Extension Agent Perspectives of Climate, Seasonal Climate Forecasts, and the AgClimate Decision Support System[1]

Norman Breuer[2], Sanchayeeta Adhikarim[3], Ricardo Brown-Salazar[4], Jose A. Clavijo[5], Heidi N. HansPetersen[6], Nicholas C. Kawa[7], Risa Patarasuk[3], and Peter E. Hildebrand[8]

ABSTRACT

A rapid participatory appraisal (*sondeo*) was conducted in 13 counties in southwest and west-central Florida. The study explored the perspectives and attitudes of various extension agents regarding seasonal climate forecasts. Study topics included awareness of El Niño and La Niña phases, communication of potential impacts to farmer clients, and sources of climate information, with a special focus on *AgClimate*, a web-based decision support system developed by the Southeast Climate Consortium (SECC), http://AgClimate.org[9]. The study found that perspectives of seasonal climate forecasts and variability differed widely among agents. Also, respondents identified a number of issues in their counties regarding the use of predictive climate information: barriers to dissemination of information; the current drought; an aging farmer population; and continuous land use change from agriculture to other uses, primarily housing. We finish by discussing the findings, drawing conclusions, and suggesting recommendations that may be beneficial to the adoption of and adaptations to seasonal climate forecasts in Southwest and West Central Florida. Further interaction with the Southwest Florida Water Management District, additional training for county Extension Agents, and the use of mass media to disseminate climate information are recommended.

[1] Disclaimer: All information presented, including all mention of the Southwest Florida Water Management District (SWFWMD) is based on perspectives of participating Extension agents and may not necessarily reflect objective realities. The SWFWMD has been working with complex hydrological models that use climate data as inputs for many years. No representative of the SWFWMD was interviewed for this report and it is not our intention to judge the merits of the policies, research, models, or management of the SWFWMD.

[2] Rosenstiel School of Marine and Atmospheric Sciences, University of Miami. Corresponding author e-mail: nbreuer@ifas.ufl.edu

[3] Department of Geography, University of Florida

[4] Department of Interdisciplinary Ecology, University of Florida

[5] Department of Agronomy, University of Florida

[6] Department of Entomology and Nematology, University of Florida

[7] Department of Anthropology, University of Florida

[8] Departments of Food and Resource Economics and Interdisciplinary Ecology, University of Florida

[9] In August 2008 the name and address of *AgClimate* changed to *AgroClimate* and http://AgroClimate.org

INTRODUCTION

Climate variability, climate change, and weather have become important topics of discussion because of their influence on the environment, economy, and society, as well as their impacts on natural resources, industries, agriculture, and human health. Climate variability, climate change, and weather greatly affect agriculture. For example, a sudden freeze can wipe out certain vegetables and fruits such as tomatoes and strawberries. Seasonal to inter-annual climate variability phenomena such as El Niño and La Niña can strongly affect water resources and temperature conditions, which in turn affect agriculture. On the other hand, long-term climate change may alter agricultural productivity by migration of tropical crops, along with their associated pests and diseases, to sub-tropical regions.

Because of the scale issues, differentiation of the three terms is needed to help clarify extension agents' perspectives. Weather has been defined as the day-to-day state of the atmospheric conditions, and its short-term (minutes to a maximum of 2 weeks) variation at a particular place. The term refers to day to day atmospheric conditions like temperature, humidity, precipitation, cloudiness, visibility, and wind. Climate can be defined as the average weather conditions at a particular place over a long period of time. The temporal scale of climate however may vary. It can be observed as seasonal, inter-annual or decadal cycles. The difference between seasonal climate variability and climate are defined by their temporal scale.

Climate change can be said to be the long-term changes in the atmospheric conditions like temperature and rainfall where the time scale is from 20-30 years to geologic era scale. Climate change is often equated with global warming, which is described as the average increase in temperature because of human influence. Seasonal climate variability drives climate in the Southeastern United States. Year to year El Niño Southern Oscillation (ENSO) cycle dynamics can result in either colder or wetter conditions in the Florida than average (El Niño) or warmer and drier condition in Florida than average (La Niña). A neutral year on the other hand may bring higher likelihood of freezes in Florida. Thus seasonal climate forecasts tentatively have potential as a risk management tool for farmers and natural resource managers.

Several federal and state agencies, including the National Oceanic and Atmospheric Administration (NOAA), predict seasonal climate variability fairly accurately (O'Brien et al., 1999). These predictions are based upon the ENSO phenomenon that determines El Niño, La Niña, or Neutral years, each of which is associated with characteristic rainfall and temperature patterns in the Southeast region of USA. The Southeast Climate Consortium (SECC) of six universities from Florida, Alabama and Georgia, (http://secc.coaps.fsu.edu/) sees evidence that seasonal, ENSO-based climate forecasts can be used to help mitigate effects of climate and reduce yield risk in agricultural production.

This study explores the perspectives, and attitudes of various University of Florida Extension agents who work within the boundary of the Southwest Florida Water Management District regarding awareness of El Niño and La Niña phases, communication of potential impacts to farmer clients, and sources of climate information, with a special focus on the SECC's decision support system AgClimate.

Seasonal climate forecasts have been available on the SECC's website since November of 2005. The decision support system was co-developed with potential users and stakeholders, some of whom were Extension agents from Florida, Georgia, and Alabama. The Cooperative Extension Service acts as a boundary organization between the SECC and farmers. After two

planting seasons of dissemination of climate information for decision support, a preliminary assessment of the stage of county agent awareness is due. This study was designed to measure awareness and to elicit feedback. This type of information may be used to design new Extension activities and add to the existing continuous stakeholder-research loop that drives the improvement of the SECC's climate based decision support system. Understanding agents' and farmers' underlying motivations, beliefs, and value systems with regard to seasonal climate, may help elucidate how farmers make decisions under uncertainty and how Extension agents make recommendations to their clientele to do the same.

