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POTENTIAL USE OF LONG RANGE CLIMATE FORECASTS BY AGRICULTURAL EXTENSION AGENTS IN FLORIDA

by

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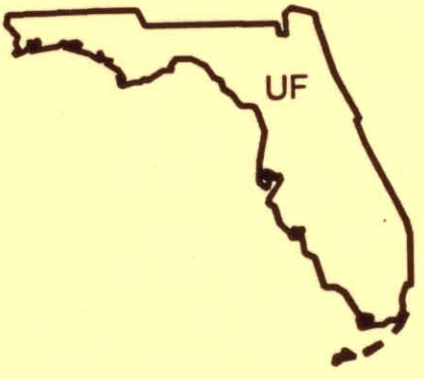

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POTENTIAL USE OF LONG RANGE CLIMATE FORECASTS BY AGRICULTURAL EXTENSION AGENTS IN FLORIDA

A SONDEO REPORT

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ABSTRACT

This study has several goals. First, it aims to ascertain how climate forecasts can be tailored for use in agriculture. Second, it provides information on the needed accuracy of the forecasts for different agricultural uses. Third, it provides an evaluation of different management options for specific forecasts. And fourth, it estimates the value of such forecasts to agriculture in the region.

The project focused on agricultural extension agents in Florida and their perception of how long-term climate forecasts are being or could be used by farmers to improve agricultural decision making. The information was gathered through informal interviews called sondeos, a team survey process that was developed to provide information rapidly and economically.

In general, it appears that the more diverse operations in the north, which are often smaller than many in the south, are in a better position to respond to climate predictions. The ability to respond also depends on the commodities a farmer is producing. Different attitudes were found among extension agents about their willingness to disseminate climate information and recommend strategies and practices based on climate predictions. At a local scale, market was found to be a more important factor than climate. However, since climate conditions in competing supply regions have a profound impact on prices, climate predictions in these areas would be very important in farmers' decision-making process. Competing producers and other stakeholders such as chemical suppliers, insurance companies, produce buyers, relief aid agencies, and banks would also benefit from climate prediction, and often to the detriment of farmers.

Key Words: Sondeo, climate prediction, farmer responses, extension use

CONTENTS

INTRODUCTION

A consortium of Florida Universities is conducting a study sponsored by the National Oceanographic and Atmospheric Administration (NOAA) to determine the potential use of longer-term climate forecasts (as opposed to daily or weekly weather forecasts) to improve agricultural decision making, and to develop methods and tools to facilitate the effective use of climate forecasts in agriculture. Recent research by climatologists has produced methods of forecasting climate and weather patterns 3 to 6 months in advance. Some of these methods use information on El Niño activity and associated shifts in global wind patterns. These forecasts appear to have considerable potential for application in agriculture. If farmers know early on what the weather will be over the next growing season(s), they may be able to adjust their practices.

Many questions must be answered before climate forecasts can be used with confidence in agriculture. If farmers have a reliable climate forecast three to six months ahead of time, what changes could they make in their strategies, and for what crops? What are the risks associated with these changes? Realizing that forecast will never be perfect, are climate forecasts a feasible tool for farmers and extension agents?

This study has several goals. First, it aims to ascertain how climate forecasts can be tailored for use in agriculture. Second, it provides information on the needed accuracy of the forecasts for different agricultural uses. Third, it provides an evaluation of different management options for specific forecasts. And fourth, it estimates the value of such forecasts to agriculture in the region.

The project described in this report focused on agricultural extension agents in Florida and their perception of how long-term climate forecasts are being or could be used by farmers to improve agricultural decision making. The information was gathered through informal interviews called sondeos. The findings have been divided into sections based on the existing extension districts.

METHODS

The sondeo (Hildebrand, 1981) is a team survey process that was developed to provide information rapidly and economically about agricultural practices in order to guide strategy in agricultural development programs. It is structured around a series of informal, conversational interviews between the team and farmers. It is a multidisciplinary process from data collection through report writing with each team ideally including people from the social and the agricultural sciences. This helps avoid a typical problem of "team" reports where the people from separate disciplines write separate reports based on their specialties and then combine them without much cross fertilization. In a sondeo, data are shared among the different teams and report writing is

done as a group so that observations are confirmed, debated and analyzed with members of the other teams. The results may be quantified or not but the accuracy of the findings is strengthened by the cross-checking process. Using this process, the final report may be completed within days of the final fieldwork, assuring the timeliness of the results.

Data Collection

The sondeo team consisted of eight graduate students from a number of backgrounds including anthropology, agronomy, agricultural extension, natural resource management, forestry, geography, and community development. Two-person teams that changed partners each day conducted interviews. Changing partners helped team members avoid creating habits and roles with their partners that would reduce a team's effectiveness.

