Incidence of Agro-Climate Variability over Grass-Fed Cattle Markets

(Selected Poster # 10313)

Bruno A. Lanfranco[1] & José Pedro Castaño[2]

1- Senior Researcher (PhD). Agricultural & Applied Economics. National Agriculture Research Institute of Uruguay (INIA)

2- Assistant Researcher. Research Unit of Climate and Geographic Systems (GRAS). National Agriculture Research Institute of Uruguay (INIA)

Poster prepared for presentation at the Agricultural & Applied Economics Association 2010 AAEA,CAES, & WAEA Joint Annual Meeting. Denver, Colorado, July 25-27, 2010

INCIDENCE OF AGRO-CLIMATE VARIABILITY OVER GRASS-FED CATTLE MARKETS

Bruno A. Lanfranco - José P. Castaño

INIA-Uruguay – bruno@inia.org.uy

Background

Inter annual and seasonal climate variability is an important source of economic risk in agricultural production. The effects of this variability over grass fed livestock markets are reflected mainly on the supply side, as production largely depends on water and pastures availability for feeding the cattle. However, as the cattle production process may involve more than one firm in the chain, the effects are also manifested on the demand for feeder cattle.

Differences in soil types and average climate conditions among regions define different geographic and seasonal production patterns. Production systems, as well as markets, are well adapted to these permanent conditions. These expected variations are reflected by price differentials between cattle lots coming from different locations. However, the occurrence of unexpected variations in the prevailing climate conditions (temperatures and precipitations) determine adjustments in demand and supply through short-term price movements. In this case, including extreme climate events that depart from the normal behavior, these unexpected variations cause further market disequilibrium. Extreme events are hard to predict in length and magnitude, at least with sufficient anticipation or precision, carrying out potential damaging consequences that sooner or later are also reflected by markets. For instance, the lack of water for pastures and direct animal consumption derived from droughts constitutes a severe problem. Cattlemen are forced to sell animals for alleviating grasslands, as they cannot sustain normal stocking rates. On the other hand, rainfall excess may turn into floods reducing grazing areas, also affecting stocking rate capacity. Both situations cause excess supply, pushing down livestock prices.

The CONEAT Productivity Index (CI)

The CONEAT program was created during the decade of 1960 with the aim of setting, through a numeric index, the average productive capacity of farmlands in Uruguay and that of each individual rural property [1]. While its creation was due to the need of implementing a new tax regime, the index became also a reference for estimating the quality of a plot and it was used to compare its productive value against other plots with different productive capacity.

The CONEAT index expresses the relationship between the production capacity of a plot, measured in terms of meat and wool with the prevailing soil types composing the plot (Capurro, 1977; CONEAT, 1979). Although the index has some known limitations, the advantage of its use lies in its easy understanding by agents (farmers, agronomists, politicians, etc.) and it has been used ever since to compare rural land productivity and rural land value in Uruguay.