METHODS

A *sondeo* is a semi-structured, multi-disciplinary team process that uses discussions rather than formal questionnaires to obtain information about topics of interest (Hildebrand, 1981). A key to the success of a *sondeo* is its informal, conversational approach. Researchers do not take notes or refer to a list of questions during discussions. While researchers direct the conversation toward a general area of interest, they also encourage respondents to discuss ancillary issues of concern. An important benefit to a conversational approach is that it elicits key issues that the researcher may not have anticipated, issues that would likely have been missed with a standard survey with a pre-established list of questions.

A *sondeo* is a multidisciplinary process from planning, through data collection, analysis, and reporting. Ideally, each discussion team includes people from both social and agricultural sciences. In this case, team members included one assistant scientist and graduate students from diverse backgrounds including agronomy, geography, anthropology, entomology, and ecology who were divided into two multidisciplinary teams, one with three the other with four members. Informal conversations with extension agents were conducted over a one-week period. Initial contacts were predominantly made by telephone the morning of the interview. Individual conversations lasted from 20 minutes to one hour and took place in County Cooperative Extension offices. Team members met each night to report and discuss conversational interviews conducted during the day. As each team presented its findings, they highlighted similarities and differences with the results of the other teams. This process of reporting and discussion served as an opportunity to identify trends, gaps in information, and new questions to be pursued. Thirteen counties were visited within the general boundaries of the Southwest Florida Management District. The teams conversed with a total of 26 agents.

The study used a small sample size and observations in this report are limited to that sample. Sampling was not strictly random. The sample was purposive with a degree of randomness introduced during each day of the field work by calling and visiting whatever agents happened to be in the office at the time. It is possible that the sample does not represent the entire population of agents in the SWFWMD. Biases may have been introduced by our own perspectives and by those of the informants. This bias is possible in that questions posed during discussions were open ended and the flow of conversations was permitted to continue toward the subjects of greatest interest to the agents. Questions were not written and our methodology stressed listening over talking. Flexibility, which is one of the key strengths of rapid appraisals, may also increase the likelihood of distortion. We attempted at all times to improve the accuracy of our findings by discussing interview techniques or challenges nightly. Thus, we were able to minimize the element of bias during information collection and analysis. We gathered sufficient

qualitative data to provide an accurate assessment of the prevalence of La Niña and *AgClimate* knowledge, but not necessarily of its extent or pervasiveness.

Study area

The Southwest Florida Water Management District (SWFWMD) encompasses all of 11 and part of 5 other Florida counties. The area covers approximately 10,000 square miles (25,900 square kilometers) and includes a human population of 4.5 million (SWFWMD, 2008) with approximately 1,800 lakes, 13 major rivers, three estuaries of national recognition and thousands of acres of productive wetlands, all bordered by the Gulf of Mexico (SWFWMD Strategic Plan, 2009-2013). Counties in this study were Sarasota, Desoto, Highlands, Hardee, Lake, Manatee, Hillsborough, Polk, Pasco, Hernando, Sumter, Marion, and Citrus.

Climate

Florida has a humid subtropical climate. For six months of the year daily maximum temperatures may exceed 90°F (32.2°C) and daytime relative humidity can be 50% or higher. The state has been divided into three zones, North Florida, Central Florida and South Florida, to take into consideration local variations present in these zones (Black, 2008). In west-central Florida, the average rainfall of approximately 53 inches (135 cm) occurs primarily from June through September (SWFWMD, 2004). The SWFWMD lies within the Central Florida climate zone is less exposed to cooling breezes than the other two zones, North Florida and South Florida and has a longer period of high-temperature, high-humidity days (Black, 2008). Because of its more southerly latitude, the period of temperatures below human comfort levels is relatively short. This region may have as little as one month of temperatures and humidity below the comfort range and as many as 7 months above that range (Black, 2008).

Soil

In general, soils in the SWFWMD are sandy or sandy loam. Most extension agents in our sample mentioned the soil as being a big reason that drought occurs frequently although total annual rainfall is relatively high. Soils have high porosity, so they do not retain rainwater for long periods. Rather, rainfall percolates rapidly through the soil profile below the root zone, resulting in the onset of plant water deficit within 5 to 10 days after a rain.

In 2008, the SWFWMD will cooperate with the Natural Resources Conservation Service (USDA-NRCS) in offering one-day workshops that are similar workshops they have conducted annually for the past 19 years. Each workshop covers the measurement of seasonal high ground water table depth (SHGWT) elevations in natural, pre-developed conditions. Emphasis is placed on the use of landscape topography and vegetation, soil colors, NRCS soils maps, and other data, to determine SHGWT depths. Man-made alterations to the SHGWT and basic storm-water management are also discussed. It is unknown if these workshops include anything about seasonal climate forecasts.

Agriculture

Florida has diverse agricultural production. It ranks first in the United States for sales of snap beans, fresh market tomato, fresh market and pickling cucumber, bell pepper, squash, and watermelon. It also ranks first in the United States in the value of production of orange, grapefruit, tangerine, and sugarcane for sugar and seed, and ranks second in sales of greenhouse and nursery products, sweet corn, and strawberries (Florida-Agriculture.com).

The major agricultural practices within the boundaries of the SWFWMD can be divided into livestock, vegetables, field crops, fruits, nuts and berries, horticulture, citrus, aquaculture, seafood and forestry products. Livestock include beef and dairy cattle, goats, horses, poultry and sheep. Although most of the counties have some livestock, Polk, Desoto and Hardee counties have the largest numbers of beef cattle with 99,000, 75,000 and 73,000 head, respectively. Other important beef cattle producers in the region are Hillsborough, Manatee, Pasco, Marion, and Sumter. Major commercial vegetables grown in the region include tomato, cabbage, cucumber, peppers, cowpea, squash, snap bean, and sweet corn. Manatee and Hillsborough have the largest vegetable industries with tomato, cucumber, and peppers as their main crops. Orange, tangerine, grapefruit, blueberry, strawberry, lemon, and tangelo are the major fruit products of the state. Polk, Desoto and Hardee counties have the largest area in citrus fruit production with orange accounting for 82,701 acres (33,468 ha) in Polk, 67,020 acres (27,122 ha) in Desoto, and 52,384 acres (21,199 ha) in Hardee. Polk has also a large area of grapefruit and watermelon. Some other counties with significant area in citrus fruit production are Hillsborough, Manatee, Lake and Pasco. Citrus County has about 150 acres (61 ha) of land for citrus fruit production. Ornamental horticulture production in the region is comprised of both field and protected culture operations which produce palm, crape myrtle, magnolia, oak, caladium, bedding plants, citrus seedlings, and many other products. Lake County has the largest amount of horticultural farming of the 12 counties with as much as 488 acres (197 ha) under greenhouses. Hillsborough, Manatee, Polk, Hardee and Pasco counties also have significant horticultural production.

