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FLORIDA LIVESTOCK PRODUCERS TO LONG  
TERM CLIMATE FORECASTING**

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## Potential Response of north central Florida Livestock Producers to Long-Term Climate Forecasting

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### Abstract

Beef cattle production in North Central Florida is based on grazing natural and planted pastures. In this tropical grass-based system cattle production is often constrained by drought and cold temperatures. We investigated the potential for using improved climate forecasting of El Niño / La Niña phases to aid ranchers in their management decisions. Stakeholder participation was included through the use of Farming Systems methodologies, especially Sondeos. Sondeos are rapid, low cost, effective multidisciplinary team evaluations of rural situations. Climate models were developed by a consortium of Florida universities in conjunction with the National Oceanographic and Atmospheric Administration (NOAA.) This paper describes the Sondeo process of interaction with stakeholders, and examines several scenarios of differential economic outcomes and potential for adoption of this technology by the rancher clientele using linear programming-based modeling. Ethnographic Linear Programming with livestock producers improved input coefficients for the model. El Niño Southern Oscillation or ENSO phase effects on growth of commonly used forage species were translated to stocking rates and used as LP inputs. The worst-case scenario was two consecutive La Niña events and the best was two consecutive El Niño phases. Beef cattle ranchers could use this information to adjust their management strategies and improve profit or ameliorate potential losses.

## 1. Introduction

Agriculture is highly influenced by climatic variability. Oram (1989) has characterized agriculture as the most weather-dependent of all human activities. A logical extension of this dependency of agriculture on climate variability is that if climate were known ahead of time, decisions could be made that would reduce the negative impacts of expected bad weather or take advantage of expected good weather conditions. Recent advances by scientists in understanding global ocean and atmospheric processes have led to new capabilities for forecasting climate several months to a year in advance (Jones et al., 2000; Hansen et al., 1999a; Hansen et al., 1999; Hansen et al., 1989b). Most of these advances rely in some way on knowledge of the surface temperatures in the Tropical Pacific Ocean and the El Niño Southern Oscillation (ENSO) phenomenon.

ENSO refers to shifts in sea surface temperature (SST) in the eastern equatorial Pacific and related shifts in barometric pressure gradients and wind patterns in the tropical Pacific (the southern oscillation). ENSO activity is characterized by warm (El Niño), neutral, or cool (La Niña) phases identified by SST anomalies. The impact of these phenomena affects interannual variability of weather in many regions (Kiladis and Diaz, 1989; Ropelewski and Halpert, 1986, 1987, 1996). Most current climate predictions are based on ENSO. Despite the fact that availability of climate data and information for agricultural use has increased dramatically in the last 20 years (Changnon and Kenneth, 1999), progress in the systematic use of climate forecast has been rather slow (Hammer et al., 2001; Goddard et al., 2001). Jones et al., (2000 a,b) suggested that there are opportunities to improve climate forecast dissemination, communication and interpretations and to develop or adapt research tools, methods and data products for translating climate forecasts into information required to support agricultural decision making.

In Florida, El Niño winter months tend to be cooler and with higher rainfall and La Niña years tend to be warmer and drier than normal in the autumn though the spring, with the strongest effect in the winter. Increased autumn and winter rainfall is associated with reduced solar radiation in El Niño years (Hansen et al., 1999). Production and economic impact of ENSO on Florida field and vegetable crops is well documented. Previous studies have demonstrated that a substantial portion of the inter-annual variability for yields of maize (Handler, 1990; Hansen et al., 1998) and several winter vegetables (Hansen et al., 1999) and tomatoes (Messina, 2002) in Florida is associated with ENSO-related weather variability. Hansen et al (2001) described the impact of ENSO events on tomatoes, bell pepper, sweet corn and snap beans (all decreasing in El Niño years), and sugarcane, tangerines and grapefruit (all increasing in EL Niño years). To date, however, relatively little attention has been paid to ENSO effects on livestock production.