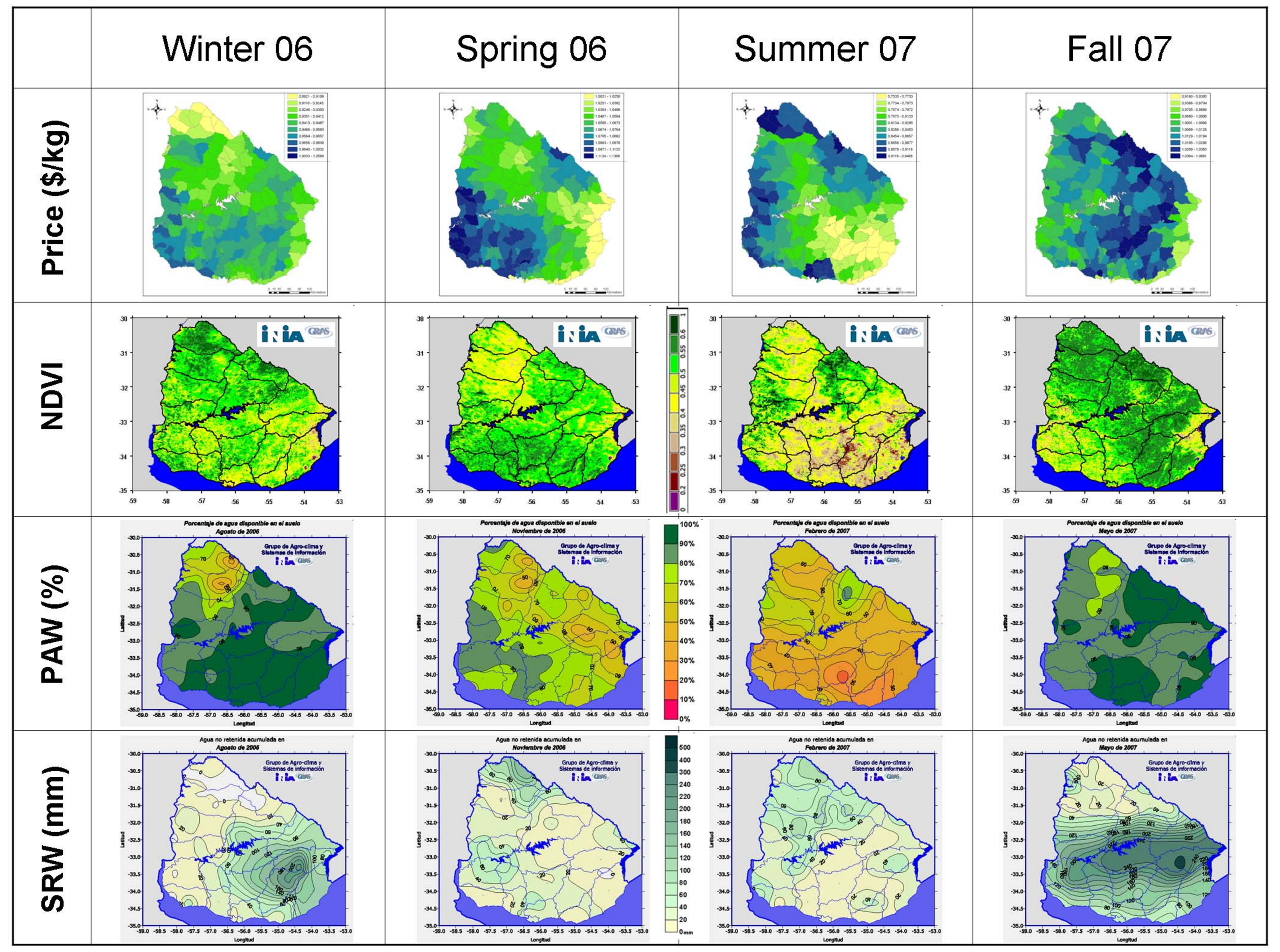
A value of CONEAT = 100 represents the average productivity level of rural lands in Uruguay. Thus, any soil with a productivity level equivalent to the national average was given the value 100. Values above and below 100 were assigned to each one of the 185 groups of soils that exist in the country, considering productive soil physical and chemical properties (depth, fertility, texture, drainage, slope). Thus, the CONEAT index of any plot or plots of any size can be calculated at any level (firm, district, region) by computing the weighted average value from soil composition. At the country level, this value adds to 100 by construction. In addition, there are correction factors considering relevant real estate characteristics such as distance to urban centers and location with respect to roads. This allows establishing a relationship between productivity and monetary value of rural lands (Lanfranco and Sapriza, 2009).

[1] Article 65 of the Law Nº 13,695, of October 24, 1968, which created the *Comisión Nacional de Estudio Agroeconómico de la Tierra*, CONEAT (National Commission for Economic Studies of Rural Land).

In a recent study, Lanfranco, Ois, and Bedat (2006) quantified the incidence of cattle traits, marketing strategies, and market conditions on beef cattle production in Uruguay, where 90% of the animals are raised and fattened under an "open sky" grazing system, from birth to slaughter. Regardless of a number of different variables found to determine the general behavior of cattle prices (size of the lot, live weight, sex, breed, class, frame, homogeneity, visual judgment, among other factors) the study remarked the existence of important seasonal and regional effects. Although these effects may be apparent to farmers and other agents of the production chain, no previous study centered the focus on identifying their causes and quantifying their real magnitude for grass fed livestock production systems.

Lanfranco, Ois and Bedat (2006) found differences between prices paid for lots of feeder cattle, depending on the geographic origin of the animals, *ceteris paribus*. They suggested that these differences were possibly masking the effects of a number of relevant variables, such as soil productivity, rainfall level (both averages and deviations), and prevailing production systems that may define nutritional aspects and cattle management issues. However, in this study, the origin of the cattle was identified using the main political divisions (*departamentos*) of the country, which are not homogeneous and certainly improper for identifying the effects of these variables. In addition, the seasonal effects were considered in terms of averages. Thus, the study was unable to clearly discriminate the effects of agro-ecologic and climatic variability. In particular, the authors suggested the inclusion of more appropriate variables in future studies for better capturing micro agro-climatic effects over cattle markets, either directly or combined through indexes.