The interviews were conducted over a period of nine days from August 9 through August 18, 1999. Each team scheduled two interviews with extension agents Monday, Wednesday and Friday of the first week and on Monday and Wednesday of the second week. Between each of those days all team members met in a common location to report and discuss the previous day's interviews. The process began in south Florida in extension District V and moved north through districts IV and III the first week. During the second week, the teams worked in the panhandle and north Florida in Districts I and II.

The interviews were conducted as informal conversations. After a team introduced itself and explained the subject of the research, the agent(s) and the sondeo team conversed about any aspects of the topic that the agent wished to discuss. This open-ended approach enabled topics to emerge and be pursued that might have been missed if the researchers had only previously formulated questions. Despite the open-endedness, a set of core themes was discussed in almost all interviews. Notes are generally not taken in sondeo interviews, although some interviewers found brief notes useful to capture the specifics of the information provided. Following each interview the partners wrote individual notes, compared them, and then wrote a joint report for the interview.

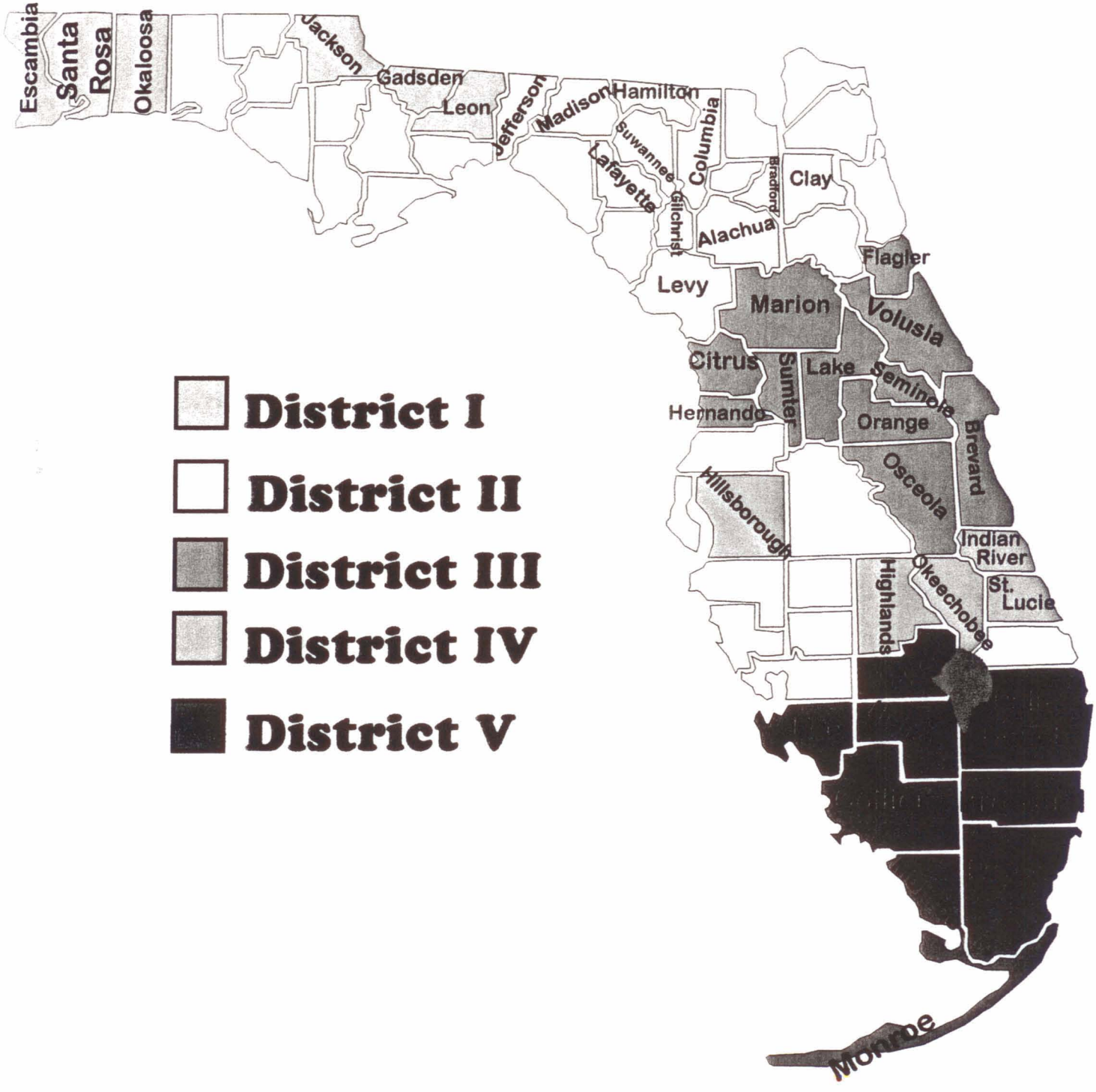
Data Analysis

The joint reports from each team were shared and discussed among all sondeo members on the days between interviews. As each team presented its findings, they could be clarified, challenged or contrasted with the results of the other teams. Everyone was expected to take notes on the findings of each team, as all members were responsible for the findings of all the teams. This process of reporting and discussion served as the opportunity to begin noting trends, gaps in information and new questions to be pursued.

