

**POTENTIAL APPLICATIONS OF SEASONAL CLIMATE FORECASTS FOR WATER MANAGEMENT  
AND  
EXTENSION AGENT PERCEPTIONS OF WATER ISSUES IN SOUTH FLORIDA**

N. Breuer, G. Canales, V. Cabrera, P.E. Hildebrand, S. Galindo, T. Kulstad,  
T. Manganyi, M. Morris, L. Ramos, E. Stonebrook, and D. Toro

*Disclaimer: All information presented, including any mention of the South Florida Water Management District (SFWMD), is based on perceptions of participating Extension agents only. The SFWMD has been working with complex hydrological models that use climate data as inputs for many years. No representatives of the SFWMD were interviewed for this report and we do not judge the relative merits of the policies, research, models, or management of the SFWMD.*

## **1. INTRODUCTION**

Water resource issues are among the most contended of our day. Important questions exist on fundamental matters such as: Who owns the water? Who controls water where? Can water managers and the general public use information to minimize risks and make better decisions regarding water management?

Relative to most other places in the US, the state of Florida has an abundance of water resources. Lakes, ponds, smaller lakes, natural springs, clear rivers, coast wetlands, beaches, and the Florida Everglades are components of this water wealth. Demographic shifts have brought a large influx of new residents to Florida. Urbanization is on the rise and pressures for recreational and residential use sometimes compete with use of water for agricultural production. As the state's population grows, water availability and water quality issues are expected to become increasingly important. Policy makers have a plethora of decisions to make regarding water as the population is expected to double from its current 16 million to over 32 million by the year 2020. The use of seasonal climate forecasts may be a tool for water planners, managers, and policy makers to better balance the many needs of the diverse water users in South Florida.

The El Niño Southern Oscillation (ENSO) phenomenon is an important determinant of year-to-year climatic variability in Florida (O'Brien et al. 1999, Cane 2000). Generally the fall and winter in South Florida during El Niño years are more rainy and cooler than in neutral years. The fall and winter in La Niña years are generally warmer and much drier than in neutral years. After the El Niño events of 1982-83, and 1997-98, research showed that the effects of these anomalies were stronger in the southern part than in the northern part of the state of Florida (O'Brien et al. 1999, Neelin et al., 1998). During El Niño years, hurricanes also typically make fewer landfalls in the southeast USA. The fact that ENSO effects are greatest in the southern part of the state led us to hypothesize that seasonal climate forecasts might have applications, especially as an aid in decision making to minimize risks in water management.

Although the full potential of seasonal or interannual forecasts has yet to be realized, forecasts have shown promise in affecting planting dates, irrigation needs, preferable crop and variety types, and fertilization schedules (Fraisie et al. 2005). Expected market conditions, pests and diseases, and the need for farm insurance for upcoming seasons can all be estimated using seasonal forecasts (Breuer et al., 2006; Cabrera et al., 2005). However, in Florida, little work has been done that relates seasonal climate forecasts to water planning and management. A first step to help understand the potential for forecasts in agricultural water management was to elicit and record Extension agents' perceptions of the major water-related issues in their work areas.

The Southeast Climate Consortium (SECC) provides seasonal climate forecasts through its dedicated website, [<http://AgClimate.org>], for the States of Alabama, Florida, and Georgia. The SECC also provides Extension agents and other end users with risk assessment indices for some crops, wildfires, as well as county-specific historical climate data. General data on climate prediction and links to weather sites are also provided.

Seasonal climate forecasts are now available for South Florida. Water managers at different scales may be able to reduce their exposure to risks associated with climate variability by using seasonal climate forecasts. The purpose of this study was to ascertain the perceptions of Florida extension agents who work within the South Florida Water Management District (SFWMD) on the water issues in their counties and on the potential usefulness of seasonal climate forecasts for water management.

## 2. METHODOLOGY

The team used the *sondeo* survey methodology (Hildebrand, 1981), which is a multidisciplinary team, conversation-based, rapid assessment. The method is informal, multidisciplinary, low-cost, and effective. No notes are taken during conversations between team members and the person being interviewed in order to foster a relaxed atmosphere and to allow flexibility of topics. The informal nature of the discussion provides freedom to explore the specific concerns of the informant, in this case the extension agent, and often elicits concerns that differ from researchers' expectations. The team directs conversations to elicit the desired information but does not impose a formal agenda. However, if conversations stray too far off course they are steered back to the topic of interest. Through conversation and experience drawn from multiple scientific perspectives, research teams obtain a wealth of data directly from the target audience.

Following each interview team members individually write their notes. Team members then assemble to discuss and compile their notes to ensure accuracy and inclusiveness. After each round of conversations, teams are reorganized to provide a variety of group dynamics throughout the study. The final report integrates the results of all conversations and the sharing and processing of information among team members. Owing to the conversational nature of the process, reports tend to be more qualitative than quantitative.

