to the ones in the lowest extreme end of the ANPP gradient. Gutierrez et al. (2020) included data from 19 administrative sections from the Basaltic geomorphological unit, within the Campos physiognomic unit of the RPG, located in the highest end of the ANPP gradient. Both sources of data included ranches devoted to either sheep, cow-calf operations and in a minor proportion dairy system. At the same time both, net secondary production (NSP) and ANPP were originally expressed in terms of energy units, $kJ.m^{-2}.yr^{-1}$. NSP was transformed to beef production, expressed in kg $LW.ha^{-1}.yr^{-1}$, through the following constant: 9900 $kJ.kg\ LW^{-1}$. For ANPP we used the conversion factor of 16760 $kJ.kg\ DM^{-1}$.

Beef production, expressed in kg $LW.ha^{-1}.yr^{-1}$, was positively associated with ANPP, expressed in kg $DM.ha^{-1}.yr^{-1}$, across the ANPP gradient observed for the RPG (Figure A1). A particular feature of the fitted model indicates that a unit change in ANPP generates a more than proportionate change in beef production. Because of this pattern the conversion of ANPP dry matter into live weight decreased from more than 100 kg DM per kg of live weight, for sites below 2500 kg $DM.ha^{-1}.yr^{-1}$ of

ANPP, to 80 to 60 kg of DM per kg of LW or even less than 60 kg of DM per kg of LW for sites located above 4500 kg DM.ha^{-1}.yr^{-1} of ANPP (Figure A1).

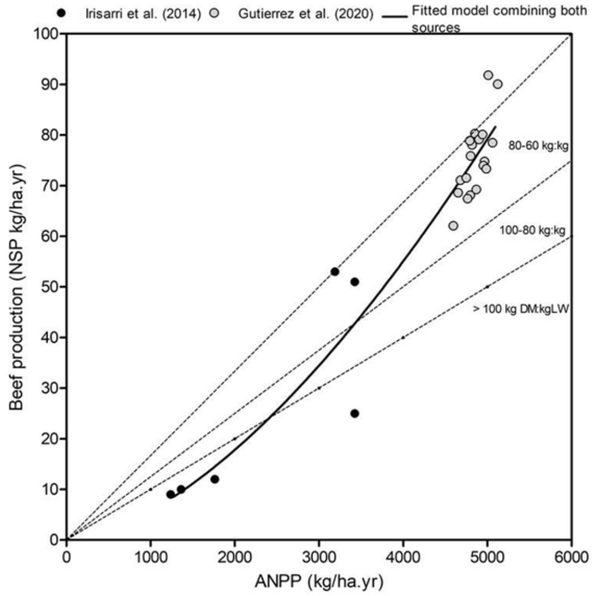

Figure A1. Relation between beef production (BP) and ANPP (in kg.ha^{-1}.yr^{-1}) according to the following fitted model BP = 0.00007489 * ANPP ^ 1.6164174 (n: 25; Adj. R2: 0.92; p-value < 0.0001). Beef production and ANPP were obtained from two sources, Irisarri et al. (2014) and Gutierrez et al. (2020). Through these two sources we included data from arid to humid rangeland within RPG. Each dot represents the average beef production for an area not less than 10000 ha.

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