Report

The report structure was discussed and agreed to by the team members as a whole. Responsibility for writing drafts of the sections of the report was taken by individuals or two-person teams that began working on them following the last day of interviews. The

Counties Visited



entire sondeo team worked together to edit and produce the final report. As the group discussed each section, changes were made to the document. Conclusions and recommendations were written collectively by the whole team at the time of editing.

FINDINGS

DISTRICT I - Panhandle Region

Background

District I covers 15 counties in the panhandle region of north Florida, west of Tallahassee. It extends from Leon and Wakulla counties in the east to Escambia county in the west. Interviews were held with extension agents in six of the 15 counties of the district: Leon, Gadsden, Jackson, Okaloosa, Santa Rosa, and Escambia.

These counties are located entirely or partly within the northern part of District 1, along the Georgia and Alabama borders, where soils are well drained and generally conducive to agriculture. In contrast, the southern part of the district, adjacent to the Gulf of Mexico, is characterized by heavy and often wetland soils, typical of emergent coastal zones. This southern section of the district also is increasingly characterized by suburban and tourism development.

The main crops and commodities in the district in terms of value and acreage include cotton, peanuts, soybeans, and pine trees. Other important commodities are corn, wheat and other small grains, beef cattle, melons, strawberries, blueberries, mixed vegetables, and hay (mostly for local use). There are also dairy farms, ornamental crops, sod, Christmas trees, goats, pigs, and catfish. Horse farms are important in some areas, such as Gadsden County near Tallahassee.

There is considerable variation among the surveyed counties in the extent of irrigation. This is true even among counties with a strong agricultural base. Farmers in Escambia and Santa Rosa counties, for example, seldom have or use irrigation, while in Jackson county, most farms are irrigated. Counties also vary considerably in the degree of emphasis placed on agricultural production and activity. All of the aforementioned counties have a strong agricultural orientation, as does Gadsden county, while in the two remaining surveyed counties, Okaloosa and Leon, agriculture represents a relatively minor economic sector. This appears to be due to soil conditions in the case of Okaloosa, and urbanization and high land values in the case of Leon County.

Weather/Climate and Existing Responses

District I is relatively unique in Florida in that it is significantly affected by frontal weather (generally between December and May), as well as by the summer convective weather that occurs throughout the state. Thus, unlike most of Florida it receives substantial rainfall during the colder season in addition to the heavy convective showers

that fall during the summer months, particularly July and August. The fall months of September to December are relatively dry, except in the event of hurricane-related storms.

Limited information was obtained on existing responses to climate and weather. In relation to several crops (unspecified), the objective is to harvest as early as possible in the fall without losing the young plants to late frosts in the spring. One agent claimed that drought conditions and events of excessive rain are equally problematic to farmers. Irrigation is relied upon only in some areas, because the amount and distribution of precipitation generally are considered adequate. Also, special drainage works are relatively uncommon. Conservation tillage aimed at moisture retention has grown in importance. Methods include strip and lister tillage. It also was noted that if summers are relatively dry, less fungicide is applied to the peanut crop. In addition, timing and other decisions related to harvesting commonly are based on one to two week weather forecasts.

Potential Responses to Improved Climate Forecasts

This section covers the responses that might be expected if the agricultural sector had access to more reliable and accurate climate forecasts. The potential responses fall into three main categories: cropping patterns and planting decisions; crop and pest management; and livestock management. In general, it was emphasized that improved forecasts would help guide decisions about 1) what crops and varieties to plant, 2) where on the property (with respect to moisture) a crop should be planted, and 3) when. Climatic factors of importance in relation to these decisions include temperature, rainfall and humidity, sunlight, and extreme events such as storms and floods, droughts, frosts and freezes, and hail. The following are examples of responsive cropping decisions that were cited by the extension agents:

-More watermelon and cantaloupe if wet weather is expected over summer months;
-Less or no vegetable production if dry conditions are expected;
-Corn and soybean would not be planted if dry weather is expected;
-Plant winter grains on sandy soils only if a wet winter is anticipated;
-Produce more sod if humid conditions are expected;
-Delay planting tree seedlings to avoid drought impacts;
-Adjust timing of cotton planting;
-Select alternate soybean varieties based on anticipated sunlight conditions in a given season;
-Select new or alternative crops to match crop tolerance with anticipated temperature ranges in a given season.