This *sondeo* focused on Extension agents in their offices within the SFWMD<sup>1</sup>. Opportunistic conversational interviews were also conducted with researchers and extension

---

<sup>1</sup> A description of the research area captured during conversations is available in Appendix 1.

specialists at University of Florida Research and Education Centers (UF RECs) in the area, local residents, and with representatives of a utility company. Interviews tended to be short and focused on climate and water issues. Extension agents are very busy and typically allotted team members 15-30 minutes for conversations. About 80 Extension agents work in the counties visited. Teams held conversations with 30 agents or 38% of all Extension agents in the study area. The target group included 14 women and 16 men. In addition to gender differences, diverse age groups and years of experience within extension were represented. The composition of interviewees is shown in Table 1. Team members visited 15 counties and drove nearly 4000 miles during an intensive week of fieldwork in early May 2005. Although targeting Extension agents in their offices could be considered a sample of convenience, unannounced visits provided an element of randomness as only agents present at the office at that particular moment were interviewed. In this report we first present our findings on potential use of seasonal variability forecasts, then Extension agent perceptions of the principal water issues in their counties, followed by conclusions and recommendations.

Table 1. Areas of expertise for extension agents and other interviewees.

<b>Area of Expertise</b>	<b>Number of Participants</b>
<b>Extension Agents for Agriculture and Natural Resource Management</b>	
Agriculture	2
Commercial Ornamentals	1
County Extension Director	1
Horticulture	1
Research	2
Environmental	1
Urban	1
Family, Youth and Consumer	2
Florida Yards and Neighborhoods	2
4-H	1
Natural Resources	5
Urban Landscape	1
<b>Research and Education Specialists (UF)</b>	
Citrus	2
Soils	1
Environmental Toxicology	1
Sea Grant and Marine	2
<b>Other Interviewees</b>	
Lake manager	1
County Utilities	1
Local Residents	2

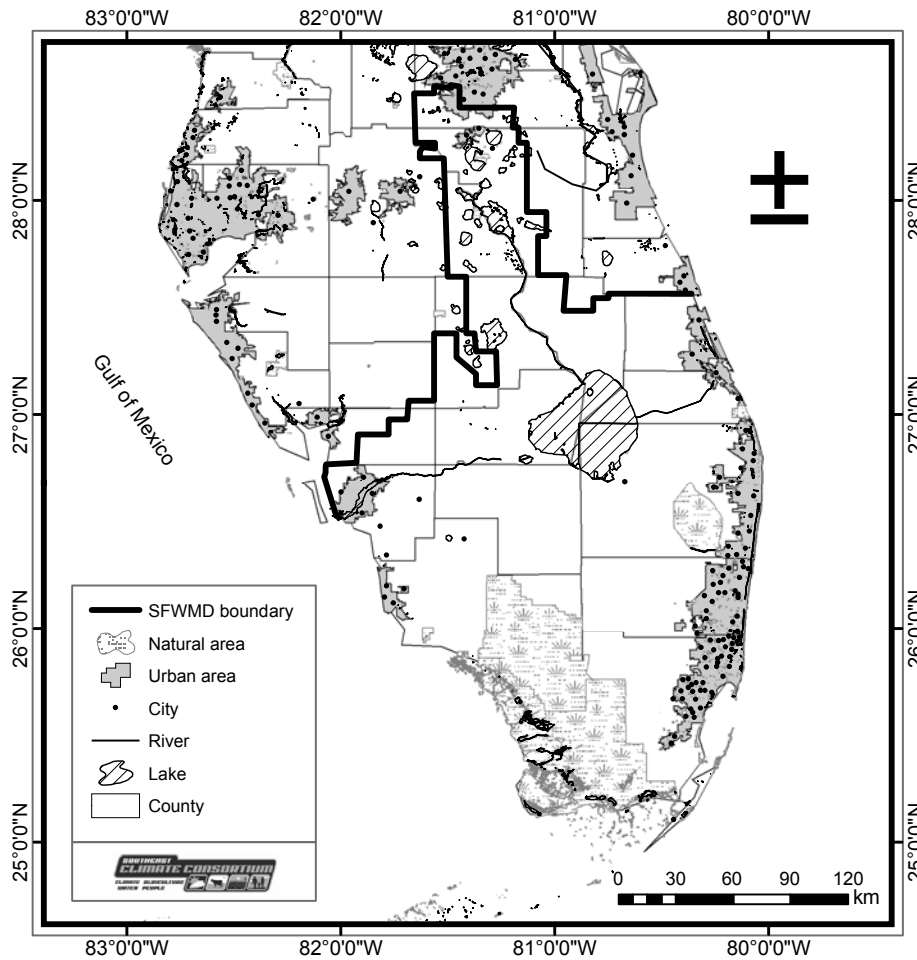


Figure 1. Counties in the South Florida Water Management District

Interviews were based on discussion of seasonal forecasts based on ENSO phase. No specific products, web-pages, or decision support tools were shown to agents during the conversations. Typically, the first part of the conversation centered on general water problems in the area. Next, seasonal climate forecasts and the role of the SECC were explained. Participants then expressed possible uses (or lack thereof) of forecasts to address water issues. Below are findings that correspond *exclusively* to interviewee statements made during our conversations.