The main field crop grown in the SWFWMD is forage. Corn, winter rye, and peanuts are also grown. The major forage acreage is found in Desoto, Hernando, Lake, Highlands, Hillsborough, Pasco, Polk and Hardee counties. However, Marion and Sumter counties lead in forage acreage with 22,702 acres (9187 ha) and 16,434 acres (6651 ha), respectively. Marion also has a significant area in peanut (forage and groundnut) production. Other fruits, including strawberry, blueberry, grapefruit, and watermelon are produced in Hillsborough, Polk, Manatee, Marion, Hardee, and Sumter counties. Hillsborough County has the largest strawberry acreage, with Plant City as the hub of growing, processing and shipping. Most of the coastal counties like Manatee, Pasco, Citrus, Sarasota, Hernando and Hillsborough have substantial aquaculture and seafood production.

RESULTS

Perspectives of seasonal climate variability

Our research was conducted during March of 2008 during a La Niña phase. Warm, dry La Niña conditions had led to pronounced drought following a dry winter season throughout Florida. Drought in the study area ranged from moderate to extreme. The southernmost counties in the SWFWMD including Sarasota and Desoto had been and continued to be most severely affected (http://AgClimate.org).

Despite our specific focus on climate, conversations with extension agents nearly always led to discussions of weather. Many agents used the terms weather and climate interchangeably. Clearly, the differences between climate and weather were not always apparent or well-distinguished by them. Those agents who clearly distinguished between weather and climate discussed the critical dependence of agriculture on weather, but few clearly defined the effect of seasonal climate variation on regional agriculture. Our discussions with extension agents on

climate variability also triggered conversations concerning climate change and global warming. Due to the controversial nature of the current public discourse on climate change, many agents were inclined to address this issue and share their perspectives. Although some agents were open to the notion of climate change and global warming, others were very skeptical.

When agents in the sample specifically discussed climate variability in their counties, the topics that most commonly surfaced were related to rainfall patterns, drought, hurricane frequency, and seasonal temperature averages. In the southernmost counties where cattle ranching and livestock are the focus of production, agents talked specifically about seasonal drought and its effects on hay production and pasture planting. In counties that produced more on horticultural commodities, seasonal variability in temperature was of greater concern because horticulturalists regularly irrigate but only occasionally respond to the threat of freezes. One agent discussed the effect of seasonal climate variability on the emergence of specific pests and diseases, specifically citing the appearance of the plant pathogens *Phytothphora spp*. and *Pythium spp*. in ornamentals during cooler and wetter conditions and spider mites (*Tetranychus spp*.) in hotter, drier years. Other agents mentioned climate variability and hurricane events as being linked to the arrival of new invasive plants and diseases that migrated from southern tip of the state, which they may have entered from origins in the Caribbean, South America, or Africa. Several agents associated the occurrence of hurricanes and other tropical storm systems with climatic variability and ENSO phases.

Some extension agents alluded to the fact that much of their climate awareness came through access to information from the University of Florida Institute of Food and Agricultural Sciences (IFAS, http://www.ifas.ufl.edu/), but not necessarily because they actively sought this information. One agent stated that in general, extension agents spend most of their time responding to the problems and needs of their constituents and do not spend as much time addressing issues about which producers are not requesting information. It is likely that climate variability has not been a primary concern for extension agents until recently because producers have not expressed an immediate concern regarding seasonal climate variability.

Most agents sampled were familiar with the terms El Niño and La Niña, and were able to identify the present phase (La Niña). However, awareness about El Niño and La Niña ranged from those who vaguely discussed the subject to others who immediately pointed out the current phase and associated it with certain climatic events in their areas. Moreover, agents expressed diverse views on how, if at all, the current phase affected their local conditions. For those agents who clearly established links between the current phase and climate, warmer and generally drier winters (with differing intensities) were recurring themes. Even though the previous two years were unusually dry in the study area, agents hoped that the relatively higher precipitation during the winter of 2007-2008 indicated an end to the current drought. However, rainfall during late winter and spring were not sufficient to return long-term precipitation averages to normal.

According to the interviewees, the perspectives that agents express regarding climate variability largely coincide with those of their constituent farmers. For example, agents said both they and their producers had observed changes over time, with less precipitation, more drought and warmer temperatures now than in previous decades. They also suggested a relationship between climate and the number and strength of hurricanes. Many agents said that farmers and ranchers had a fair understanding of climate variability simply through the experience of working in a specific locale for an extended period of time. Several agents also said that producers were largely interested in isolated weather events (e.g. hurricanes and freezes) and

were less concerned with larger patterns of seasonal climate variability. Rainfall and its distribution are the only climate variables about which agents and their clients were enthusiastic.

Agents suggested that livestock producers and horticulturalists differed in their concerns with seasonal climatic patterns. Some agents felt that horticulturalists (e.g. tomato and citrus producers) were more attuned to this information, but also had greater control over their systems because they use of irrigation, black plastic mulch, and other practices that increase soil temperatures and allow earlier planting. On the other hand, many agents said that climate variability had significant impacts on pasture planting and hay production. Planting dates are critical to ensure sufficient soil moisture for pasture establishment and ranchers often ask extension agents to recommend optimal planting dates for warm-season pastures, such as Bahia grass planted in the spring or early summer, and cool-season pastures, such as annual ryegrass planted in October or November. Some extension agents also mentioned warmer winters as a potential problem for adequate establishment and development of cool-season pastures.