Florida has been characterized as being particularly vulnerable, with an excess of over 30% of the normal seasonal total precipitation across much of the state during an El Niño winter. During La Niña years, the opposite effect occurs. Deficits of 10% to 30%

of decreased yields of major Florida crops attributable to climate change has been studied by Hansen et al. 1998, 1999a, 1999b; and Letson et al. 2001. Messina and others (1999) investigated optimal land allocation in the Argentine humid Pampas during different ENSO phases. They found that tailoring land allocation to different crops could result in increased net farm income of between US\$5 and US\$ 15/ha/year. We attempt to build upon this incipient yet valuable body of knowledge, by adding another realm of production, i.e. beef cattle in Florida, as another area studied as to how ENSO phases affect production systems economically. By using several scenarios of combinations of ENSO phases, we attempt first to understand how climate change interacts with grass production, and then what management decisions managers may make to reduce risk and vulnerability and perhaps enhance profits. A longer term objective of these types of study is to develop user-friendly decision support systems for the agricultural production clientele.

## **2. Materials and Methods**

### ***2.1. Interacting with the clientele: Sondeos***

Hansen (2002) pointed out the usefulness of distinguishing between descriptive and modeling approaches to evaluating decision responses to a given forecast. He also suggested that the best elements of both approaches can be combined. The process described in this paper combines descriptive work, where data are elicited from livestock producers, and modeling (normative or prescriptive) methods. The Florida Consortium, made up of researchers from the University of Florida, Florida State, and the University of Miami, has outlined a framework for assessing the potential use of climate forecasts in agricultural decision-making. One of the fundamental objectives of the consortium is to reach out to multiple stakeholders in Florida (Jagtap et al. 2002). Four Sondeos were conducted from March 1999 through March 2001. The Sondeo (Hildebrand, 1981, 1986, 1999) is a team survey process that was developed to provide information rapidly and economically about agricultural practices in order to guide strategy in agricultural development programs. It is structured around a series of conversational interviews between the team and farmers. It is a multidisciplinary process from data collection through report writing with teams ideally including people from the social and agricultural sciences. In a Sondeo, data are shared among the different teams and report writing is done as a group so that observations are confirmed, debated and analyzed with members of other teams. The results may be quantified or not but the accuracy of the findings is strengthened by the cross-checking process (Cabrera et al., 2000 after Hildebrand 1981, 1986.)

In all, 38 ranchers and 41 extension agents were interviewed. Three of the Sondeos were conducted in conjunction with a graduate class at the university of Florida (AGG 5813, Farming Systems Research Extension Methods), and one was conducted with graduate students at UF hired specifically for the purpose. An enormous wealth of qualitative as well as quantitative data was gathered using this technique at very low cost.

The first Sondeo, conducted with Florida Cooperative Extension Agents, identified livestock producers and the forest industry as potential users of improved climate

ranchers could reduce their risks and increase profits by using currently available methods for forecasting climate to adjust various decisions.

Cow-calf production in Florida involves keeping breeding females and raising calves born to them each year. Calves are weaned at 6-8 months and often sold to a feeding operation until slaughter. Typically Florida stockers go to feedlots in Arizona and the Texas Panhandle. Weaned calves weigh between 182 and 273 kgs when sold. Calves can also be over wintered and sold in the spring. Although buying weaned calves and bringing them up to slaughter weight with feed exists as a system in Florida, by far the most prevalent beef cattle production system is the cow-calf operation.

The objectives of this research were to determine which livestock management practices might be changed if future climate conditions are known and to estimate the potential value of using ENSO-based climate forecasts to improve beef cattle ranch management decisions in North Florida.

### *2.2.1. Resources required*

Typically, 0.8 ha of grazing land is required for each cow-calf pair. When cattle present weights beneath certain benchmarks it is a sign to cattle producers that the pastures are stocked too heavily. Because stocking rate is a principal determinant of economic outcome, and the amount of land available is limited to the property plus whatever amount can be leased profitably in a given season, land is a major constraint on production and profits. A hypothetical 160 ha ranch considered to be representative of many ranches in the North Central Florida area, was modeled in our study. Because El Niño/La Niña events affect rainfall, temperatures, and evapotranspiration, they affect pasture growth and thus stocking rates.

