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Forage Production Estimated Using In-Situ Ndvi

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INTRODUCTION: Native grasslands of Uruguay and Brazil are part of the largest biome in the region and provide valuable economic and ecosystem services. Despite its diversity and resilience, this kind of pastures show large variability on aboveground net primary productivity (ANPP) related to rainfall. In this context, the economic result of livestock enterprises based on native grasslands is associated with the ability to cope with climate variability. Therefore, the development of tools to predict forage production may have significant impacts to aid in the implementation of more sustainable grazing management practices.

Remotely sensed vegetation indices integrate measure of photosynthetic activity and canopy structure, which is useful in monitoring analysis among other studies (Huete et al., 2002). Normalized difference vegetative indexes (NDVI) are commonly used to evaluate plant growth, biomass, and nutrient content (Solari et al., 2008). Recent developments of portable optical sensors are complementary for the traditional satellite assessments, since it make possible detailed measurements of NDVI at ground level with higher spatial and temporal resolution. Therefore, comparative studies between grassland productivity and high-accuracy NDVI obtained from ground-based measurements could be an effective way to predict ANPP. In this study, we aim to evaluate the potential use of in situ NDVI measurements to estimate native grassland productivity from an irrigation-fertilization experiment and to select a multiple regression model combining ANPP and species composition data.

MATERIAL AND METHODS: Research was conducted from September 2014 to February 2015 in an experimental field near Tacuarembó, Uruguay (31.53´ S, 56.14´ W). The vegetation is typical basaltic grassland, dominated by C_4 warm-season perennial grasses mixed in a lesser extent with C_3 cool-sea-

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son perennial grasses. ANPP was assessed in an irrigation-fertilization split plot experiment with three replications. In the main plots (24 x 16 m) supplementary irrigation and rainfed treatments were placed, and in the split plots (8 x 4 m) seven combination of nitrogen-phosphorus fertilization treatments and one unfertilized control were located. Prior to each biomass evaluation, the percentage aerial cover of the dominant species was visually estimated in 5 squares of 0.25 m^2 in each split plot. Forage was harvested by clipping 3 central stripes of each split plot at five cm height and then dry matter content was estimated on a subsample of 200 g fresh weight which was oven dried at 70°C, until constant weight

Three cuts were made (corresponding to the growth periods of early spring, late spring and early summer) when fertilized treatments reached the 95 % of interception of the incident light (after 44 to 48 days of regrowth). In addition, every 7 to 10 days NDVI measurements were taken using the Greenseeker handheld sensor (NTech Industries, Ukiah, CA). To compare different growth periods, ANNP was expressed in a daily basis and NDVI values were weighted averaged considering the number of days between measurements. Regressions analyses, testing lineal, logarithmic and exponential relations were performed to establish relationships between NDVI and ANPP. In addition, we proceeded to test multiple lineal regressions between ANPP with NDVI incorporating the proportional cover of the two most dominant C_3 grasses in the pasture.

Results and Discussion: A positive and statistically significant exponential relationship between ground-based NDVI and ANPP in all of the growth periods evaluated was found (Figure 1). The relationship between NDVI and ANPP was higher at the end of spring and early summer compared to early spring ($R^2 = 0.89$, $R^2 = 0.92$ and $R^2 = 0.63$, respectively). Analyzing the early spring relationship between NDVI and ANPP it was observed that most of the more distant points upper the slope line were those with the highest coverage of Bromus auleticus, the most dominant C_3 grass. When the coverage of Bromus auleticus (the most dominant C3 specie) was incorporated in a multiple regression model the coefficient of determination of the models turned higher (R^2= 0.85) resulting in the following equation:

