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Relationship between rainfall and annual forage biomass to build a forage-balance guarantee system in Brazilian semiarid

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Introduction

Semiarid regions around the world are characterized by elevated annual evapotranspiration and irregular rainfalls (Creswell and Martin, 1998), resulting in a negative water balance in most part of the year. The high rainfall variability associated to a high pressure on natural resources generated a scenario of degradation, which is worrying for the future of many rangelands. In this sense, it is urgent to understand the processes involved in the sustainability of vulnerable ecosystems to keep them productive and profitable. Among the rural activities in the semiarid regions, the raising of livestock has been contributed to become the farms viable. To cope with this potential, it is necessary to develop a tool to quantify the rangeland production pattern in response to rainfall (Lukomska *et al*., 2010), thus, optimizing the use of the available natural resources. In this context, the aim of this study was to establish a relationship between rainfall and annual forage biomass in Brazilian semiarid rangelands, considering those variables as a base to maximize the potential of such a guaranteed production system.

Materials and Methods

Evaluations began with a literature review of information on estimated annual forage biomass (EAFB) production, in kg ha^{-1} $year^{-1}$, and the rainfall occurring in the same evaluation period, taking into account only exclusion areas and ecological sites that represent the variation in the Brazilian semiarid during 30 years ago. Annual rainfall ($mm \cdot yr^{-1}$) was regressed on and total forage biomass production ($kg \cdot ha^{-1}$) by using the SPSS program. ($P<0.05$ by F test).
From the expected rainfall data, rainfall randomly estimated from the historical local rainfall behavior, the tests of adherences of these series were conducted with different theoretical models of probability-distribution curves, according to the chi-squared test at the level of 5%. Subsequently, in checking the adjustment of the data, long synthetic series were generated, with 3,000-value simulations using Vensim PLE software.
Expected rainfall and EAFB was base for the simulations of response of the forage-biomass-supply adjustment system we used the Vensim PLE software, whose operating basis was the application of the basic concepts of systems dynamics, according to the simplified model shown in Fig. 1, adapted from Silva *et al*., (2013).

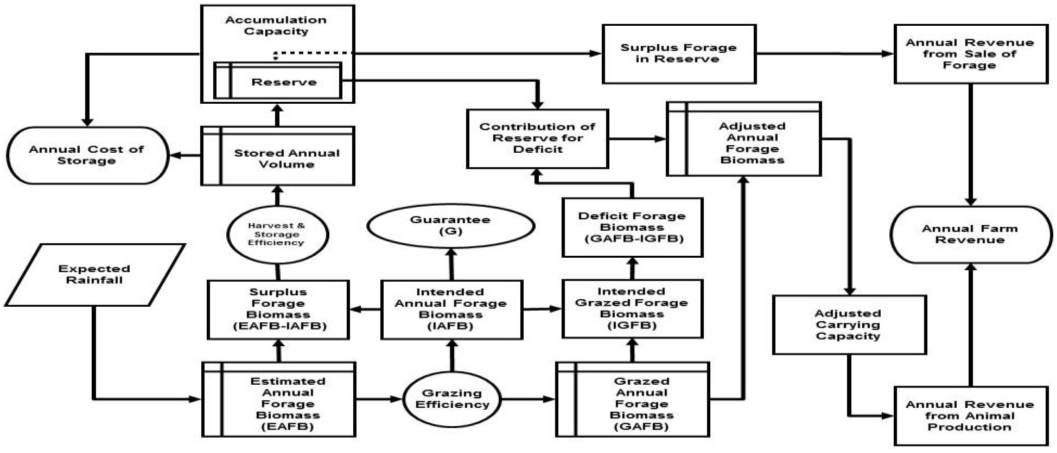

Fig. 1: Framework of the forage-balance guarantee system (Adapted from Silva *et al*., 2013).

In this model, the guarantee concept (G) was used to establish reliability in achieving forage supply. The guarantee concept is the long-term probability of success in providing supply during one year. The guarantee defines a certain level of success for a given level of forage supply, taking into account the variability in the expected rainfall as described in Campos (1996).