With respect to crop and pest management, the following actions in response to climate prediction were mentioned:

-Managing frosts and freezes in fruit production. No example was provided, but presumably this includes the use of irrigation, heaters, etc.;

-Applying less fungicide to peanuts if dry conditions are expected;
-Expanding or contracting irrigation systems on a farm;
-Taking steps to avoid pest (including weed) problems, particularly through IPM. For example, it was noted that the number of heat units reportedly affects cotton pests and pesticide requirements.
-Making decisions about chemical defoliation in cotton.

In livestock management it was mentioned here, as elsewhere, that a farmer might expand the herd if wet weather and thus good forage production were expected. On the other hand, if dry conditions were anticipated, herd size may be reduced and/or an effort would be made to store feed in advance of the dry conditions at a lower price.

Other Important Factors

Some agents maintained that market factors have a much greater influence on agricultural decisions than climatic factors. Forecasted climate for other regions of the country and other world regions would help with decisions about supply and marketing. Such information also would be useful to those engaged in futures and options trading.

Poor prices and market conditions for agricultural commodities in the district encourage conversion of agricultural land to forest plantations and suburban development. The Conservation Reserve Program and high land values provide additional incentives.

High accuracy and reliability is critical to increasing reliance on forecasting for decision-making. Another factor is cost and accessibility of the service for farmers.

DISTRICT II – North Central

Background

District II consists of 17 counties in north Florida of which Levy, Alachua, Bradford, Clay, Gilchrist, Lafayette, Madison, Jefferson, Suwannee, Columbia and Hamilton were included. The main agricultural products in the district are peanuts, tobacco, cotton, corn, timber, dairy cattle, beef cattle, pasture, vegetables, ornamentals, watermelons, strawberries, and poultry. Other minor agricultural products include goats, soybeans and blueberries. Most of the counties in this district have very diverse agriculture. In each county a large portion of the agricultural products listed above are present. There seems to be a wide variation in the amount of land and crops irrigated throughout the district. In some areas drip irrigation is increasing, while in others irrigation is not used.

Traditional agriculture is declining in the district and much of the land in agricultural production has recently moved to other uses. Much of the soybean and corn areas have been put into timber through the Conservation Reserve Program (CRP) or the Forestry Incentive Program (FIP) due to market, taxes, and demographic reasons. The CRP pays the farmer more per acre per year to take highly erodible land out of production than the

marginal profits of corn and soybeans according to one agent. Some land has been converted to urban development, while other land is reportedly left idle when a farmer retires because the younger generations are not continuing in agricultural production.

Weather/Climate and Current Responses

All of the extension agents interviewed in the southern counties of District II mentioned that the past few years have been drier than usual, especially the springs. They also said that drought is harder to deal with than excess rain in terms of management practices. One implication of a dry spring is the reduction in hay production that increases the producers' costs because they have to buy more feed for their cattle. Heat also was mentioned as an important factor influencing pollination, especially for corn. Currently, farmers are using weather forecasts mainly for pesticide and fertilizer decisions. One important factor for rainfed agriculture is the variation of weather over a short distance, making predictions more difficult to use.

There are examples of farmers and extension agents who have already used climate predictions.

-One agent mentioned that he currently uses climate predictions in the Midwest to estimate the price of feed.

-When one farmer learned of an adverse climate prediction for California, where Chinese cabbage is grown, he decided to plant more of this crop. As a result of this decision, he made a good profit.

-An extension agent received climate prediction information at a meeting and conveyed the information to farmers. According to the agent, the farmers who responded to the prediction did better than those who did not.

Potential Responses to Improved Climate Forecasts

The majority of agents felt that climate predictions would be very useful. Climate predictions could influence crop type and location. It may influence the variety planted, but with fewer options as varieties are usually related to other factors, such as pest resistance. They may change maturity groups based on predictions. However, it seems that in some counties it would not influence the crop planted (i.e. peanut-producing counties) because farmers are locked in to certain commodities. Late spring freezes are a threat to tobacco, watermelon, corn and pasture. Farmers could push back the planting date of these commodities but then would lose market windows and risk harvesting during hurricane season.

Corn

Some producers may choose not to plant corn if the summer is expected to be dry or they may change their planting season from March to July depending on early or late wet seasons. They may also change the amount or location of corn planted.

