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Chamaillé-Jammes, S. and Bond, W. J. 2010. Will global change improve grazing quality of grasslands? A call for a deeper understanding of the effects of shifts from C_4 to C_3 grasses for large herbivores. – Oikos 119: 1857–1861.

Appendix 1

We here briefly present the simple vegetation component of the model, and provide references for a description of the GRAZPLAN herbivore model. The whole model runs at daily time-step.

Vegetation model

We modelled the dynamics of both green (G) and dead (D) grass biomass in day t+1 as follows:

$$G_{t+1}=G_t+R_t\left(r_G - c_G G_t\right) - \delta_G G_t - IG_t - IGSR_t SR$$

$$D_{t+1}=D_t+\delta_G G_t - \delta_D D_t - ID_t - IDSR_t SR$$

where R is daily rainfall (mm); r_G the rainfall-driven productivity at very low biomass (kg ha^{-1} mm^{-1}); c_G a unitless friction parameter which reduces growth with increasing biomass; δ_G a senescence rate of green grass to dead material, δ_D a decomposition rate of dead material – both may vary between the wet and dry season; green and dead grass have different digestibilities. IG and ID are the intake of the modelled individual cattle in green and dead grass respectively. IGSR and IDSR are the intake of one non-pregnant non-lactating cow in green and dead grass respectively. IG, ID, IGSR and IGSR are calculated at each time step from animal and forage characteristics using the animal model. SR is a stocking rate (i.e. a density of non-pregnant non-lactating cows) assumed constant over the course of the simulation.

Default parameter values were: r_G = 20 kg ha^{-1} mm^{-1}; c_G = 10; δ_G = 0.01 and 0.03 for the wet and dry season respectively; δ_D = 0.1 and 0.01 for the wet and dry season respectively; SR = 1 individuals ha^{-1}. Default digestibility of green grass was 0.8, and digestibility of dead grass was assumed to be 0.2 units lower than the green grass digestibility (apart from simulations presented in Fig. 1). The annual distribution of daily rainfall was built from the probability density distribution of a Weibull distribution, with parameters selected to represent a rainfall dynamics characteristic of semi-arid rangelands, with an alternation of wet ($R_t > 0$) and dry ($R_t = 0$) seasons.

The outcome of the simulated vegetation dynamics with default parameter values and in absence of grazing is presented in Fig. SI.1.

To build figures presented in the paper we run simulations with different values of:

1) green and dead grass digestibility.

2) grass productivity. We varied grass productivity by modifying the parameter r_G. r_G is directly linked to, but because of grass competition (parameter c_G) does not represent, annual productivity, which is more commonly measured in the field and easily apprehended. To establish the relationship between r_G and annual productivity we ran simulations of the vegetation in the absence of grazing and with the value of r_G to be evaluated, and calculated the actual annual productivity. Annual productivity was then used for the figures.

3) Dry-season senescence rate of green grass (δ_G).

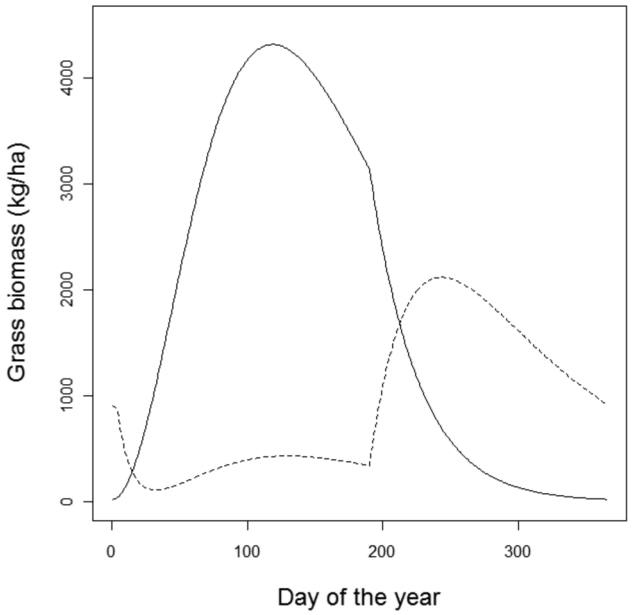

Figure SM. 1. Seasonal dynamics of green and dead grass biomass (continuous and dotted lines respectively) modelled using the default parameter values and in absence of grazing.

Animal model

To simulate cattle growth we used the GRAZPLAN model. It is a highly detailed, deterministic, model of forage intake and utilization for ruminants, which describes energy and protein assimilation and allows tracking animal weight change. The model is too complex to be described here and we refer the reader to Freer et al. (1997) and Freer et al. (2008) [for the revised version used here] where the mathematic formulation can be found. This model is widely used as an advisory tool for pasture management in Australia. Online information can be found at <www.grazplan.csiro.au>.

We used this model to simulate the weight growth of a just post-weaned cattle (initial body weight: 100 kg) until 24 months of age (with an adult standard weight of 450 kg). For simplicity we used the default parameter values for cattle, as published in Freer et al. (2008).

References

Freer, M. et al. 1997. GRAZPLAN: Decision support systems for Australian grazing enterprises – II: The animal biology model for feed intake, production and reproduction and the GrazFeed DSS. – Agric. Syst. 54: 77–126.

Freer, M. et al. 2008. The GRAZPLAN animal biology model for sheep and cattle and the GrazFeed decision support tool. – CSIRO Plant Industry Technical Paper. <www.pi.csiro.au/grazplan/files/TechPaperApr09.pdf> accessed May 2009.