The drier climate had reduced hay production throughout the southeast. One agent said, “The grass is shorter this time of year than it used to be." Reduced hay production is significant because cattle production take 2 to 3 years to recover from a drought, which has long-term impacts on the cattle reproduction life cycle. Additionally, warmer temperatures and dry conditions adversely affect animal comfort, which is particularly important for dairy cattle.

Droughts in other states also affect agricultural in Florida, For example, agents reported that North Carolina and Georgia were buying hay from Florida mainly because those states experienced serious drought in recent years. Many Florida ranchers found themselves in a similar hay "importing" situation during 2006.

The perceived effects of changing climate are illustrated by the following examples. In one county we visited, the typical planting time for grass was mid April. Now, planting is being delayed until the end of May. Similarly, another county agent reported that rainfall used to start in June and that was the time for planting, but now farmers are planting in July, “The rainfall has been pushed back” mentioned one agent with more than 10 years of experience working at one location. These changes have led county agents to change their recommendations to farmers on when to plant grasses.

Ornamental plant sellers are taking advantage of the warming tendency by selling more tropical trees and ornamental plants. The perception in some cases is that when the next hard freeze occurs many of these “new” tropical species will die.

Sources of climate information

Extension agents draw climate data from a variety of sources. When asked about the sources they use for information regarding climate variability, some agriculture and livestock agents specifically mentioned the SECC. One agriculture agent relays information from the chilling-hour accumulation tool on *AgClimate* to his blueberry growers. Several livestock agents use La Niña and El Niño predictions to make recommendations for winter forage planting. Most informants regularly search NOAA and FAWN websites. Other sources that extension agents mentioned include a USDA climate site, the National Weather Service, and media outlets such as the Weather Channel and radio. Other important sources of information include agent-to-agent contact, UF/IFAS personnel, and published materials, especially the 2007 Climatological report ONA. One week before the *sondeo*, climate was a topic discussed at a meeting for area livestock extension agents. Several interviewees mentioned Clyde Fraisse, a climate extension specialist with the SECC, as a direct resource. One regional livestock group plans to invite him

to give a seminar at a future meeting. David Zierden, the State Climatologist, was also mentioned by name as a good resource for climate information.

Both clients and agents are interested in historical trends for rainfall and temperature, including freeze events. Interviewees were familiar with FAWN and use it regularly o access this type of data. Livestock agents in counties closest to the IFAS Ona Research and Education Center rely on weather data collected there. Many agents who lead educational programs, such as Florida Yards and Neighborhoods (FYN) and 4-H, or those whose primary client base is homeowners were less aware of seasonal climate variability and had not heard of *AgClimate*. They do not include climate in educational materials for their constituents. Their target audiences are not concerned with seasonal climate variability nor are they making decisions based on climate or weather.

Because weather strongly influences agriculture, farmers are constantly aware of temperature changes, rainfall, as well as frost and hurricane forecasts. Farmers rely on short-term weather data and remain connected to data through Internet sites including FAWN and NOAA, television, and through a Nextel® system that delivers weather information. Many measure weather variables on their own farms and share this information with fellow producers. Many farmers regularly contact county extension personnel to request both historical and current weather data. For seasonal forecasts, many long-standing farmers refer to the Farmer's Almanac. In Polk County, some farmers use oak tree acorn production to predict the next season's climate. According to this 'rule of thumb,' when oak trees are loaded with acorns, a cold, winter will follow. If acorns are sparse, winter will probably be dry.

In general, we found that agents have much more confidence in delivering climate information to clients about past events than climate phase prediction. For example, most agriculture and livestock agents regularly provide FAWN data to their clients via newsletters, bulletins, phone, personal visits, field days, and presentations. They also commented that their clients are online and able to access information through the FAWN website. Polk county produced a booklet titled, "Winter Weather Watch," which has an entire chapter addressing climate. *AgClimate* was the key resource for this chapter, which addresses seasonal variability as well as El Niño and La Niña effects. Those agents who delivered information to their clients about El Niño and La Niña stated that they were always very careful to emphasize that these forecasts were not necessarily accurate, i.e. "This is what the climate people are saying…" Many of the agriculture and livestock agents in our sample were hesitant to make concrete recommendations based on predictions of El Niño or La Niña because of the lack of precision associated with these forecasts. Several agents mentioned that during the past two years there had been rapid shifts between El Niño and La Niña or "La Niña-like" conditions, which made them more skeptical of the usefulness of ENSO phase forecasts. They believe the science of climate prediction needs to be refined before seasonal climatic variability recommendations can be confidently delivered to their clientele without risking the loss of credibility of the Cooperative Extension Service. Many informants are longstanding members of their community, having worked there for more than 20 years. These agents are more inclined to provide historical, quantifiable data to maintain their rapport and level of trust in the community.

In urban counties, agents responded to climate questions with concerns about drought and local water supply. For these agents, most of whom work with homeowners or young people, natural resource conservation and reducing home water use are major concerns. Interviewees employed myriad innovative methods to deliver information specific to their audiences, including environmental science day camps, restaurant placemats, decals for measuring fish,

newspapers (the Citrus county Cooperative Extension team produces more than 100 articles annually in four different publications), public radio, and television. These delivery methods are specifically for water management and natural resource conservation issues and do not include seasonal climate forecasts. However, these methods may provide a guidance and opportunity for the SECC to disseminate climate information in the area.

Water management and drought

One of the biggest concerns of some of the agents interviewed was salt water intrusion. New housing developments increase demands for ground water. In the words of one agent, "There are an awful lot of straws in the same cup and the number of straws has been increasing." Even in counties that do not suffer from this problem yet, agents in our sample mentioned that they would not be surprised if salt-water intrusion began to occur because they know it is happening in neighboring counties. Problems with availability of ground water are common in all the counties. All interviewees agreed that groundwater levels have been declining. New wells have to be bigger and deeper, while old ones run dry during part of the year. One agent mentioned that her well ran dry for the first time in December 2007. Another agent in a coastal county described his concerns about water restrictions imposed by the SWFWMD and that he felt homeowners do not pay adequate attention to water conservation. He stated that farmers are doing much more to conserve water because they are more aware of the problem. Recently there has been communication to homeowners to water their yards every other week, rather than not at all, because there have been abundant rains lately. To illustrate why some counties are encountering water shortages, one agent informed us that homeowners in her county use an average of 224 gallons of water/person/day. This compares poorly with the statewide average of 150 gallons/person/day. Her perception is that homeowners waste water by using automatic sprinklers for their lawns. She noted that automatic systems currently in place irrigate whether or not the soil is dry because many homeowners are unfamiliar with automation technology.