### 3. FINDINGS

#### 3.1 Potential Applications of Seasonal Climate Forecasts for Water Management

The potential uses for seasonal climate forecasts seem deceptively simple and can be summed up as “to hold water ahead of droughts, and to release water ahead of rainy events.” Within this overall context the following specific uses and users were mentioned:

- Agents agreed that the SFWMD was in a position to make the greatest use of seasonal climate forecasts.

- The water management district and county utilities generally clean ditches and canals in late spring. If a seasonal forecast predict a greater probability of winter rains, they could also clean and widen canals before winter
- A forecast of increased rain probability could influence the water management district to pulse release water from Lake Okeechobee to avoid sudden changes in salinity levels in estuaries.
- Farmers and homeowners could use forecasts to more easily comply with Best Management Practices (BMPs) by tailoring their water use to according seasonal climate variations. BMPs are a series of practices designed to reduce waste and minimize negative impact on the environment that the SFWMD has designed, but these BMPs do not yet consider seasonal climate variations or forecasts.
- County planners could use climate forecasts to manage small lakes by draining before El Niño winters or by increasing water flow to them before La Niña winter and springs. Such management practices should reduce lake management costs.
- Crop planning and timing of irrigation could be aided by seasonal forecasts. Fields and orchards would need to be irrigated more frequently during La Niña winter and springs. Knowledge of expected conditions is necessary to reserve sufficient water and seasonal forecasts could provide this information
- The Comprehensive Everglade Restoration Project (CERP) is investing millions of dollars to construct wetlands and impoundments. Forecasts could aid decisions on whether to retain or release water.
- Policy makers, planners, and regulators could use seasonal forecasts in several ways.
  - They could provide information for decisions whether to withhold or release water from Lake Okeechobee.
  - Burning off muck and weeds from shallow lakes and wetlands could be done more efficiently if decision makers knew it was going to be a dry winter ahead of time. The current practice is to work according to budget.
  - Managing small and medium lakes according to climate forecasts could save the county and the state money because lake restoration and maintenance could be scheduled for a year when the climate was such that the job could be done less expensively.
  - Water use planning in general, whether agricultural or urban, could simply and effectively use climate forecasts by conserving water before La Niña events and by reducing the amount of stored water before El Niño phases.
- Forecasts have potential to be useful for agricultural and other commercial issues
  - Irrigation scheduling for citrus.
  - Extension agents serve a great diversity of farmers and producers and, in general, forecasts of climate anomalies would interest all of them. They already possess knowledge of typical seasonal variations.
  - If farmers knew when it was going to rain in January they would avoid fertilizer application during that time. They could use even fewer than the three applications recommended in current BMPs.
  - Farmers could save money by using less fertilizer on fields and less electricity or diesel in irrigation pumps during a La Niña phase.
  - It would be useful to develop models that predict disease outbreaks during particular years in citrus, melons, and tomato as related to climate variability.

- In sugar cane areas forecasts would be most useful in farm operations management, especially to plan pumping water out of fields and into canals
- Knowledge of water availability in California, Mexico, and Chile would be used by farmers for risk aversion. For example, Florida growers might plant more of a specific vegetable or herb crop if a seasonal forecast suggested that production would be less in competing regions. Alternatively, Florida growers might cultivate less of a specific crop if a seasonal forecast suggested high production levels in competing regions.
- Forecasts would be useful for strategic use of water in botanical gardens that are restricted by water quotas
- Many persons could use their water strategically at “critical stages” of the year if they had a forecast. “Anyone who uses a water body could use their water more rationally if they have a climate forecast.”
- Livestock producers might benefit greatly from forecasts to build catchments ahead of time if they knew that a less rainy year was coming.
- A strong need is perceived for the forecasting of extreme events, especially hurricanes, so that residents can prepare.
- Forecasts have great potential as educational tools.
  - To educate Extension agents and Extension specialists on seasonal climate variability and the interpretation of forecasts.
  - Greenery or landscape service providers can be educated using AgClimate.org as a training tool. One agent pointed out: “Most people no longer cut their own grass, they hire a company.” If this target audience were to adopt climate forecasts into their management it could have a large impact in aggregate on water quality and quantity.
  - To warn farmers and residents of impending flood-prone seasons.
  - To teach how forecasts can be used for risk aversion. For example, ranchers could move their cattle away from flood-prone land before El Niño winters. Similarly, water could be conserved before a predicted La Niña winter.
  - To help teach about water conservation, recreational uses, and risk avoidance for Florida Neighborhoods and Yards, 4H, master gardener, master naturalist, and other programs.
  - For marine agents to educate fishermen on how climate variability impacts on species availability in coastal areas.
  - To educate clients on the possible negative effects of using climate forecasts.