Temporary Effects over Live Cattle Prices: State of Vegetation and Available Water



Water Balance Model for Soils of Uruguay (PAW)

The other tool used in the IDSS is the "Water Balance Model for Soils of Uruguay" developed by the INIA – GRAS, Unit jointly with the Water and Soils Department of the Ministry of Agriculture (MGAP) and the National Meteorology Direction of Uruguay. The model estimates the soil water content integrating the water precipitation data from 85 climate stations, the atmosphere water potential demand, the vegetation transpiration, and the water holding capacity of each soil type. This model runs daily and generates ten days and monthly means outputs in map format of: water runoff (mm), and soil water content (mm and %).

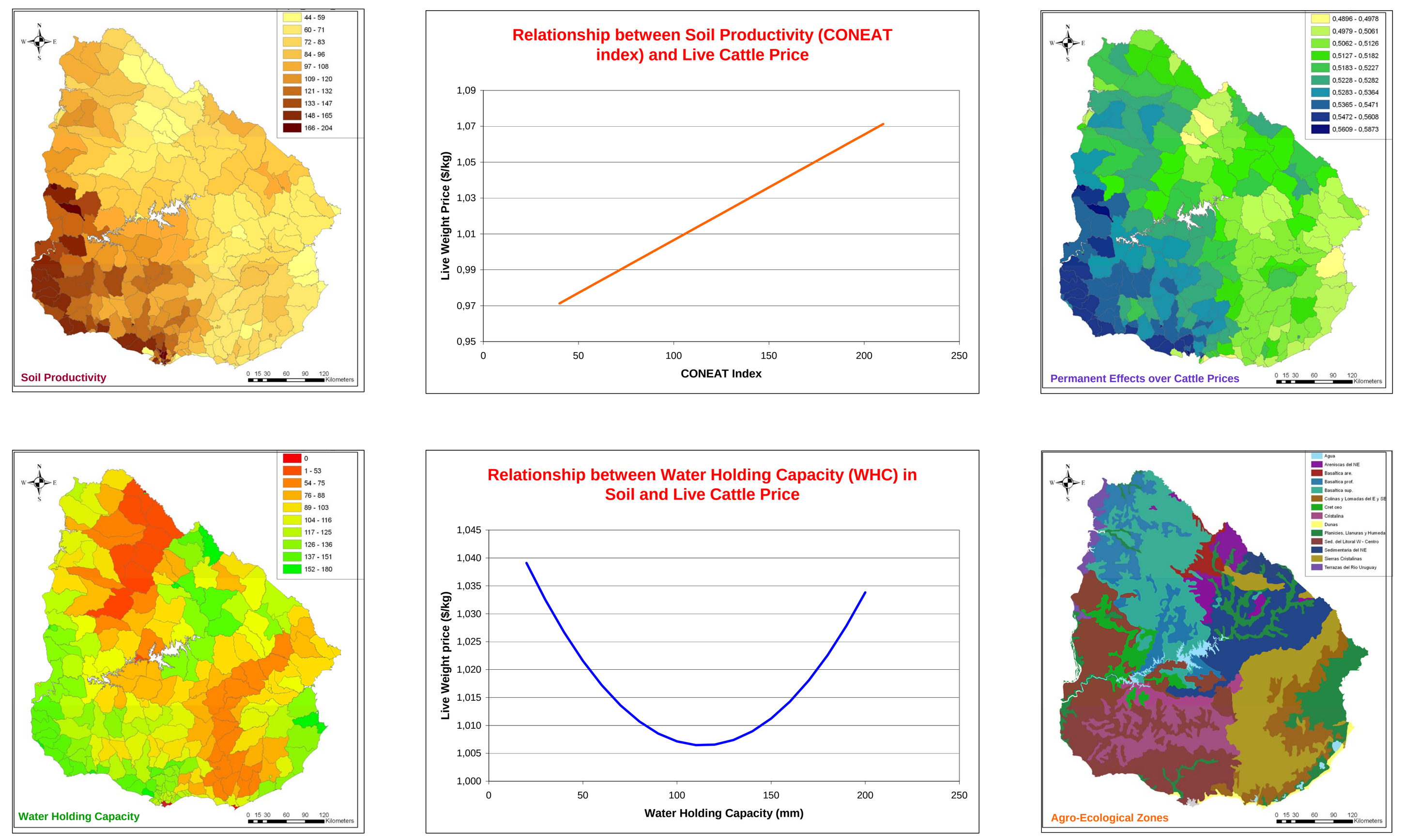
Percentage of Available Water (PAW)

Expressed in terms of percentage, the PAW measures the soil water content, with respect to field capacity (100%). Three-month average values of PAW estimated by the GRAS unite were used to run the model in this study.