In some counties seasonal residents make up a large portion of the population. Many homeowners rely on landscape maintenance companies to make all management decisions or they depend on automated irrigation systems that may or may not have sensors to indicate whether watering is needed. One agent mentioned that some homeowners in her area were using as much as 90,000 gallons of water per month and that the greatest faction of water is used in outdoor landscaping. Even in a county with a high level of public commitment to conservation, seasonal climate variability was described as "off the radar" for homeowners and local farmers, except in the case of hurricane and frost events. Human migration to Florida from other states adds more 'straws' to the cup. Some of these new residents are not familiar with the pattern of wet and dry seasons in Florida. According to some agents, these seasonal migrant residents may have a general knowledge of El Niño and La Niña because they watch the Weather Channel or local news. However, homeowner awareness does not always lead to action as can be observed by simply looking at the utility bills and how much this sector of the population pays for water.

Most agents agreed that Florida homeowners are generally not aware of the reality of long-term water scarcity. One agent believes that use of words like "emergency" in reference to water shortages leads the public to understand the problem as temporary. Once a rainfall occurs, many residents feel the water crisis is over and discontinue water conservation practices. However, water use restrictions will likely become permanent in Florida. The SWFWMD will soon begin penalizing utility companies $10,000 dollars per day for exceeding standard water use quotas. These fines will be reflected in increased water bills for consumers. Thus, 'reduce-

use' programs are a large component of urban extension programming. Nearly all of the Cooperative Extension offices that we visited had demonstrations of Florida-friendly gardens.

In general the perception is that counties near the coastline have more urbanization issues. The inlands counties have larger areas with agriculture and ranching. Cattle ranchers are now spending more money on hay because of the lack of adequate pastures and scarcity of hay in certain periods of the year. Two county agents mentioned that there is not enough grass to cut and bale as hay compared to typical years. In one coastal county, however, conditions are improving and the pastures are resuming near-normal growth. Livestock agents informed us that livestock farmers were concerned with knowing if it would be dry in order to know if they can plant winter forages or if they will need to stock up on hay or have to buy hay to feed during winter. Most counties use some sort of licensed quota system for apportioning water to farmers. For example, in one county the agent reported that during the first month farmers can water a crop frequently, after the first month they can water only once a week. Thus, phenology has been taken into account by the district and local agents in designing their permits.

Because SWFWMD counties have experienced drought during the past several years, more producers have installed drip or micro-sprinkler irrigation systems. However, these systems do not provide freeze protection for crops. Overhead sprinkler irrigation systems use more water; but they also provide freeze protection. Many blueberry producers in Sumter, Citrus, and Hernando Counties have no irrigation, but some freeze protection.

Nearly all of the agents sampled mentioned water regulations in reference to the current drought conditions. According to SWFWMD (2007) on November 28, 2007, these regulations were updated and the third Board Order Modifying Water Shortage, Order SWF 07-02 was passed. This statute extended the modified Phase II (Severe Water Shortage) restrictions through June 30, 2008. These regulations limit homeowner water use by assigning one day per week for lawn watering for each household. These restrictions will remain in effect for a specific period of time and will be reviewed periodically by public and private utilities to determine their impact on wells and surface water sources. Some cities or counties have more stringent measures in place and residents must abide by local mandates. For example, in Sarasota County, chemical fertilizers are not sold for homeowner use. Commercial garden centers carry only organic soil amendments. Fertilizer application is prohibited during the rainy summer months to reduce leaching. Golf courses, agricultural operations, and other water-using industries must follow specific mandates developed by the district as well.

Changes in social climate

The term "social climate change" was used by an agent we interviewed. He saw the issue of climate variability and climate change as a social issue as well as a production one. We use his terminology here to communicate four interrelated issues in the adoption and adaptations to seasonal climate forecasts in our study area and sample. These issues are demographics, level of user technology, land use change, and beliefs and values.

Demographics

Research conversations often led agents to discuss differences in their clientele that was attributable to age. Most agents mentioned that older producers are less aware of climate terminology such as El Niño and La Niña. These older farmers were also more inclined to manage by tradition, that included what they learned from their parents and grandparents, and to use the Farmer's Almanac rather than the Internet. Conversely, younger producers were

generally spoken of as being more aware of El Niño and La Niña, and generally interested in obtaining information from the Internet compared to the older or more traditional producers. Extension agents estimated that the average age of producers in the SWFWMD counties is 55-60 years. One agent also mentioned that he serves at least one livestock producer who is 75 years old. In general, the agents shared that older producers were reluctant to adopt information technology and do not utilize Internet resources to obtain weather and climate information. They also rely less on email to receive or request information from Extension agents One Extension agent told us that he tries to bring his older clientele "into the information age," by distributing an online newsletter and designing websites that link climate and weather information.

In contrast, the majority of the producers in ornamental horticulture are men and women in their 30s and 40s. Many of these farmers have a bachelor's degree. In general, they are more inclined to access information using Internet technology. Ornamental producers are typically more aware of climate variability and many are aware that we are currently in a La Niña phase. Because many producers employ what could be described as more scientific farming methods, they may be more open to using climate information. Many have already taken several risk management measures including installing irrigation and spray nozzles for freeze protection. In another more urbanized county, the agent had not noticed any differences between older or younger producers with regard to the use of information technology.