Scale becomes an issue regarding how agents perceive potential uses of seasonal climate forecasts. The Extension service is seen as potentially being able to use forecasts at the farm, home, recreational, fishing, and urban level, the SFWMD is perceived as the agency that might potentially use climate forecasts for management of Lake and canal levels, and wetlands construction and management. They could also use the forecasts as an aid to designing policies and plans that reduce risk for the many stakeholders on the demand side of water use.

## 3.2. Perceptions of Water Issues

*Sondeo* team members studied how agents perceive general water issues or problems in their areas. While this topic of discussion did not refer specifically to seasonal climate forecasts, it was intended to initiate discussions that would lead into use or potential use of climate forecasts (see section 3.1).

### 3.2.1. Water Quality

Water quality is a widely recognized problem in this area. Conversations revealed that issues of quality were secondary to quantity concerns among the sample population (see Appendix 2). The principal issues are:

- Nitrogen (N) and phosphorus (P) pollution.
  - Manure from livestock intensification contributes to N and P pollution, and runoff into surface waters seems to be a greater problem in South Florida than is nutrient leaching to contaminate ground water.
  - Residences, golf courses, nurseries, and general agriculture contribute to pollution in local water sources. Of these diverse land uses, Extension agents perceive residences, golf courses, and nurseries as bigger N and P polluters than farms.
- Agents mentioned that pesticides are problems that generally receive less attention than N and P. Pesticides leach into the water table and runoff over the surface due to non-point source pollution, with about half of the pesticides coming from urban sources and half from agriculture.
- Estuarine degradation, especially in the Indian River Lagoon, threatens aquatic resources and tourism livelihoods.
  - High turbidity is caused by nutrient overload, and also by particulate runoff from urban construction areas and other land clearing operations. Interruption of photosynthesis in aquatic plants then affects the entire ecosystem.
  - Charlotte Bay on the West Coast experiences most of the same problems as Indian River. In addition, Charlotte Bay now includes an anoxic “dead zone” in the heart of the bay attributed to excess influx of fresh water that prevents appropriate mixing of the water column.
- Around Lake Okeechobee the flavor of drinking water is seen as a quality issue. The water is hard because of high calcium and sodium content. Those who can afford to purchase bottled water.
- Several other areas also have a problem with water flavor and taste. The SFWMD monitors phosphorous by publishing levels every two weeks. This information is public and available online. The Everglades is a phosphorous limited ecosystem, making the phosphorous data crucial to biodiversity in South Florida.
- Salinity and salt water intrusion are problems in several counties due to excessive withdrawal from wells.
- Storm runoff and sewage also affect water quality.
  - Sewage is dumped into the ocean after extreme rainfall events, which creates algae growth, turbid water, and presence of fecal coliforms that sometimes cause beach warnings and closings.
  - Toxic red tide is an occasional but serious problem in all coastal counties.

- Lake quality in residential and recreational areas is often poor. Residents desire a clear lake where one can observe fish. The aesthetic quality of the lakes is compromised by algal blooms. In some cases this is natural, but in many cases it is caused by N or P loading, mostly from excessive application of fertilizers to home lawns.
- In tropical southern Florida excess iron and herbicides are quality problems.
- Nitrogen pollution is a non-issue to one agent who noted: “The only way to stop N pollution in this area is by quitting agriculture altogether because the N is naturally occurring!”

### 3.2.2. Water Quantity

Water quantity issues are shortage and excess, especially during the rainy season. Excess is more associated with summer and lack of water with the winter and spring months. Large urban areas suffer most during droughts. The principal issues are:

- Excess water during the rainy season.
  - Sugar and vegetable-producing areas south of Lake Okeechobee are often flooded, but nearly always in the summer rainy season.
  - Cattle get foot rot and other diseases are transmitted in standing water.
  - Influx of excess fresh water to the Indian River Lagoon was blamed on the SFWMD. Release of water from Lake Okeechobee is a water quantity as well as quality problem because it affects the level of the lagoon.
  - Agricultural or urban planners and users were not expecting the 2001 drought, and it caught them off guard.
  - A lack of water for citrus irrigation occurs at some times in the year.
  - Runoff from rooftops, roads, and parking lots could be as much of a contributor to an excess of water as that from agriculture because they act as catchments or runoff surfaces, especially in coastal areas.
- Hurricanes and storms are considered major factors causing floods.
  - Sugar cane, vegetable, and fruit orchard farms in the Homestead and Belle Glades area are especially hard hit. For agriculture, excessive water is a very difficult problem to solve because of pumping and canal issues. For example, in southern Miami-Dade County, a one-inch rise in the canal causes a six- to nine-inch rise in the water table in fields. The spread of diseases is associated with excessive water.
- Drought occurs in many of the same areas that are often flooded in different seasons. Agents commented:
  - Urban areas must restrict many uses.
  - Long periods of decreased rainfall are acute for livestock producers Excessive use in landscaping is seen as a major contributor to water shortages. Irrigation systems are often improperly gauged. Enforcement of irrigation regulations is perceived as lax.
  - For regulation purposes, Florida should be considered to be in a constant shortage of water.
  - Residents would like better management of boat dock levels on residential and recreational lakes. A constant level is the desired outcome. Most residents do not realize that levels of a healthy lake often fluctuate.