Poultry
Because chickens are raised on contract, the biggest influences on production are the policies and decisions of the company. Farmers may change chicken density and/or sex ratio. If they expect an extremely hot summer they could better prepare their cooling systems.

Cotton
Flexibility to adjust harvesting dates based on climate predictions is limited because the farmers have to supply the gins when requested.

Peanuts
The main sources of flexibility with peanuts are variety and maturity group. Farmers may also change the planting date; however, there is a small planting window.

Dairy Cattle
With extreme heat predictions farmers may choose to dry their cows early or sell them. They may also make contracts for grain purchases earlier to receive a better price if they knew it would be necessary to buy more grain than normal or that grain would be in higher than usual demand.

Tobacco
There are not many changes a farmer could make with climate forecasts in this crop because it is mostly irrigated. If wet weather were expected they could plan preventative spraying of fungicides.

Beef Cattle
Responses to climate predictions in beef cattle could include selling cattle sooner or later than usual and increasing amount of pasture planted and/or increasing irrigation of pasture. They may also stockpile feed.

Other Important Factors

Almost all agents in this district mentioned market values or the economy as the main driving factor behind farmers' decision-making. For example, in Madison and Jefferson Counties market values and poor soil conditions were identified as the main factors influencing the change to pine production. Other related issues were also mentioned such as availability of crop insurance and disaster aid. One county agent said that the availability of disaster aid serves as a disincentive to use best management practices. However, now that the disaster aid program is becoming more strict in its distribution policy, farmers may have more incentive to use climate predictions. Finally, two agents mentioned that labor availability was a major influence on producers of such commodities as strawberries, watermelons, and some vegetables.

DISTRICT III - Central

Background

District III is located in central Florida, extending from the Gulf of Mexico to the Atlantic Ocean. We spoke with extension agents in seven of the 13 total counties including Citrus, Flagler, Marion, Orange, Osceola, Seminole, and Sumter. Much of the land use variation is due to the demographics of the district. Some counties have a large population of retirees who are not interested in inviting non-agricultural industries for employment opportunities, resulting in relatively stable land prices and agricultural importance. Others attract industrial development through tax incentives or entice large populations of tourists. The world's main tourist center, the Orlando area, has significantly influenced the main economic activities in the region.

The major agricultural commodities discussed with the extension agents in these counties included nurseries and ornamental horticulture, citrus, beef cattle, horses, hay, pasture, sod, timber, fruit such as watermelons, cantaloupe, blueberries, strawberries, vegetables such as peppers, tomatoes, peas, beans, okra, squash, potatoes, cabbage, winter greens, and peanuts.

Recently there has been a shift from traditional crops to other more commercially oriented produce such as ornamental plants and sod grass for landscaping. In many areas, horses are replacing cattle. In general, other more competitive forms of land use are replacing traditional agriculture. As one extension agent put it, "...agriculture is no longer as popular as it used to be due to urbanization, severe freezes in the 80s and better returns on other investments."

Overall, citrus is declining, due to both urbanization and the freezes of the last decade. There are also trends that represent regions within District III. For example, in the eastern counties, the more profitable blueberries and strawberries often replace citrus. The vegetable industry is shrinking.

Current Responses to Weather and Climate

As a result of the changing climate and erratic weather conditions, farmers are slowly getting out of agriculture. The remaining farmers who cope with these challenges are interested in climate and weather issues. To some, climate prediction is currently used as a forum of social conversation and there is not much confidence in prediction and/or reliability. Others, such as some large-scale Marion County farmers, use their own funds to pay for weather data from at least three sources. They select the two that most nearly agree. Some extension agents noted that the South Florida Water Management District is more likely than farmers to use climate prediction because of their water resource management mandate.

Farmers are already using techniques aimed at conserving water such as plastic mulching. Nurseries are irrigated and heated, so only drought-induced water restrictions would

affect their ability to produce. In Osceola County, cattle graze mostly in swampy areas that require minimum pasture management. According to agents in Osceola County, there has been an increase in temperatures and less frequent freezes over the past four years. This has frustrated citrus farmers who have already switched their fields to sod to avoid the impact of freezes.

Among vegetable growers and horticulturists, there exists more interest in an accurate and reliable 24-36 hour weather forecast than climatic prediction. Due to the variability of weather from location to location, farmers would also prefer a specific, rather than regional forecast. It was noted that the USDA Forest Service is far ahead in weather prediction. Extension offices obtain data from them at times. It was also noted that large-scale farmers in this District are better able to respond to climate predictions than are small farmers, who have almost no ability to change their practices.