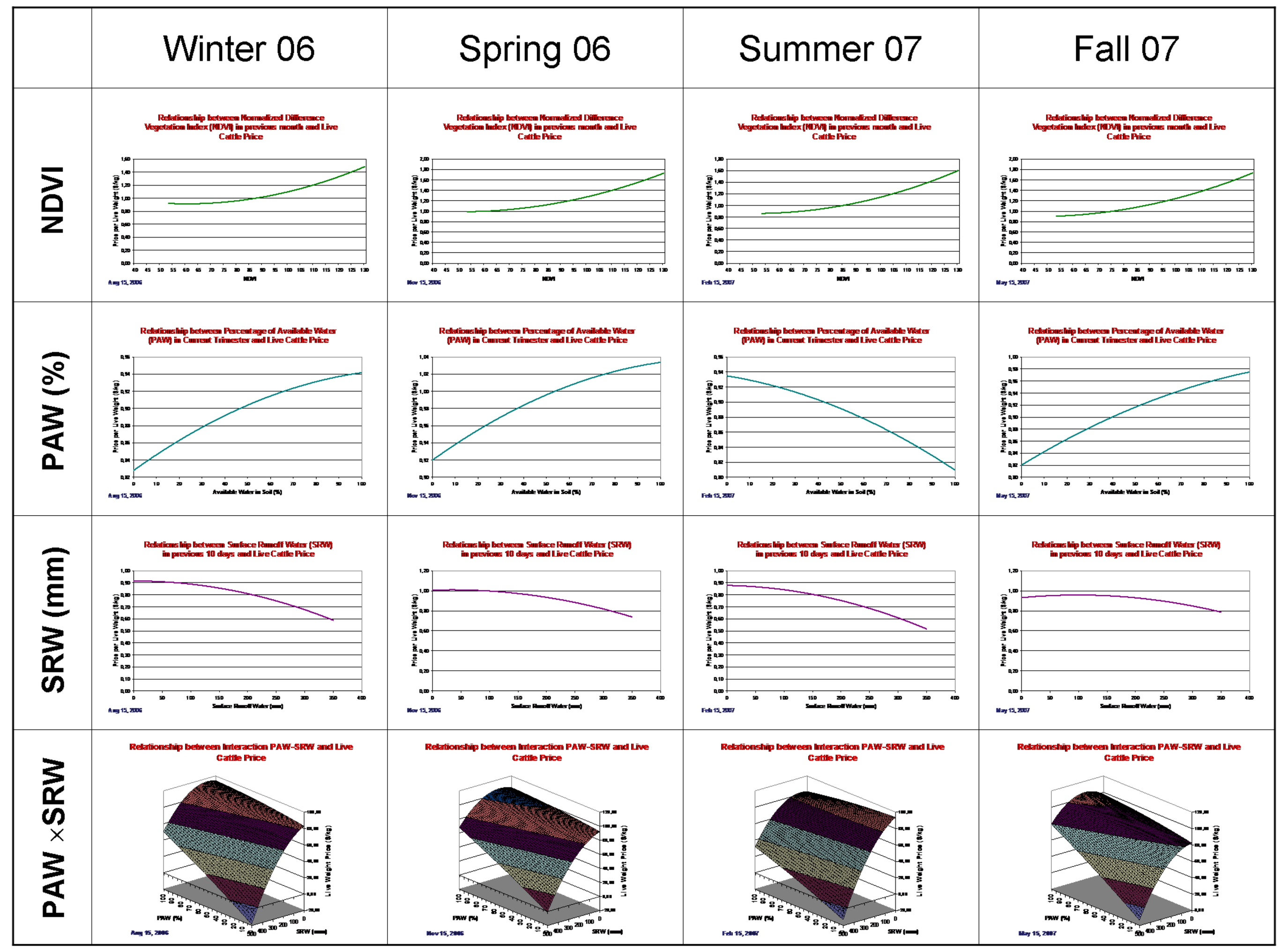
Surface Runoff Water (SRW)

This variable is estimated as the sum of surface runoff and excess water that is not retained in the soil, exceeding field capacity. Ten-day accumulated values of SRW estimated by the GRAS unit and expressed in millimeters (mm) were used to run the model in this study.