#### 4. CONCLUSIONS

Extension agents perceive that seasonal climate forecasts would be more useful for other stakeholders concerned with water management than themselves. The research team did not hold conversations specifically with hydrology or water agents, but rather with a cross section of agents from many areas of specialization. The best use would be in planning reservoir budgeting and policy decision, which is in the domain of the water management district. Potential uses at the extension agents' scale include educating farmers to pump water from agricultural fields to canals ahead of forecast rainy seasons or advising on holding water for irrigation or for cattle to drink if a dry season is forecast. It is important to note that Extension agents have to believe in the value of climate information before they use it as anything more than an educational tool.

Extension agents will use climate forecasts to *educate*. Many participants perceived urban sprawl as having stronger effects on water issues than agriculture. Forecasts then have potential to be used for a wide range of water management decisions both urban and rural. Opinions reflected deficient communication between Extension and research agencies and water management districts. Participants perceived that the water management district has a limited understanding and knowledge of the local effects of water management practices. It is clear that water is a controversial subject and will continue to be in the future.

Water quality problems are excessive nitrogen, phosphorous, pesticides, and salt. Seasonal climate forecasts have potential to be used by extension and other agencies as a risk aversion aid in water management.

It is anticipated that this report may serve to guide SECC research, development, and Extension efforts with regard to climate forecast-based water management at various scales in the future.

#### 5. RECOMMENDATIONS

- Workshops, in service training, brochures, and electronic mail should be designed and conducted to further diffuse the transfer of climate forecast technology as a decision aid in South Florida. *AgClimate* should be designed as a one-stop web site for climate information needs.
- Nursery, fernery, and the greenery-landscape industries use enormous volumes of water as do tourist parks and residential and commercial urban areas. Climate variability effects on these activities should be promoted.
- Partnerships should be strengthened among the SECC, the Cooperative Extension Service, county and city managers, crop associations, the water management district, and utility companies because climate forecasts have potential to be used “across the board,” but a lack of communications among these stakeholders will hinder adoption and development of adaptations to climate forecasts for the complex issue of water management

- Water policy, regulatory frameworks, and economics as affected by climate are needed future foci of research.
- The SECC needs to broaden its focus in water management to include urban uses for climate forecasts in South Florida. Urbanization and population growth make this effort essential

## 6. ACKNOWLEDGEMENTS

We thank the Florida Cooperative Extension Service for agreeing to interviews; the National Oceanic and Atmospheric Administration for funding; and Dr. Guillermo Baigorria for the GIS map of the study area.

Map Disclaimer: The map is a conceptual tool utilized for research purposes only. This map is not self-executing or binding, and does not otherwise affect the interests of any persons including any vested rights or existing uses of real property.

## 7. REFERENCES

- Breuer, N.E., Cabrera, V.E., Ingram, K.T., Hildebrand, P.E., and K. Broad. 2006. Potential Value of Seasonal Climate Forecasts for Agricultural and Natural Resource Management: A case study in participatory decision support system development. *Agr. Systems In Review*.
- Breuer, N., Gilreath, P., McAvoy, G., Letson, D., Fraisse, C. 2005. Using seasonal climate variability forecasts: Risk management for tomato production in South Florida. University of Florida, Institute of Food and Agricultural Sciences, <http://edis.ifas.ufl.edu/AE269>.
- Breuer, N., Church, S., Dagang, A., Gough, A., Grier, C., Messina, C., Mudhara, M., Mwale, A., Peme, L., Sol, G., Vivas, B., Ziecheck, J. 2000. Potential use of long-range climate forecasts by livestock producers in north-central Florida. The Florida Consortium Technical Report Series. Technical Report FC-UF-2000-02. Gainesville, FL.
- Cabrera, V.E., Letson, D., Podesta, G. 2005. The value of climate information when farm programs matter. SECC Technical Report 2005-4. Southeast Climate Consortium, Gainesville, FL.
- Cane, M. 2000. Understanding and Predicting the World's Climate Systems. Kluwer Academic Publishers, Dordrecht, pp. 29-50.
- Fraisse, C., Zierden, D., Breuer, N., Jackson, J., Brown, C. 2005. Climate forecast and decision making in agriculture. University of Florida, Institute of Food and Agricultural Sciences, <http://edis.ifas.ufl.edu/AE267>.
- Hildebrand, P.E. 1981. Combining disciplines in rapid appraisal: The sondeo approach. *Agricultural Administration* 8:423-432.
- Neelin, J.D., Battisti, D.S., Hirst, A.C., Jin, F.F., Wakata, Y., Yamagata, T., Zebiak, S.E. 1998. ENSO theory. *Journal of Geophysical Research* 103:14261-14290.
- O'Brien, J.J., Zierden, D.F., Legler, D., Hansen, J.W., Jones, J.W., Smajstrla, A.G., Podestá, G.P., Letson, D. 1999. El Niño, La Niña and Florida's climate: Effects on agriculture and forestry. The Florida Consortium Staff Paper.