In this context, it is important to note that even though some many producers may benefit from seasonal climate forecasts, Extension agents are often reluctant to include forecasts in their newsletters. This is because, we were told, there have been inconsistencies in the predictions in recent years. However, the majority of the Extension agents agreed that it would be beneficial to the producers if the farmers were aware of El Niño and La Niña and used AgClimate.org so that they can see for themselves about long-term trends and be able to plan ahead and protect their crops before an anomalous climate event occurs.

In addition to demographics of the residents, agents often mentioned land use changes related to producer age and economic factors. One agent mentioned that climatic events like hurricanes and "free rides" via the movement of plant material have allowed too many new pests into citrus production areas. Citrus canker disease followed by citrus greening disease have discouraged even long-time producers. In urban counties near large cities, a large number of citrus growers and dairy farmers have sold their land to housing developers for urban expansion because the areas "are becoming dry compared to when they began farming," and because of high land prices. Abandoned orange groves are a common site driving through several SWFWMD counties. Agents informed us that this was a sign that they had already been sold for housing development, or were pending sale. One agent described to us how some farmers were considering shifting from pasture and citrus to sweet sorghum to produce the biofuel ethanol because of the recent droughts and pest and disease pressure (in citrus). Newer farmers are keenly interested in seeing how sweet sorghum cropping will impact the region. There is some hope that this diversification of crops might help the overall IPM measures to control canker and greening problems that affect citrus plantations.

Beliefs and values

Knowledge of El Niño and La Niña phases as well as the utilization of climate resources like the AgClimate.org website is influenced by belief and value systems. Some of the agents have the knowledge on El Niño and La Niña and these agents link the El Niño and La Niña phenomenon with the climate change that is happening in their areas. For example, these agents

know that this year is a La Niña year and a La Nina year is associated with the drought period. When the word 'climate' was mentioned in our conversation, some of these agents started to talk about weather, others about global warming. One of the agents stated that he *believes* in climate change, but does not *believe* in global warming. Others automatically mentioned that it is getting warmer, a few were careful to qualify that they don't necessarily *believe* in global warming, while others clearly believe that action must be taken to reduce climate change.

One of the extension agents has observed cyclical changes in the region that fit the patterns in El Niño and La Niña. However, this agent does not *believe* that predictions are accurate. Moreover, this Extension agent does not *believe* in forecast information on El Niño and La Niña. He feels that providing producers with this information would not make an impact on cattle production. Another Extension agent stated her doubt of the reliability of these predictions based on her observations of the El Niño and La Niña shifts during the last two or three years, as compared to what was predicted. Another agent shared the same opinion stating that last year climate forecasters predicted an El Niño year and it was comparatively dry and this year is said to be a La Niña year and in his county it has been relatively wet in recent months.

When we asked about where the agents obtain the sources of the weather and climate information, the majority said that they prefer to use IFAS as a source because it is unbiased. These agents *feel* that the information obtained from IFAS is honest and straight forward. Some of agents *believe* that they have a strong sense of responsibility when providing weather and climate information from IFAS, *AgClimate*, or other sources to the producers because if the information is wrong it could affect producers negatively.

Although some producers have knowledge of El Niño and La Niña, they do not see the value of long-term or seasonal climate predictions. They are more concerned with weather forecasts for short-term predictions. Producers recognize that awareness of climate is important. However, they are reluctant to use the information on the seasonal climate predictions because of the inconsistencies in the forecasting. Some of these producers have a perception as "The forecasters can't get the weather right, yet they want us to believe they can get climate." Therefore their producers often rely on the traditional forecast by using the Farmer's Almanac. They like its ease of use and simple advice. They believe that if their parents and grandparents used the almanac and got by, this should also apply to them.

Some producers, especially those with large ranches, believe in the "heritage" values of farmlands. They are trying to preserve these farmlands for future generations. These producers believe that if they practice appropriate burning and other measures it might help to restore the biotic community to a more natural balance with increased biodiversity principally due to improved habitat, such as bringing the quail population back to the farmlands so that their children and grandchildren can learn to hunt just as their parents and grandparents did. At least one county we visited is conducting research in this area. A high value is placed on fishing and hunting as ways to learn and "become a man." However, seasonal climate forecasts are not currently applied to wildlife conservation and ecological restoration efforts.

One pervasive belief is that the entire ecosystem is off kilter because the Army Corps of Engineers "messed with the Kissimmee river by straightening it out." Many also hold the conviction that the Comprehensive Everglades Restoration Project is "going to mess it up again."

Risk management and decision making

According to the majority of our sample, markets, weather, tradition and local, experiential knowledge play a larger role in management decision making than does climate information.

Most extension agents and agencies work reactively rather than proactively. They are extremely busy and have several dozen programs running simultaneously. Therefore, until producers actively demand climate information, it is unlikely that a plan will be developed upstream in response to downstream needs. The two things most agents and farmers review at least once a day are prices and weather. They feel there is nothing they can do about prices, but they want to know where they are standing financially on a daily basis. Local weather and conditions in competing production regions comprise a large part of risk management and decision making.

According to informants in the study area, hay producers are interested in how daily weather will affect their ability to produce high-quality hay. They are also interested in how the weather is affecting this same activity in other parts of the state and in neighboring states. This gives them a clearer picture as to how much they should be producing, and an idea of what prices their hay might command on the market. Another factor that plays a large role in the study area is the abundance of regulations that affect production. For example, in many counties water restrictions due to drought affect commercial nurseries, urban homes and neighborhoods. Likewise, fertilizer rates are regulated at many sites. These are the same for vegetable producers as for private homes, although limits are based primarily for urban areas. In coastal portions of our study area, which are typically more urbanized than inland counties, regulations and best management practices (BMPs) factor strongly in decisions by agents and their clients.

Insurance, markets, labor requirements, and voluntary practices, such as integrated pest management (IPM) affect decision making under uncertainty with the aim of risk reduction on a daily or weekly basis. Farmers who produce high value crops, such as tomato or ornamental palms (one palm = $10,000), may be aware of climate phases and their effects but do not place high priority on climate information because other factors have a greater influence in their view. The fact that these producers are aware of climate phases and seasonal climate forecasts may mean that they might take this information more into account in the future.