Running fences and checking cattle are the only constant labor a cow-calf operation needs. Winter-feeding and health treatments are occasional labor inputs. Although quality labor is often difficult to obtain at the right time, overall availability does not usually limit the cattle production system in Florida.

Facilities include start-up infrastructure (one-time expenses) such as pastures (\$110-330/ha), fencing, corral, a squeeze chute, loading ramp, feed and mineral boxes and automatic water sources. Yearly costs include fertilizer, depreciation for machinery, land use, supplemental feeds including protein in the form of liquids or pellets, mineral blocks, hay or silage, molasses, and manufactured feeds; veterinary attention and medicine, insurance, taxes, maintenance and repair of buildings, interest on loans and miscellaneous supplies and repairs. Price per head for the average 136-227 kg. calf varies typically between \$1.65 and \$2.20 /kg.

winter at \$520. Prices can be easily altered according to changing circumstances through user-friendly macros in using Microsoft Visual Basic® and Excel®.

#### **2.2.2.4. Decision-making**

“The job of the ranch or farm manager is to develop and coordinate programs which have the best chance to result in a profit from a given set of resources. This job is best accomplished by advanced planning for the future with the plans based on reliable records from previous years of experience (Hentges 1977).” Reliable climate forecasts run through trustworthy models may aid in decision making. Sondeos described above also suggests the need to address the probabilistic nature of climate forecast and deliver them to ranchers in a manner that is clear, timely and user-friendly.

### **3. The Model**

#### **3.1. LP model of livestock ranch**

Historically, LPs have been used to study the role of cattle in farming systems. Boggess et al., (1979) reported findings in which it was necessary to force a cow-calf herd into the final optimal solution. Melton et al., (1980) took a critical look at the above and many other models and concluded that the whole-farm LP models were inadequately representing the reality of cow-calf production. More recently, several studies on cattle ranching and sustainability have been published (Griffith and Zepeda 1994, Bouman and Nieuwenhuyse 1999, Kaya et al. 2000).

In the Farming Systems program at the University of Florida researchers apply novel interaction and participation techniques to elicit first-hand data from producers. This has resulted in both Ethnographic Linear Programming and the initial applications of Participatory Linear Programming (Hildebrand 2001, Bastidas 2001, Kaya, 2000, Breuer, et al. forthcoming). While both these analytical tools were designed primarily for the analysis of small farm livelihood systems (Hildebrand 1986, Kaya 2000) many elements belonging to them have been used successfully to overcome difficulties associated with modeling cow-calf systems from secondary data. Sondeos, in-depth interviews and participatory model calibration were all used for this study.

For the current study, a two-year plus third summer, dynamic linear program was developed for the conditions of north central Florida cattle ranch operations. A hypothetical 160 ha cow-calf production unit was simulated. The model included calves, stockers, heifers, and cows; their pasture requirements, and their connections with climate conditions. The model was constructed on an Excel® spreadsheet, which was connected with user-friendly Visual Basic® forms that allow easy and fast interactions. Coefficients from secondary data were improved by interacting with local ranchers in February 2002 using a modified Participatory Linear Programming process.

### 3.1.2. Constraints

Each year there are 17 constraints, nine in Summer and eight in Winter. With the exception of the fixed land acreage constraint (160 ha) the others are tracking constraints that keep the money flow throughout the model. All of them, with the exception of the last money transfer, are less than or equal to zero constraints. The last constraint is greater or equal to zero and is the maximization objective function.

The mathematical model can be summarized, for each year, as:

Activities:	$X_i$	$i = 1$ to 33
Constraints	$B_j$	$j = 1$ to 17
Coefficients	$a_{ij}$	

Objective function: 
$$\text{Max } \Pi = \sum_{i=1}^{33} X_i C_i$$

Model Constraints: 
$$\sum_{i=1}^{33} a_{ji} X_i \leq B_j \text{ and } X_i \geq 0$$

### 3.1.3. Client Participation in model calibration

The LP model was tested with real data through farm interviews in the winter of 2002, and proved to be trustworthy. A wide range of ranch types, sizes and resource endowments, were represented. Livestock systems were relatively homogeneous regarding production practices. Extension Agents from three north central Florida counties (Marion, Alachua, and Levy) provided names of several beef cattle producers in their districts. Interviews were arranged by phone and the research team visited the producer *in situ* with the model on a laptop computer. Farm-specific data were re-entered into the model through input tables. After running the nine basic scenarios, outputs were discussed with ranchers. After each visit, the model was modified and prepared for the next ranch visit. These interviews were continued until the model satisfied the team, and the clients. This methodology, Participatory Linear Programming, could be promoted in future work of this type.