For various reasons, current sources of climate and weather predictions are often unreliable for farmer use. For example, the Southwest Water Management District has good weather data but the relationship between Extension and the water district is not conducive to encourage free sharing of this important information. Data from the media are said to be not accurate due to the powerful interests of the tourism industry. For example, it was alleged that during winter, reported temperatures in Orlando are often an average 10-12°F higher than the actual reading.

Potential Responses to Improved Climate Forecast

Citrus

The value of climate prediction varied by county according to perceptions of the extension agents, but general trends indicated more usefulness in large-scale operations. For example, it was indicated that large-scale citrus farmers in Seminole County would be interested in climate prediction to plan for production strategies. They have more economic flexibility to adjust than do the small-scale farmers.

A climate model would also be useful in planning for irrigation in citrus. In Osceola County, it was noted that citrus farmers could use climate predictions for planning acquisition of infrastructure and equipment, such as generators and irrigation equipment, as well as planning fungicide applications.

More skeptical agents noted that, while long-term predictions may be useful to the citrus packaging industry in preparing for an early harvest, farmers already harvest as early as possible to avoid frost damage. In Marion County, citrus industry has little recourse for changing their patterns based on climate predictions.

Cattle, hay, and pasture

There was a general feeling throughout the interviews in the District that climate prediction may be more useful in livestock and the pasture/hay industry. Cattle producers would be very interested in predictions as far in advance as possible to prepare for gestation and weaning periods. Beef cattle farmers would use the prediction models to

determine whether or not to plant pasture grass. Information would also be useful in deciding to stockpile hay. Predictions would be used to determine herd size in order to ensure a steady supply of feed and pasture management through stocking and de-stocking. This would assist farmers in avoiding unexpected additional expenses of supplementary feeding. Farmers would also be better advised as they decide on the grazing regimes between the wet and dry periods.

Horse farms, hay and pasture
Knowledge of the rain patterns would assist farmers to manage their pastures and to know the stocking capacity for the imported winter horses. They would be able to know how much hay they need to import and could determine their horse stocking levels depending on the predicted pasture availability. Pest control in pasture management is another area that could benefit from climatic predictions, as farmers would be able to determine when to spray, having knowledge of the conditions that favor the proliferation of pests.

Timber
Forest managers would use the models to assist them in deciding on the planting season. See the forest summary in a later section for more details.

Vegetables
Freezes were widely acknowledged to be a major problem in the vegetable industry. Growers would use the models to predict freeze seasons and plan accordingly. Irrigation strategies would benefit from wet and dry season climatic prediction. If farmers were informed in advance, they would ensure an economically effective plan of irrigation. However, other extension agents expressed reservations about the applicability of climate predictions in this industry. They argued instead that there is a need to address vegetable marketing and to cover costs related to infrastructure, rather than predicting climate.

In addition to freezes, floods were mentioned as another key factor that affects potatoes and cabbage. Climate prediction would assist in flood planning by pumping water out of the fields prior to heavy rains. Crops also may be planted in raised beds to avoid root submersion.

Ornamental Horticulture and Plant Nurseries
Ornamental horticulture would also benefit from climate prediction, as growers could plan to change the main soil substrates needed for potted plants. Weather forecast would assist them to determine the plant pot placement and such other activities that would enable them to protect plants from frost. The ornamental industry might use the climate prediction to protect their ornamental plants or opt for importing instead of growing the plants, based on probability of drought.

Peanuts
Farmers could change planting dates based on weather and climate forecasts. Small-scale farmers would use weather data to determine when to apply fungicides or, where possible, to determine planting and harvesting dates. Forecasts that accurately predict

temperatures below 30°F could be very useful in peanut growing. However, some skepticism was expressed for the value of climate predictions for this commodity, as there is little flexibility to change practices.

Another application of climate predictions mentioned during the interviews was the farm disaster aid preparedness. Prior knowledge of impending bad years would give the aid programs ample time to prepare.

Other Important Factors

Marketing is an important factor in determining the planting and harvesting season. Even a one-week planting delay could affect the profit margin of a crop by 50%. However, if farmers expect a freeze, they would delay the planting even if they fully know it will affect their profit margin. The main constraint to agriculture in the district is marketing of the vegetable produce. Small farmers need to better organize themselves to tap into the niche markets for their economic survival.

Trade agreements, such as the North American Free Trade Agreement (NAFTA), are also important in determining the prices of agriculture produce. Several extension agents suggested that climate prediction should also be available for other production areas such as Mexico, Central America, and the Mid-west. This is very important for marketing purposes.

Historical trends in climate are important in the relationship to agricultural changes, such as the movement of citrus growers from north to south Florida over the past century. In District III, the trends have promoted urbanization, affecting land prices that heavily influence agriculture. Increased land prices and urbanization reduce the attractiveness of agriculture.