We learned of one livestock producer who based decisions whether to plant winter forages on climate forecasts. Decisions that cattle ranchers make about burning, both for optimizing forage production and improving wildlife habitat, depend on climate information in part, but they also depend on weather, regulations, permits, management calendars, custom, and both wildlife and livestock BMPs. The area is prone to hurricane damage, which affects many decisions in all types of agricultural systems. To date short-term decisions outweigh long-term or seasonal ones in the perspectives of most of our sample. Climate information will occupy a larger or smaller part of the decision making field, when other factors are better controlled. In a situation with less risk from markets, regulations, and similar short-term factors, climate information is expected to play a larger role.

Agents use their experiential knowledge to inform clients of the risk-level of an enterprise. For example, a Polk County agent shared with us the experience of one of his producers who wanted start a watermelon operation on 20 acres. The Extension agent advised him that although watermelon can be lucrative, it is a high-risk crop for several reasons, including climate and weather. He recommended an initial planting of 5 acres, which yielded a profitable harvest. Based on this success the grower increased to 50 acres during the following year contrary to the advice of the agent. That year losses were so great that the man lost everything and nearly lost his business as well. The agent attributed the losses to climate variability.

Conservation and climate

Agents frequently mentioned environmental issues, such as water management, wildlife habitat quality, and increased potential for invasive species establishment, during our conversations on climate variability. Undoubtedly, issues concerning climate and subterranean water availability were of high concern in the study area, and thus were addressed separately in our study. All of the counties visited were part of the Southwest Florida Water Management District (SWFWMD), a state agency that oversees and regulates water management in parts of 16 counties in southwestern portion of the state. The agency regulates the amount of surface and ground water used by agriculture, sets guidelines and directives for land use in terms of water management, and actively engages in projects with stakeholders, including farmers and ranchers, to help maintain water supplies and quality. Several agents mentioned SWFWMD support of their efforts to conserve water and to preserve and restore watersheds. One agent commented on a local dairy farm that had received funds to mitigate nitrogen runoff into the Kissimmee River and nutrient leaching into groundwater. The project included the construction of culverts sufficient to retain water in the event of a 25-year flood. These structures remove standing water rapidly, reduce infiltration, and consequently limit nutrient leaching into the water table and runoff into rivers. Cow excreta is composted in a large digester, then redistributed for use off-site, and all collected water is recycled.

In terms of wildlife quality, the recent dry years were noted in Desoto County as being potentially beneficial for populations of bobwhite quail (*Colinus virginianus*). This species has been on the decline in the Southeastern US in general, and at annual rates of around 3.9% for Desoto County. The agent mentioned that coveys of quail with 15-20 birds were previously common in the area whereas coveys now typically consist of 5 to 6 birds. This decline has been linked to habitat loss, specifically insufficient cover for nesting. Fire ecology plays an important role in restoring quail habitat. Although agents mentioned that loss of quail populations was more related to land management than climate, they stressed that controlled burns were necessary to regenerate the native plant communities that are essential for adequate nesting cover. Dry conditions, such as those typical of La Niña years, would benefit chick survival. He recommends a 3-year burn cycle to provide optimum cover for nesting quail. Drought benefits were also linked to increased brood survival. Newborn chicks are unable to thermoregulate and cool wet conditions contribute significantly to mortality. Another observation that surfaced was that white-tail deer populations appear to remain in velvet year-round and are noticeably smaller. These observations were tentatively linked to warmer than average winters, however nutrition, habitat, and other factors may also explain these observations.

DISCUSSION

Perspectives of seasonal climate variability differed widely among agents, but nearly all agreed that distinguishing patterns in seasonal climate was difficult even with predictive technologies. In several counties drought had affected producers, leading agents to believe that its perceived relationship to La Niña had made people more aware of the effects of ENSO phases. However, other agents did not articulate a direct relationship between recent droughts and La Niña. Moreover, microclimatic variability (specifically rainfall) within the water management district confounded local perspectives of the effects of El Niño and La Niña. While many agents recognized the seasonal effects of El Niño and La Niña, its varied spatial impacts

within the region seemed to defy the notion of a uniform regional pattern. The pervading perception is that the temporal effects of ENSO phases might be well predicted, but the spatial effect is something that cannot be forecast yet with any reasonable accuracy.

The agents sampled served two distinct groups of constituents: commercial agriculturalists such as ranchers and horticulturalists, and non-commercial agriculturalists, such as urban homeowners, 4-H participants, and lifestyle "hobby" farmers. Climate was reported to have little or no value to urban homeowners and participants in 4-H programs while it had significant bearing on the livelihoods of commercial agriculturalists. Despite these differences, agents pointed out that one climate issue that affects both of these groups is the relationship of climate with ground water. Nearly every agent in the sample mentioned the role SWFWMD in relation to the current drought. Agents also talked about the tremendous effect that urban and seasonal residents had on water resources in the region. While agents felt that some urban and seasonal residents were unaware of water management issues, others felt they were simply unconcerned with the conservation of water resources as reflected in their higher rates of water use.

Agents identified several problems with the use of predictive climate information. In some counties, agents said that when the pattern of El Niño and La Niña flipped from one phase to another within a single season, as occurred in the spring of 2006-2007, their recommendations became irrelevant and may have caused producers to lose trust in the agent. As a result, some agents felt seasonal climate prediction information was too inaccurate to be useful. In contrast, others agents said that any additional information for producers was useful for decision-making and risk reduction. As such, most agents recognized the value of seasonal climatic predictions, but not all saw it as being directly useful for their producers' operations. Livestock agents and ranchers felt that horticulturalists were more concerned with seasonal climate variation, but because ranchers depend on rain-fed forage crops, we surmise that ranchers may benefit more from predictive climate information. Nonetheless, most agents contended that seasonal climate predictions had yet to take a prominent role in producers' decision-making. According to agents, most farmers preferred to rely on more reliable and accurate short-term weather forecasts for purposes of decision-making.