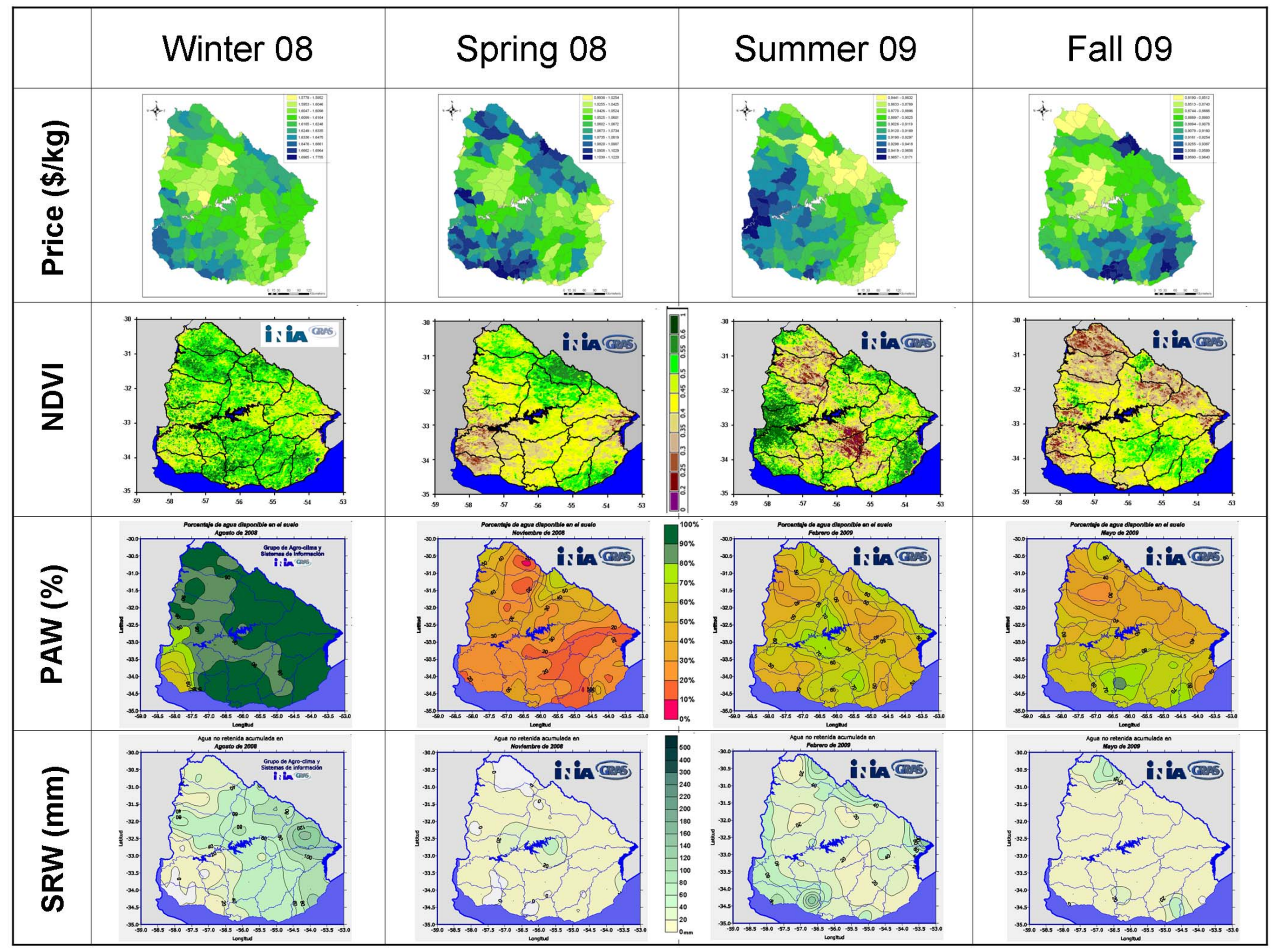
Permanent Effects over Live Cattle Prices: Soil Productivity and Water Holding Capacity