## 3.2. Crop model component

Regionally adapted and tested crop simulation models prove useful to study variation in yields in response to climate variability (Boote et.al., 1996; Boote et.al., 1998). The biophysical nature of these models allows us to translate climate forecasts into agricultural outcomes (Phillips et al., 1998). Combined with extended weather series these models can be used to evaluate decision capacity provided that the decision variables can be handled by the models (Jones et al., 2000). Models exist for many crops, such as maize, soybean, peanuts, rice, and wheat (Jones et al., 1998). However, we did not have access to comprehensive models for the pasture species considered in this study (winter rye grass (*Lolium multiflorum*), rye (*Secale cereale*), and bahia grass (*Paspalum*

used to relate the different classes of cattle to carrying capacity. Relating the ENSO phase to stocking rate was accomplished by using crop growth curves for bahiagrass in summer and a mix of rye-ryegrass in winter as follows.

Considering a neutral year for Florida as baseline for bahia grass growth. Production in an El Niño year was considered to be Z of neutral production. In an La Niña year, bahia grass was calculated to produce X of neutral. Similarly, growth of rye in a neutral year in Florida was considered to be the baseline. Rye in an El Niño winter was calculated to produce Y, and rye in a La Niña winter was calculated at 0.X of neutral production. These ratios were translated into carrying capacity in the model. Indexes are available in Table 1.

#### 4. Results

When crop production for the grasses is translated into carrying capacity, La Niña winters are significantly lower than in neutral or El Niño years. These results imply that cow-calf management could benefit by taking into account ENSO phase predictions.

In order to analyze the effects of different combinations of possible ENSO phases, different scenarios were tested in the 2-year plus one summer model for a hypothetical 160-ha ranch. Overall economic results varied from the worst-case scenario (two consecutive La Niña events) to the best-case scenario (two consecutive El Niño events, Figure 1). Differences observed were due to the variation in carrying capacity caused by available pasture as affected by climate conditions, Table 1. Variations were generated from historical temperature data.<sup>2</sup>

##### 4.1. ENSO effects on pasture production

Table 1. Bahia and Ryegrass responses to different ENSO phases

<b>Indexes</b>	<b>Bahia grass summer</b>	<b>Rye winter</b>
Niño	1.050981	1.091682
Neutral	1	1
Niña	1.042820	0.859967

Bahiagrass can carry approximately 10% more cattle in either El Niño or La Niña years than it can in neutral years (this is why ranchers ordinarily plan for neutral summers; it is the worse case scenario.) The rye-ryegrass mix on the other hand, carries about the same number of head in a neutral as in an El Niño year. In La Niña winters, carrying capacity is greatly reduced. By planning ahead according to an expected La Niña winter prediction, ranchers could buy hay in the summer, which ordinarily costs about half as much as what they would pay in winter.

<sup>2</sup> Available: [www.fawn.ifas.ufl.edu](http://www.fawn.ifas.ufl.edu)