## **Appendix 1. Additional data gathered**

*Sondeos* are useful for eliciting qualitative data and for diffusion of additional and potentially useful perceptions. Relevant information is also gathered during conversational interviews. We present a range of this type of secondary data and comments here. Although many participants in this study mentioned potential agricultural management practices that could be implemented in light of forecasts, only those relevant to water management are presented.

### **Description of Study Area**

Many counties in the SFWMD are among the leading citrus producers in the state, in spite of sandy soils which require high levels of irrigation and fertilization. Within the orange-growing community, many farmers voluntarily comply with Best Management Practices (BMPs). Recreation activities are common in all counties. These include jet skiing, canoeing, fishing, and others. Lakes of all sizes and characteristics are the natural setting for many of these activities. Many local residents are generally unhappy about the rise in “development.”

Cattle production is another leading enterprise in most counties. Sugar cane, sweet corn, beef and dairy cattle, winter vegetables, and horse breeding are activities in the several counties that surround Lake Okeechobee. Environmental horticulture (nursery and fernery) is a large economic activity in all areas visited.

Counties that lie on the spine or ridge of Florida have naturally occurring phosphates that include some of the greatest deposits in the world. Further south, much agriculture is carried out on “muck” soils. These are organic and have a high level of nitrogen and natural denitrification occurs. To summarize, farmers do not necessarily purchase all the nitrogen and phosphate needed in agriculture. Rather, in many places one or another of these nutrients is a naturally occurring part of the environment.

Around Lake Okeechobee a question exists as to who is responsible for maintaining healthy water quality. Artificial wetlands have been designed and built to filter phosphorous. After the recent hurricanes, a decision was made to send the water to one constructed wetland and it was virtually destroyed because it was not designed to handle such a large influx of water. The most urgent water problem at Belle Glade is hurricanes-caused flooding. Sugarcane producers often divert excess water to cattle ranching neighbors, which sometimes lower income of ranchers. Snakes and alligators are a problem for animals and people during flooding events.

In urban areas of South Florida little agricultural production activity exists aside from home lawns, gardens, nurseries, golf courses, and athletic fields. Housing prices have increased dramatically over time. Lakes and canals are human-made and recreational fishing is important. Landscaping, golf courses, and car washes are industries that are major water users. Golf courses were identified as a particularly large user of water resources. Many counties, especially those on the coast, are 50% urban and 50% agricultural.

The southern-most area covered in this research is highly urbanized. Only the Homestead-Redlands area remains agricultural. Ornamentals, winter vegetables, tropical fruits

such as avocado, star fruit, and lychee are major crops. Hurricanes and other storms have caused flooding and remain the principal concern here. Freezes can be devastating to the ornamentals industry, which is the largest in the country.

### **Water Shortages**

Actual shortage may not exist but if development continues most agree that real shortages will occur. Two agents noted that the SFWMD is overstating the urgency of water shortages so that residents learn to conserve as population grows. Many counties restrict lawn irrigation to three times a week. This is perceived as being too strict. On the other hand, one agent mentioned that his grass grows better under dry conditions because it develops deeper roots. He noted most lawns can be “trained” to adapt to less irrigation, but the general population seems unwilling to make the effort. Two extension agents said that they worry about people who water their yards even when it rains. Fortunately, xeriscaping with Florida native plants is being promoted in most counties.

Large catchments or impoundments are being built in many counties to deal with water withholding or release. Decisions are made based on Lake Okeechobee and not on local conditions. Recently the residents of West Palm Beach experienced a water shortage Pumping water from Lake Okeechobee temporarily solved the shortage, but affluent West Palm Beach residents complained about the flavor and smell of the water.