Relationship between NDVI, PAW, SRW, and PAW×SRW with Live Cattle Prices



Temporary Effects over Live Cattle Prices: State of Vegetation and Available Water



Objective

The objective of this study was the quantification of the effects of intra-annual and seasonal agro-climate variability over market conditions, for "open sky" livestock production systems such as those prevailing in Uruguay. Permanent conditions (soil type, including productivity and water storage capacity), pastures seasonal average growth cycles) will be discriminated from not permanent conditions (intra-annual and seasonal climate variability), identifying regional patterns using iso-price maps. The magnitude of the effects of the selected variables is reflected by their marginal contribution to the price received by cattle lots in the market at a certain point in time. Almost eight years of available per-lot trading information from live cattle video auctions is utilized to construct confidence intervals over the average price patterns. Information about abnormal intra-annual and seasonal variability, especially the occurrence of extreme events, will be used for monitoring unexpected changes and sudden short term cattle price movements.

Normalized Difference Vegetation Index (NDVI)

This index estimates the state of vegetation based on the measurement, with remote sensors, of the radiation intensity of certain bands of the electromagnetic spectrum reflected by the vegetation. Monthly NDVI values are periodically published by the Research Unit of Climate and Geographic Systems, GRAS (*Unidad de Agroclima y Sistemas de Información*) of the National Agriculture Research Institute of Uruguay, INIA (*Instituto Nacional de Investigación Agropecuaria*) [1] (INIA-GRAS, 2009). NDVI satellite data is downloaded from the NASA/ESDIS [2]. The NDVI is a normalized ratio of the red (R=0.58–0.68 mm) and near infrared (NIR=0.725–1.1 mm) spectral wavelengths. Fifteen-day maximum values of MODIS-NDVI are estimated from daily data collected along all the year. Fifteen-day NDVI imagery create a relatively cloud-free data set by choosing NDVI pixels from days (daily data) when radiance interference is lowest and sun angle is highest with the assumption that the selected pixel is most representative of actual ground reflectance (Holben, 1986).

[1] INIA-GRAS. http://www.inia.org.uy/gras).
[2] NASA's Earth Science Data Information Systems (ESDIS). Warehouse Inventory Search Tool (WIST) https://wist.echo.nasa.gov/api/