Daily ANPP = -151.6 + 245.1NDVI + 0.84 *Bromus auleticus*

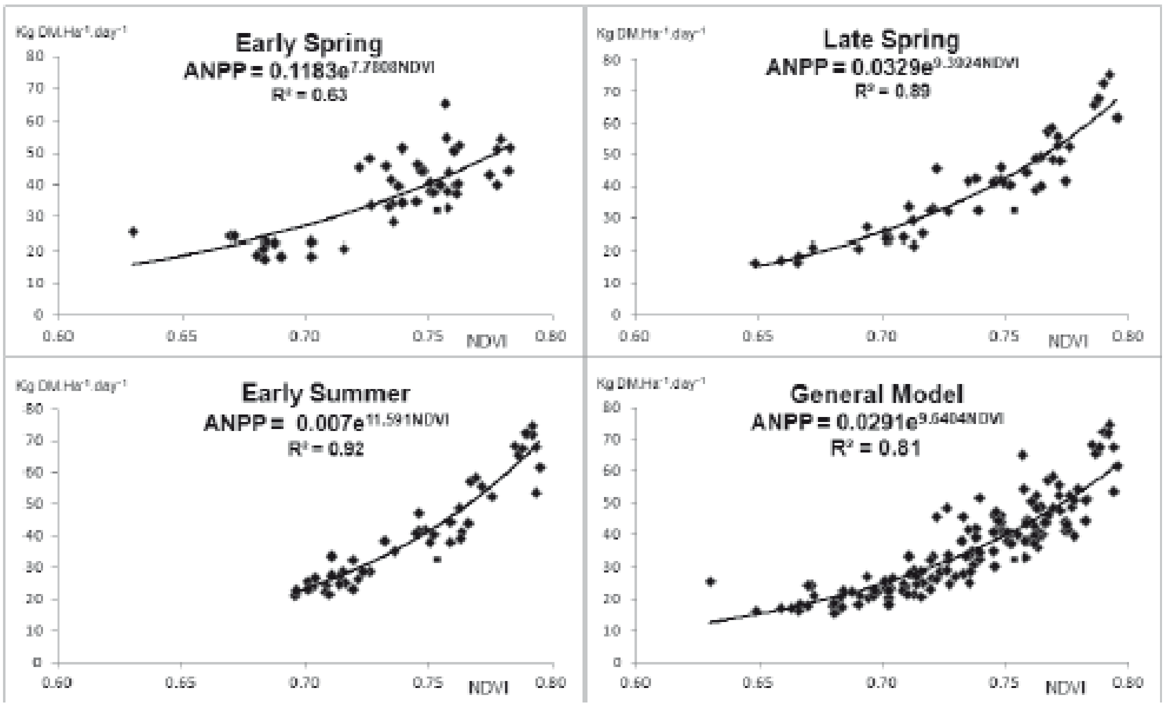

Figure 1. NDVI-ANPP relationships in early spring, late spring, early summer and a general model including all data.

Cool season C_3 grasses like *Bromus auleticus* are more active in the early spring, mainly in N fertilized treatments. This differential sensitivity of C_3 and C_4 grasses could be related to differences in phenologic stage and leaf nitrogen content, since these grasses have an asynchronous seasonal profile as reported by Foody and Dash (2007). Such effect, was important in this experiment only in the early spring period, characterized by a 2.4 C_4/C_3 species ratio. However, the species composition does not influence the NDVI-ANPP relationship in late spring and early summer, due to the C_4/C_3 species ratio increased to 7.1 and 11.5 respectively.

CONCLUSIONS:

- Our results suggest that ground-based NDVI assessments make possible an accurate description of the variability of native grassland ANPP through simple and stable relationships that could be used in different periods of the growing season.

- Deviations of the general model may be expected for grasslands with high proportion of C_3 grasses, however it can be adjusted including this variable in multiple regression models.

- The present findings revealed the potential of a new tool that would help in forage planning for a more sustainable management Nonetheless, more research is needed in order to validate the proposed general model in seasons and years with different climatic conditions and in different grasslands types with contrasting C_4/C_3 species ratios.

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