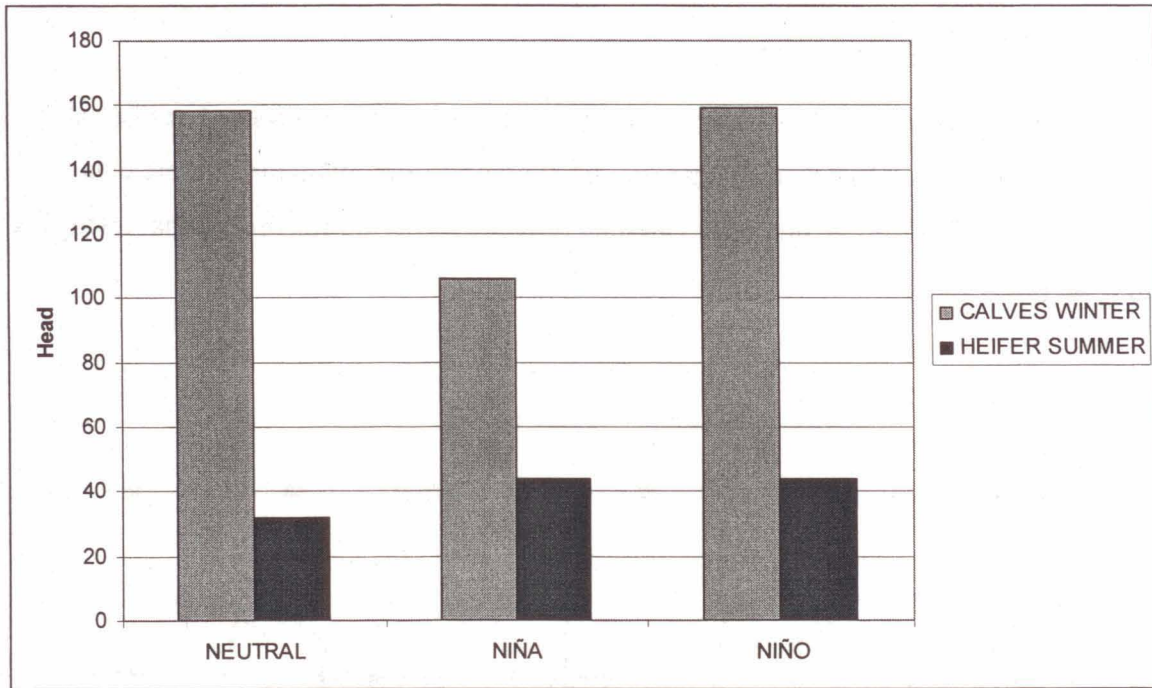


Figure 2. Changes in herd size in different scenarios

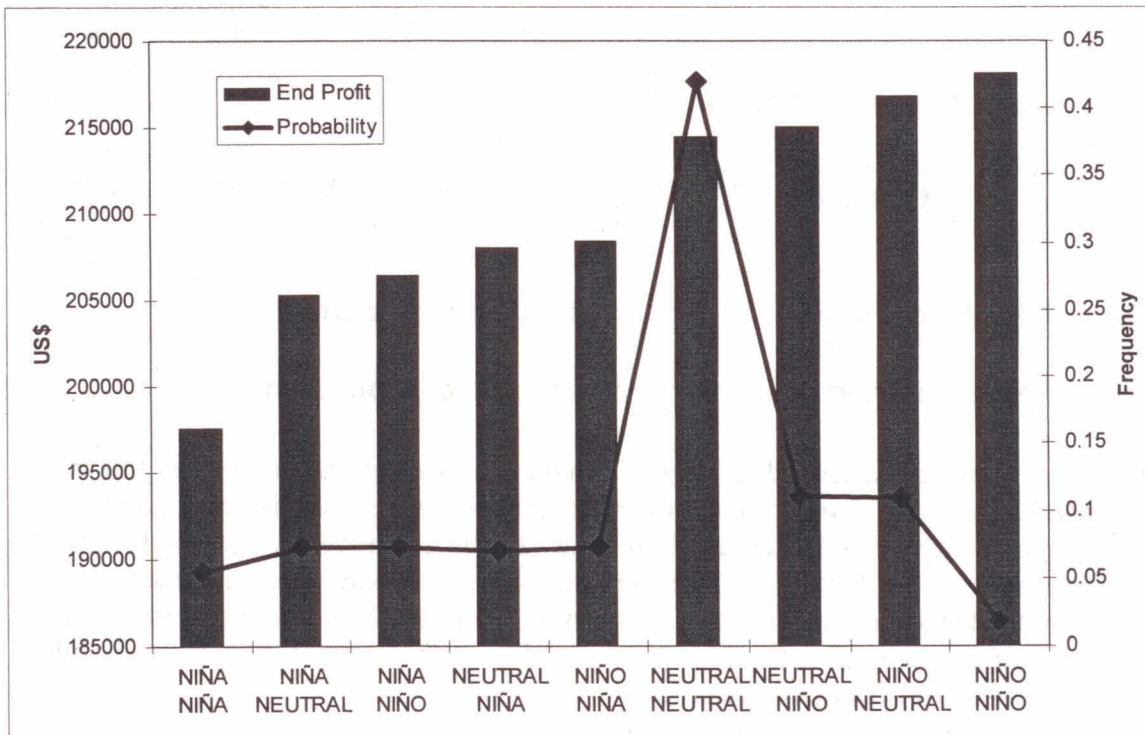


Figure 3. Two-year economic output values for nine scenarios tested and probability of occurrence.

- Ryegrass is established (correct climate prediction) or
- Ryegrass is not established (incorrect climate prediction).

When the rancher follows the recommendation and the prediction is correct, the incurred costs will be from planting on time and there are no unexpected costs. When the rancher follows the recommendation and the ryegrass is not established because the prediction was not accurate, the rancher not only loses the money of planting the ryegrass, but also he or she needs to buy expensive hay in the winter to maintain the herd. In the case that the rancher does not follow the recommendations and does not plant any ryegrass, meaning that he or she buys cheap hay in the summer (preparing for the winter) there are no unexpected costs. Table 2 and Figure 5 show the difference in end value of herd plus Gross margin under different ENSO scenario combinations.

Overall, end value is double or more when recommendations are followed and are correct versus the case where the rancher does not follow recommendations. The worst-case scenario is when the rancher follows recommendations and establishment fails due to incorrect climate predictions. These results represent a “perfect case” and do not take into account probabilities of occurrence or relative strength of a particular El Niño or La Niña event.

Table 2: Ryegrass production and risk associated with ENSO predictions

						cows	heifers	calves	Gross Margin +
									Herd Value
W I N T E R	NIÑA	PLANT RYEGRASS 307.82	ESTABLISHED	correct prediction	follow recommendation	155.90	27.43	105.70	11990.55