Despite the potential benefits of seasonal climate forecasts, there are clearly limitations to their adoption. Some extension agents want to facilitate farmers' access to online information and outside information on climate and weather so that the agents can bring producers into "the information age." In doing this, agents can avoid making recommendations based on uncertain climate forecasts by encouraging producers to make their own judgments with the information available online. Understanding probabilistic information is essential before growers accept seasonal climate forecasts. As described above, weather predictability is perceived as being much more reliable and quantitative than climate predictions. Agents and their producers continue to ask for a track record of previous climate forecasts. Beyond limitations to the adoption of climate forecast, there are many barriers to dissemination of information. Factors that influence dissemination include age of producers and agents, issues of tradition, resource level of producers, probabilistic nature of climate forecasts, and variable effects of La Niña or El Niño in a producer's home area. Agents and producers take into account many factors other than seasonal climate variability that when making management decisions. A preliminary estimation of the relative importance of the various factors producers consider in their decision-making process is: prices = 25%; weather = 25%; BMPs = 12%; insurance = 9%; regulations = 8%; climate = 8%; labor = 6%; tradition = 5%; and other = 2%.

CONCLUSIONS

Drought continues to adversely affect many counties in southwest Florida. One short-term challenge is to help agents and producers minimize risk by recognizing that despite experiencing some recent rainfall, drought may persist.

Cooperative Extension offices often work reactively rather than proactively because of the large number of clients and the small number of extension agents. Recent university-wide budget cuts further stress extension services in the state and programs designed to educate producers on issues of climate variability are unlikely to develop unless producers themselves actively petition for them.

Two recent El Niño events flipped into La Niña or "La Niña-like" conditions, which decreased agents' confidence in seasonal climate prediction and has made them hesitant to communicate climate information to their producers. Many agents have spent years or decades building trust and credibility among their constituents. Most would rather not put this hard-earned rapport at risk by disseminating a forecast that is, in their minds, so imperfect. Variability among different types and scales of farming systems is also challenging (Table 1).

Table 1. Agricultural systems in southwest and west-central Florida and relative likelihood that decision makers in these systems are aware of or would use climate forecasts or recommendation based on climate forecasts according to extension agents.

Location	Agricultural system	Awareness level	Likelihood to use forecasts
Urban counties	Home landscape	Low. Homeowners do not perceive their landscape to be agricultural or natural.	Low. Homeowners consider irritation to be automatic.
Coastal counties	Horticulture, citrus	High. Growers recognize the importance of weather and climate to agriculture and look for pertinent information.	High. Horticultural producers perceive forecasts as a way to manage risk. Most citrus is irrigated, but growers are sensitive freezes and other events.
Inland counties, south	Livestock, citrus	Low. Many farmers are selling land to developers rather than attending to agricultural production.	Low. Many ranchers consider climate variability to be normal and would not manage differently for different climate phases.
Inland counties, north	Livestock, blueberry	High. Ranches are smaller than the southern area so farmers can make more adjustments to production systems	High. Extension agents are aware of climate research and are likely to disseminate climate information. Blueberry is very susceptible to water deficit.

Agents and producers in coastal counties with large urban centers and largely ornamental, citrus, and blueberry production are more aware of the current climate phase. The agents in these counties are also more likely to communicate seasonal climate information to their growers. In contrast, agents in inland counties where production is focused largely on livestock appear less concerned with climate issues and admit to be more hesitant to deliver climate information to their producers.

Climate information may be important for wildlife management on large cattle ranches in SW Florida. One case brought to our attention is an initiative in Desoto County to encourage ranchers to conserve habitat, including native grasses in pastures, for bobwhite quail. Natural resource agents may be able to employ this information in wetland restoration and education programs as well.

Disseminating climatic information through Extension agencies presents a number of challenges. However, the growing number of issues relevant to climate including water management and land use change suggest that predictive climatic information ultimately has great potential throughout the region.

RECOMMENDATIONS

Based on this research, we propose the following recommendations on how seasonal climate predictions can be more useful to agents and producers.

- Collaboration between the SECC and SWFWMD will foster information dissemination and help the district by providing information to better manage water resources based on climate variability. Seasonal climate variability forecasts could be built into jointly sponsored workshops for producers.
- By targeting existing Extension programs, Extension working groups, and commodity associations (i.e. Florida Cattlemen's Association), the SECC may disseminate predictive climatic information. This can help to distribute information among specific groups of producers (e.g. citrus farmers) and individual counties.
- Distribution of seasonal climate forecast information through mass media should commence. This is because so many of our interviewees mentioned that many producers' primary source of climate information includes TV, radio, and newspapers. Mass media would also likely create a "pull" effect where producers would ask their agents for more information on seasonal climate variability.
- Training materials should be developed to teach agents about probabilistic interpretation for decision making. In doing this, agents will be better equipped to help producers make their own decisions based on the probabilistic models available to them.
- Workshops should be developed in order to inform producers on issues of risk related to climate variability. In these workshops producers can also be introduced to potential management adaptations in response to climate forecasts.
- The SECC should conduct further work with Extension agencies to develop recommendations on appropriate methods for the delivery of climate information. This may

bridge the credibility gap for agents who are concerned with distributing information that they feel to be inaccurate or easily misinterpreted.

- Greater dialog should be fostered between university personnel and Extensions agents in concerning the use and implementation of predictive climate information. There is some evidence that some counties have been targeted more than others in the past.
- Funding should be secured for further research on the usefulness of predictive climate information as well as producers' and agents' perspectives on these issues, and their decision-making processes for farm management.

REFERENCES

R.J. Black. 2003. Florida Climate Data. Document EES5, Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available online at: http://edis.ifas.ufl.edu/EH105

Hildebrand, P.E. 1981. Combining disciplines in rapid appraisal: the sondeo approach. Agricultural Administration 8:423-432.

SWFWMD. 2008. Board Order Modifying Water Shortage. Order SWF 07-02. Nov 28, 2007. Hillsborough Co., Florida. http://www.swfwmd.state.fl.us/rules/files/swf07-02_thirdmod.pdf

SWFWMD. 2005. Issue papers: sinkholes. http://www.swfwmd.state.fl.us/about/isspapers/sinkholes.html