Data and Methods

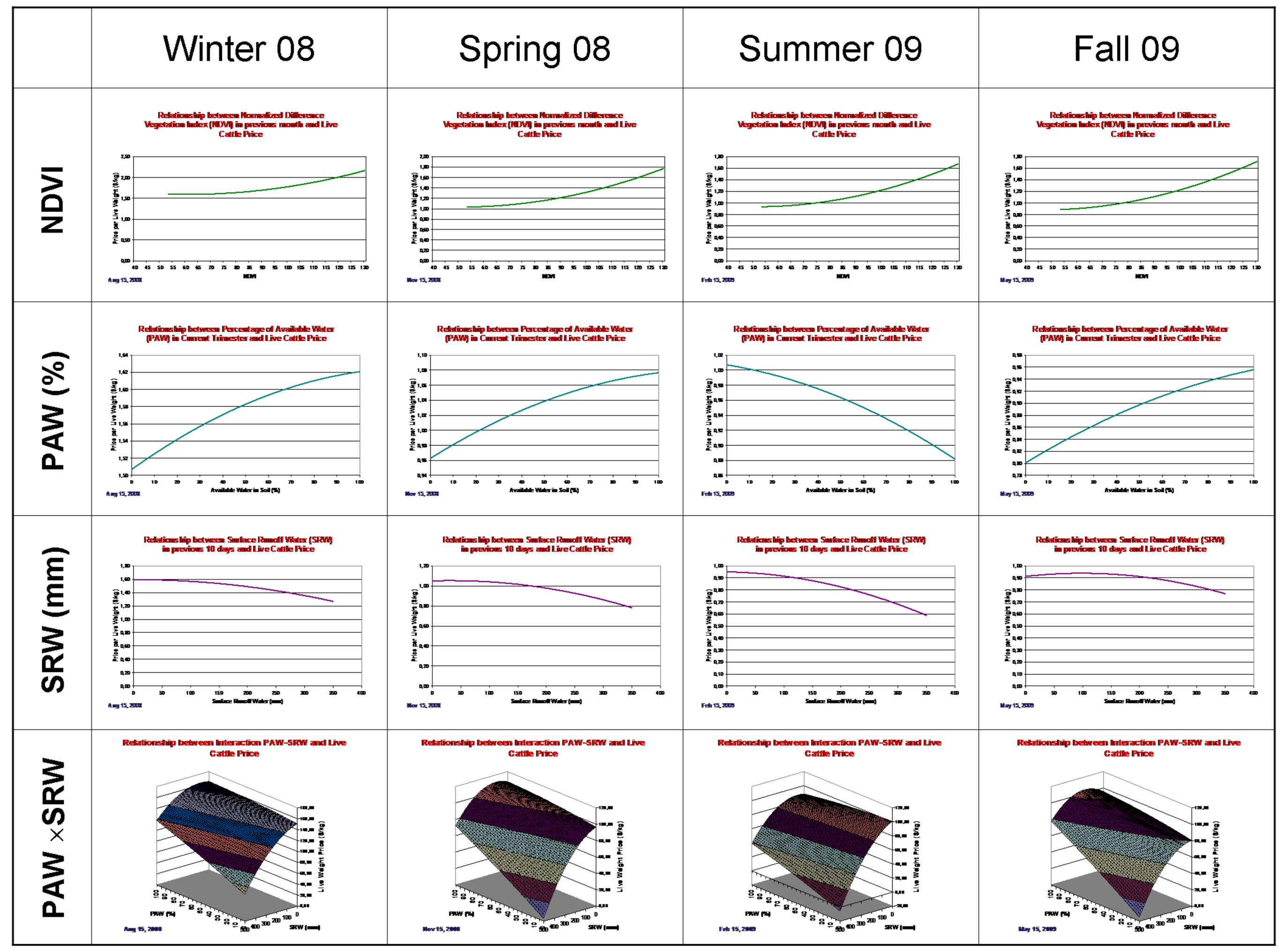
This study revisits the theoretical model used by Lanfranco, Ois and Bedat (2006), who adapted Ladd and Martin's (1976) approach about prices and demand for input characteristics to Rosen's (1974) theory of hedonic prices for differentiated products. As this study analyzes livestock markets using live cattle video auctions, it also recognizes the direct contribution of several previous studies (Sporleder and Mahoney, 1982; Faminow and Gum, 1986; Bailey and Peterson, 1991; Bailey, Peterson, and Brorsen, 1991; Bailey, Brorsen, and Fawson, 1993; Dhuyvetter and Schroeder, 1999; Avent, Ward, and Lalman, 2003; Dhuyvetter, 2004), as well as the extensive literature available about cattle trade and traditional and electronic live cattle auctions.

The contribution of this paper is given by the direct incorporation of some relevant variables into the model for capturing the permanent effects derived from agro-ecological regional differences, as well as the temporary effects caused by prevailing agro-climate conditions at the time cattle lots are traded. A couple of quantitative variables were introduced for assessing the permanent agro-ecological effects. The first variable, named CONEAT, represents soil productivity measured trough the so-called *CONEAT productivity index*. The second variable, referred as, stands for *water holding capacity* (WHC) represents the potential level of water storage of soils, measured in millimeters (mm).

On the other hand, the temporary effects were captured by three quantitative variables, one for assessing the volume and quality of pastures through the so-called green index, or *normalized difference vegetation index* (NDVI) while the other two are the *percentage of available water* (PAW) in the soil profile, with respect to field capacity (100%), and *surface runoff water* (SRW), which is the sum of the unsaturated overland flow (infiltration excess) plus the saturation excess overland flow.

It was assumed in this study that this set of agro-climate variables (CONEAT, WHC, NDVI, PAW, and SRW), either individually, combined, or interacting with other variables, are all envisaged by market agents like any other cattle trait, marketing strategy or market condition. Thus, they can be econometrically treated in the same way as the remaining variables in the model. The empirical estimation was performed using a dataset containing information from the three major national video auction cattle markets operating in Uruguay, comprising more than 12,000 lots of feeder cattle (steers, cull cows and heifers) traded in 95 auctions between Jun 2002 and Feb 2009. As pointed out by Rosen (1974), the empirical estimation of the model can be done by ordinary least squares. Heteroscedasticity of the variance-covariance matrix was corrected by using a heteroscedasticity-consistent covariance matrix estimator devised by White (1980) with the corrections recommended by Davidson and MacKinnon (1993).