				summer buy hay	0.00				
		FAILURE	wrong prediction	follow recommendation	155.90	27.43	105.70	-11367.14	
	NOT PLANT RYEGRASS		winter buy hay	338.46					
			not follow recommendation		155.90	27.43	70.57	5544.86	
			summer buy hay	338.46					
NIÑO	PLANT RYEGRASS 117.21	ESTABLISHED	correct prediction	follow recommendation	155.90	27.43	159.09	22433.97	
			summer buy hay	173.49					
	FAILURE	wrong prediction	follow recommendation	155.90	27.43	159.90	4275.27		
NOT PLANT RYEGRASS		winter buy hay	142.68						
		not follow recommendation		145.57	27.43	122.02	11409.00		
		summer buy hay	316.17						
NEUTRAL	PLANT RYEGRASS 216.80	ESTABLISHED	correct prediction	follow recommendation	155.90	27.43	159.09	28315.31	
			summer buy hay	63.89					
	FAILURE	wrong prediction	follow recommendation	155.90	27.43	159.09	-3348.10		
NOT PLANT RYEGRASS		winter buy hay	236.01						
		not follow recommendation		129.38	27.43	133.47	8452.40		
		summer buy hay	299.90						

study. Research should be extended geographically to include other areas of the state of Florida and the southeastern United States. Simultaneous effects of ENSO phenomena in more distant areas of the country are a topic for further investigation. Among these, corn and soybean prices, as well as climate conditions in feedlot states may be important. Above all, ENSO predictions must be delivered in user-friendly ways to be useful to ranchers. Additional analysis is needed to understand the broader consequences of using climate forecasts in livestock management, in particular to understand the wider aspects of value and risks associated with this approach. Future studies should take this into account, because ranchers are highly concerned about uncertainty and risk, not just average responses.

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