### **Water quality and coastal counties**

In coastal counties, the main issues are perceived to be septic systems, water quality, water quantity, marine health, excessive use of water in yard maintenance, seasonal homeowners, and tourism. Marine issues include fishing and fishing tourism. Seasonal residence of so called “snow birds” makes enforcement of water conservation laws difficult in many counties. Recently, a new invasive species of algae has appeared in the lagoon. New BMPs for contractors have been initiated recently in St. Lucie County to deal with turbidity caused by runoff from construction sites. Salt water intrusion in coastal residential wells was mentioned as a problem. Apparently, political pressure exists to restore the Indian River to a “pristine” state, or at least to what it was like 40-50 years ago. Algae blooms are almost permanent because of excessive nitrates.

In Indian River-Ft. Pierce, agriculture *and* development cause phosphorus runoff. Construction also creates and exposes other pollutants that are washed into the lagoon and cause red-brown algae blooms. Not all nutrients enter the lagoon from Lake Okeechobee. Rather, a large checkerboard of canals not originating in the Lake, run into the lagoon. A current study is using oysters as a sentinel species to measure health of the estuary. Heavy rainfall events hurt oyster populations. Additionally, decreases in salinity may inhibit spawning making population recovery difficult. Dissolved oxygen also declines because of nutrient loading.

Economic disparities sharply divide coastal counties. Homes on the ocean can be worth \$800,000 and more, have highly manicured landscapes that owners insist on maintaining. Residents in the interior of these same counties are largely Hispanic and Haitian, and resource-

limited. Agriculture is the main activity in these inland areas. Residents in agricultural areas are concerned with water quality and water quantity issues. Many migrant workers are illiterate and cannot speak English. Some drink water from irrigation canals because it is too far to walk to where the companies provide water. Three babies have been born recently with birth defects and there is some suspicion that a connection might exist to water quality in migrant worker areas.

### **Lakes and ponds**

Lake management is a good potential use of forecasts. This refers to small and medium residential and recreational lakes. Lake Hancock is the most polluted lake in the state. The county is building two wetlands to filter the water from the lake before it goes to the river and climate forecasts could be useful for those creating wetlands. Most counties have many natural and man-made lakes. Unfortunately, many residents are not aware or do not understand that lake levels fluctuate naturally and keep the lake ecosystem healthy. If forecasts were used to manage lake levels according to the desires of local residents it might have negative impacts on the environment. This is a good example of “winners and losers” from climate forecast use.

### **Environmental awareness**

Extension agents would like to see an increase in environmental consciousness among the general population. Ecological corridors and conservation are important extension topics in the northern part of the SFWMD. This is due to the fact that large theme park companies have a strong influence and use much of the land and water resources. Tourism is the main industry, and guests typically visit the area for only a few days. In spite of this, citrus, nurseries, greenery (landscaping) continue to be important activities. For example, one nursery alone can be as large as 200 acres. Landscaping and tropical plants consume large quantities of water and their products are principally used by theme parks. County agents strive to balance environmental needs with keeping the vegetation lush so that tourists will vacation in their counties instead of further south. Large quantities of water are needed to maintain this tropical look.

Many extension activities consist of risk aversion in natural resources and urban landscaping. Several important botanical gardens exist in South Florida and have to restrict water use by employing a quota system. Increased tourist industrialization and urbanization are destroying habitat for wild animals. Manatees and sea turtles are being threatened by urbanization in coastal areas because of development. For the last five years wildfire activity has been high in the area.

## **Appendix 2. The nature of extension service delivery in South Florida**

While South Florida has many interesting and important water-agricultural issues, the extension service is also concerned with and devotes considerable resources to a wide range of urban and community issues. Extension services are conventionally conceptualized as agricultural, livestock, and forestry related. This research revealed that extension services in the study area varied according to the type of clientele in each county. Extension priorities in delivery of services tended to differ according to the geographical location in the state. Agricultural services were conducted mostly in counties that were inland, while counties lying on the coast focused more on urban issues such as landscaping. Golf courses, large theme parks, and winter residential homes are important to extension in at least parts of these counties. The wide range of services offered by the agents has somewhat changed the “face” of extension.

Not all clients served by Extension Services are permanent residents of the area. Many are transient or seasonal clients. These clients are extremely disparate. On the one hand, large numbers of seasonal residents come to the area in winter and tend to have little knowledge of local environmental issues. As a result, many of those who purchase expensive homes are inclined to invest heavily in maintaining their yards. This makes landscaping a big industry in South Florida. The need to educate residents on responsible yard maintenance led extension to initiate landscaping programs such as the Florida Yards and Neighborhoods (FYN) and Master Gardeners programs. Through voluntary participation in these programs, residents are encouraged to practice Better Management Practices (BMPs) which are believed to have a huge impact, particularly on issues related to water. At the other end of the seasonal client spectrum, large numbers of migrant farm laborers with different cultural and linguistic backgrounds work seasonally in the area. Educating these workers presents great challenges to extension. One agent who works with migrant farm workers said that both he and they have little decision making power.