Results and Discussion

The Forage-Balance Guarantee System states that the variations in average and maximum rainfall values can cause variation in the Estimated Annual Forage Biomass (EAFB) in kg $ha^{-1}y^{r-1}$, which according to the type of probability distribution associated, must be took into account in the production system planning, as the decisions to be taken must respect each system potential, which in turn is related to the local prevalent rainfall condition.

Considering the relationship between estimated annual forage biomass (EAFB, kg $ha^{-1}yr^{-1}$) and expected rainfall (mm yr^{-1}), the model that best fitted ($P<0.05$) was quadratic (Fig. 2), where with the a maximum EAFB was of 2999 kg with when 1664 mm of rainfall was 1664 mm.

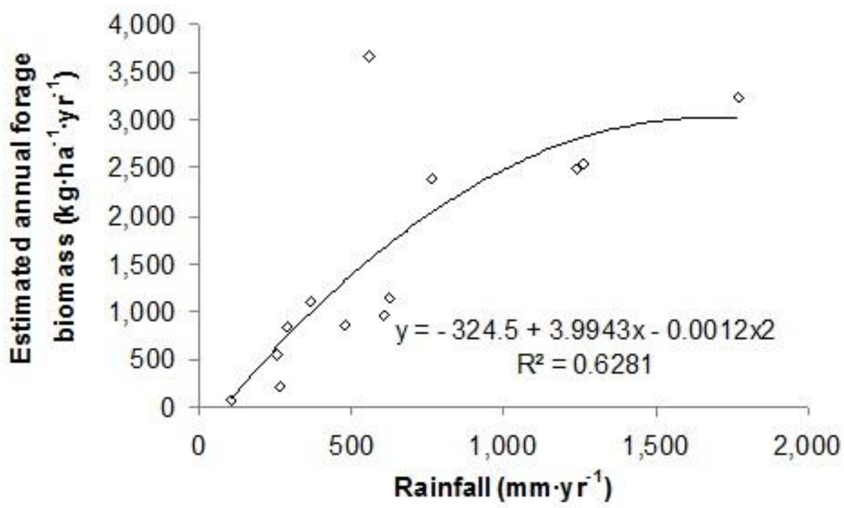

Fig. 2: Relationship between rainfall (mm yr^{-1}) and estimated annual forage biomass (kg ha^{-1} yr^{-1}).

This biomass behavior apparently discrepant from rainfall is a consequence of the prevalent soils in the studied region, as well as their, interactions with the climate and the plants evolved in this ecosystem (Silva *et al*., 2013).

The soils in such a semiarid environment are weakly developed and are predominantly shallows, having a very low storage capacity and a high risk to runoff, that exacerbate the effects of the region characteristic irregular rainfalls, present in most years. This effect is stressed in very wet years when the effectiveness of the rainfall will be lower, because most of the water will be lost by the same reasons mentioned before.

Regarding to climate, the high potential evapotranspiration and the irregularity of the rainfall reduces its effectiveness. Also, the high intensity of some rains reduces the positive effects of the water because it is not balanced with the plant demand, causing high humidity stress.

From the plant side, the herbaceous layer is composed in most part of ephemerals, which may have finished their life span before this total rainfall has reached. On other hand, the woody layer can have stopped the growth as a consequence of inter and intraspecific competition for light and nutrients.

To sum up, the ecosystem resilience is directed to low rainfall years adaptation, making the years of exceeding rainfall to promote better the reservoirs refuel than the plant growth.

The high variability in EAFB as a consequence of the random rainfall pattern (Silva *et al*., 2011) makes the carrying capacity along the years highly unpredictable, so the use of a model summarized in Fig. 1, associated to the guarantee concept, permits the adoption of a carrying capacity adjusted by an accumulation capacity built in the farm, stabilizing the animal production in the long term, to a stated guarantee level.

Conclusion

The use of a model associated to the guarantee concept has proved to be useful to estimate an adjusted annual forage biomass, even in regions with high variability in rainfall.

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