DISTRICT IV - South Central

Background

There are 12 counties in District IV. For this sondeo we surveyed five of them: Okeechobee, St. Lucie, Hillsborough, Highlands and Indian River. The commodities grown in the district include dairy and beef cattle; vegetables (such as potatoes, corn, peppers, watermelon, carrots, cabbage, all greens, strawberries, and tomatoes), citrus, blueberries, blackberries, sod, and ornamental nurseries (including outdoor landscaping). The extension agents for the district reported varied uses of water management. For example, the coastal counties of Indian River and St. Lucie reported that water supply is a major concern for production of citrus and urban nurseries. All the farmers pay close attention to drought forecasts. Among vegetable and citrus growers, irrigation and drainage works are commonly used. However, with too much rain, drainage issues may be problematic. The ridge soils of Highland County are better drained than the flatwood and muck areas of the region.

Weather/Climate and Existing Responses

Farmers currently use weather forecasts but generally lack confidence with climate predictions. Some farmers respond to El Niño predictions, while others do not. The recent El Niño has not drastically influenced climate forecasting in the District.

Cattle farmers use Bermuda and Bahia grass for cattle grazing. As a management strategy, cattle farmers supplement feed during cold winters with imported hay, because local pastures are scarce. During wet summers the grazing areas are limited and muddy conditions prevail. Muddy conditions during the rainy season cause disease. Walking in these conditions requires more energy, leading to lower milk production. Wet conditions also present pest problems. During the summer dairy cows are cooled using ponds, showers, and fans to avoid severe shortage of milk production.

Vegetables are a major crop in this District. Frost and excessive rains affect the crops. In Highland County farmers plant their crops in areas that are relatively wet or dry based on predicted climate forecast. Citrus is also affected by excess rain. Therefore, water availability influences vegetable, citrus and nurseries more than any other climate factors.

Ornamentals are affected less by weather than other industries in the District, although dampness with these crops brings on pest problems. The sod industry is also severely affected by wet weather that can ruin the crop.

Potential Responses to Improved Climate Forecasts

Extensionists in the District mentioned that improved predictions of dry or wet conditions would greatly influence how farmers manage water. Farmers with advance predictions would clear drains in anticipation of wet weather as well as prepare to flood fields in anticipation of frost conditions.

Reliability is a key aspect in climate forecasting. Information regarding climate would help improve farmers' decision-making. Farmers must have confidence in the forecasts in order to respond in any significant way. Not all of the extension offices in the district disseminate information on climate forecasts. But if given more accurate climate predictions they would make the information available to the farmers.

Climate forecasting would help farmers decide on options for new crops. Farmers are always seeking to try new crops or commodities for financial benefit.

Climate forecasting information would be useful for pest control.

Vegetables
Vegetables are somewhat more flexible than other commodities. Contrary to comments from other districts, small-scale vegetable producers in this District can more readily alter or change crops and timing in response to climate predictions. For example, a predicted frost could alter the scheduled planting date of sweet corn, or even whether to plant. In

addition, predictions may influence the use of pest resistant vegetable varieties based on climate forecast. Forecasting also may affect the decision of whether or not to plant a second crop.

In the case of blueberries, only a six-week marketing window exists, so there is limited flexibility. Local climate forecasting also would not have much influence on the ornamental industry.

For cattle (dairy and beef), a three year forecast or longer is desirable in this district. Because forage and hay production is determined by climatic conditions, cattle farmers can modify herd size based on predictions. Farmers can also produce a surplus and stockpile when they expect a shortage. With forecasting, calves could be sold at reasonable prices prior to a feed shortage. Farmers might also anticipate a larger snail population and therefore a higher incidence of fluke disease. When drier and/or cooler conditions are expected, incidence of liver fluke would be expected to decrease and farmers could reduce vaccinations.

Climate forecasting can be used in weed management. For example, it was noted that weeds such as tropical soda apple, a common weed in pastures, increases in wet weather. Preventative action could be taken according to the predicted forecast.

Freezes are a major hindrance for citrus crops. Accurate winter temperature predictions could be extremely useful. However, because they are perennials, other climate predictions may not be of much use.

Other Important Factors

A key aspect of climate forecasting is reliability. Farmers must have confidence in the forecast in order to respond in any significant way. The general impression from District IV is that farmers do not have much confidence in climate predictions. However, if predictions were accurate, they would use them.

Seasonal climate and weather influence consumer habits. For example, in the summer when the weather is very warm people can be expected to consume more fruits and vegetables.

One extension agent emphasized the need to know the climate forecast of foreign markets and how other places will be affected by weather. For instance, if local growers could anticipate inclement conditions in foreign production areas, they could increase production. "It's all about market."