### **Agriculture and urban development**

The agricultural base in Florida is heavily affected by urban development. Many farmers have been forced out of farming by competitive industries, especially tourism. Commercial development can afford to pay high prices to buy farms. Counties are under pressure to respond to tourist expectations of tropical greenery that may or may not be in keeping with what is best for the local environment. In all, the focus of extension is shifting somewhat toward natural resources and environmental matters in many areas. This shift is fueled by the growing concern of residents with environmental issues.

### **Regulations**

A general perception exists that the Southwest Florida Water Management District enforces a “one size fits all” policy for nitrogen use for the entire district, which does not take into account the local issues such as denitrification or availability of water resources, which differs widely among counties. Natural salinity exists in some wells in this part of the state.

Interviewees opined that restrictions are directed more toward urban than toward agricultural areas. Regulations are often perceived to be difficult to enforce. “Neighbors do not tell on neighbors or report excessive water use,” one agent reported. In the vegetable and fruit production region, water use restrictions are perceived to be unnecessary and unfair because there is a persistent source of water in wells. A permit is required to drill for a well and another permit is necessary to use the water from it. Residents must pay for water and can only water plants on certain days every week. Nurseries, by far the largest money-making industry in this area, sometimes use 100 to 1000 times more water than the plants need.

A disconnect was mentioned between policy and research about the disputed necessity of conserving water. The results and implications of conserving water are conflicting. It is not “good public policy to tell the residents to use all the water they want,” said one agent. Restrictions are perceived to be part of an educational process for residents as many more people move into the area. One county on the west coast uses only a five-year planning horizon. They do not have a plan for water security beyond that time. They are actively looking for alternative sources of water and are trying to arrange to buy it. Agents are trying to educate the residents to recycle their water by using bath or dishwashing water to water the plants.

### **How empowered is Extension to deal with water management?**

Extension agents work on a smaller scale than the SFWMD. Agents gave the impression that they felt powerless and experienced a lack of communication with the SFWMD. Also, forecasts may have a more limited use in this highly irrigated area than in rain fed areas. Farmers are not likely to ask for climate forecasts. Extension agents would need to go out proactively and show people how to use the seasonal climate forecasts for their benefit. Also, AgClimate.org has to be proven for people to gain trust.

It follows that a general perception exists that agents duties relate to a short-term scale and that climate forecast would be better used for long-term planning and regulation, which are not in the Extension realm. The level of understanding of the difference between climate and weather forecasts varies among extension agents and they requested education on the subject. Because many participating agents were not agriculture agents, they did not necessarily mention principal crops in their counties when asked about water uses. Agriculture was perceived as less important than other water issues in many places in South Florida. The Comprehensive Everglades Restoration Project (CERP) pumps water back into the Everglades. One agent noted that this affected water quality negatively.

According to interviewees, pesticides and phosphorus are well-known water contaminants in this area of largely vegetable and fruit production. Anecdotally, one agent told horror stories about pets developing large gall stones probably due to bad water in South Florida. One agent commented that the SFWMD has a long-term goal to never release water from Lake Okeechobee but he thinks it is an unrealistic and unachievable goal.

## Reliability of climate forecasts

Two extension agents who used NWS and NOAA forecasts had been waiting for rain all winter. They had told farmers: “Don’t worry the rain will come. It is an El Niño year.” The rains did not come and they were surprised to hear from us that COAPS had predicted a neutral year all along. The discrepancy between Federal forecasts and SECC forecasts must be somehow overcome in the future as it leads to confusion and general lack of trust in forecasts. Either this, or diffusion efforts must be stepped-up so that all agents use AgClimate.org as the default source of climate forecasts.

The fact that some agents are skeptical about climate forecasts should not be overlooked. One extension agent perceived a wet winter in his area to be impossible. “We have never had a wet winter. How can you forecast something that never happens?” Agents were not always in agreement about water quality. One said there is no water quality problem, and that the environmentalists want to make it an issue. Another noted that problems with phosphorous, iron, and salinity exist. Quantity and quality issues are seen as combined because there is “less water and therefore more concentration of pesticides and pollutants in storm runoff.” Two agents perceived real time monitoring and access to information to be much more important than climate forecasts because freezes are the main concern in nurseries and tropical fruit areas. Several agents did not believe a water shortage ever exists in their area. They described the water shortage problem as “fictitious.” By this they meant that the so-called “shortage” of water is simply a policy projection for the future. Environmentalists are also blamed by some for generating and inflating a water shortage picture that does not conform to current reality.

Finally, the number one potential application of seasonal climate forecasts mentioned by most agents was as an *educational tool*. It can be inferred from this that, aside from education being extension’s primary role, agents would need to “buy in” to climate forecasts first. In this sense, climate forecasts in South Florida are in the very early stages of an extension where “awareness” is sought as an objective.