Relationship between NDVI, PAW, SRW, and PAW×SRW with Live Cattle Prices



Results and Discussion

The results suggest that, for grass fed beef cattle production systems, intra-annual and seasonal agro-ecological and climate conditions affect short term supply and demand of live cattle, deriving in prices differentials for cattle lots coming from different agro-ecological zones, *ceteris paribus*. There are also price differentials for cattle coming from the same zone at different periods in time due facing different local or regional weather conditions. The occurrence of extreme events can also exacerbate those differentials. Differences among soils in depth, texture, fertility, drainage and water capacity, determine different responses to the same climate events that may exhibit different impacts among regions. The results of the model estimations are not presented in this poster for the sake of its readability and aesthetics. However it is available from the authors upon request.

Concluding Remarks

The marginal contribution of each of the selected variables was quantified in terms of premiums and discounts and mapped as dynamic iso-price regions that illustrate geographic and seasonal permanent price patterns for feeder cattle, as well as changing market conditions derived from unexpected climate and weather variability. The graphic representation of how price patterns may change with climate variability allows for a better understanding of short term market disequilibrium derived from this type of variability. This may help cattle operators and producers improve farm management and making informed decisions.

Basic Literature

Avent, R.K., C.E. Ward, and D.L. Lalman (2003) "Market Valuation of Preconditioning Feeder Calves." Paper submitted to *Journal of Agricultural and Applied Economics*.

Bailey, D.V., B.W. Brorsen, and C. Fawson (1993) "A Comparison of Video Cattle Auction and regional Market Prices." *Rev. of Agr. Econ.* 15(1): 103-119.

Bailey, D.V. and M.C. Peterson (1991) "A Comparison of Pricing Structures at Video and Traditional Cattle Auction." *West. J. Agr. Econ.* 16(2): 392-403.

Bailey, D.V., M.C. Peterson, and B.W. Brorsen (1991) "A Comparison of Video Cattle Auction and regional Market Prices." *Amer. J. Agr. Econ.* 73(2): 465-475.

Capurro, M. (1977) *Reseña de la Metodología Adoptada para Determinar la Productividad a Nivel Predial*. Fundación de Cultura Universitaria. Montevideo: 42 pp.

CONEAT (1979) *Grupos de Suelos CONEAT. Índices de Productividad*. Comisión Nacional de Estudio Agroeconómico de la Tierra, Ministerio de Agricultura y Pesca. CONEAT-MAP. Montevideo: 167 pp.

Davidson, R. and J. MacKinnon (1993) *Estimation and Inference in Econometrics*. Oxford University Press, New York.

Dhuyvetter, K.C. (2004) "Preconditioning Beef Calves: Are Expected Premiums Sufficient to Justify the Practice?" Selected Paper. Presented at the *Western Agricultural Economics Association* (WAEA) Annual Meetings. Honolulu, HA.

Dhuyvetter, K.C. and T.C. Schroeder (1999) "Determinants of Feeder Cattle Price-Weight Slides." Selected Paper. Presented at the *Western Agricultural Economics Association* (WAEA) Annual Meetings. Fargo, ND.

Faminow, M.D. and R.L. Gum (1986) "Feeder Cattle Differentials in Arizona Auction Markets." *West. J. Agr. Econ.* 11(2): 156-163.

Holben, B. N. (1986) "Characteristics of Maximum-Value Composite Images from Temporal AVHRR data." *International Journal of Remote Sensing,* 7: 1417-1434.

Ladd, G.W. and M.B. Martin (1976) "Prices and Demands for Input Characteristics." *Amer. J. Agr. Econ.* 58(1): 21-30.

Lanfranco, B., C. Ois, and A. Bedat (2006) *Variabilidad de Corto Plazo en la Formación de Precios en el Mercado Vacuno de Reposición*. INIA Serie Técnica 155: 58 pp.

Lanfranco, B. and G. Sapriza (2009) "Productividad de la Tierra y Formación del precio a través del Índice CONEAT." *Revista Agrociencias* (in review).

Rosen, S. (1974) "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." *J. of Political Econ.* 82(1): 34-55.

Sporleder, T.L. and K.A. Mahoney (1982) "Allocative Efficiency in Electronic Marketing for Feeder Cattle." Selected Paper. Presented at the *American Agricultural Economics Association* (AAEA) Annual Meetings. Logan, UT.

White, H. (1980) "A Heteroscedasticity-Consistent Covariance Matrix estimator and a Direct Test for Heteroscedasticity." *Econometrica*. 48(4): 817-838.