DISTRICT V - South

Background

District V, south Florida, consists of 10 counties, of which eight were visited (Broward, Collier, Dade, Glades, Hendry, Lee, Monroe, and Palm Beach). This district rarely experiences freezes. Its soils range from some of the best organic soils in the U.S. near Lake Okeechobee to sandy soils with deep water tables that make irrigation difficult in drought conditions. Land use in this district is characterized by conversion to urban development in the coastal areas and agriculture based mainly on citrus, other tropical fruits, sugar cane, mixed vegetables, and ornamentals. Several extension agents stated that currently market conditions are much more important than climate or weather in determining farmers' strategies about what to plant and when. Most of this District's crops face strong competition from abroad.

Sugarcane is a major crop in District V, being first or second in importance in several counties. Planted through vegetative cuttings, it is harvested annually, with rootstock providing sprouts for the following year's production. Large farms dominate the production of sugarcane. The cost of labor and the demands of sugar mills are more important than weather in affecting the profits and timing of sugar cane activities. Sugarcane is irrigated using a dike and flooding system and is typically fertilized four to five times a year.

Citrus also is first or second in economic production in several counties in District V. The district is favored for citrus because freezes rarely occur. The two types of irrigation used for citrus are ditch and dike, and micro spray. All groves use ditch and dike, while some also use micro spray. Few have the capacity to irrigate all of their acreage with the latter technology. Florida citrus is in competition with citrus from California, Brazil and other areas, hence climate predictions for those regions are of great interest to Florida citrus farmers.

In Glades and Hendry counties, cattle production is of great economic importance and occupies the largest amount of land. Scales of production vary considerably. Large-scale producers characterize some counties, while small-scale holders dominate the more urbanized counties, such as Lee.

The main vegetable crops in this district are tomatoes, bell peppers, cucumbers, potatoes, watermelon, other melons, and leaf crops such as lettuce, and Chinese cabbage. Some of these counties are regional and even national leaders in the value of vegetable production. The fields are irrigated with a ditch and dike system and some of the holdings are quite large for vegetable operations, typically ranging from 600–800 acres in Palm Beach County. Several of these crops compete with producers in California and Mexico. The profitability of these crops is heavily influenced by the prices in competing regions. NAFTA was mentioned as a major cause of low prices to Florida farmers due to cheap Mexican imports. These low prices contribute to economic insecurity among farmers in this line of production.

In Broward and Dade Counties, ornamental horticulture, including houseplants, bedding plants, and woody landscape plants, is the main form of agriculture. Urban development has led to the proliferation of golf courses and an increased demand for turf. The purchase of nursery products for landscaping is often determined more by scheduling of construction than by weather or climate.

Weather/Climate Impacts and Existing Responses

Sugar

Periods of low rainfall have minimal effects on sugarcane, as it is irrigated. Conversely, extremely wet conditions can lead to fungus problems in the crop. Wet conditions at the time of harvest lower the sugar content of the cane, reducing its harvest value. Periods of heavy precipitation can also leach fertilizer from the soil. A wet fall from El Niño would lower the sugar production and the profits. Cane is slightly more freeze tolerant than citrus and is protected by flooding the fields. In extremely dry conditions, irrigation is adequate to maintain production on organic soils, while on sandy soils, it may be impossible to provide adequate irrigation. High winds can knock over sugarcane, spoiling the crop and complicating harvest.

Citrus

Citrus became established in south Florida as severe freezes destroyed groves in the northern and central parts of the state. Dry conditions have little impact on orange production because all groves are irrigated. Wet conditions may lead to fungus problems and can reduce the quality of the crop by lowering the sugar content of the fruit. The impacts of a dry event in a La Niña winter may lead to unwanted multiple periods of flowering. This in turn causes fruit to ripen at different times on the same tree, thereby requiring multiple harvests in one year, which increases labor costs. An extremely dry event in the winter can cause the flowers to weaken to the point where they will not produce fruit.

Vegetables

Leaf crops are the most susceptible to a freeze and are also quite vulnerable to fungus problems. Freezes are quite uncommon in this district, but if a short freeze is expected farmers commonly flood their fields for protection. Planting and harvesting dates can not be changed much in response to the weather because crops must be ready for market by a given date. Changes in irrigation are used to adjust to dry or wet periods. Fungicides are applied in advance of extreme wet conditions.

Cattle

Production of cattle is based on hay and forage production, which in this area is a function of rainfall. Warm winters combined with precipitation can cause the proliferation of army worms, which consume grasses thus competing with livestock. Climate and production in competing markets such as Texas and Mexico, as well as trade agreements such as NAFTA directly influence the cattle industry. A drought in a competing market can cause ranchers in those areas to sell off livestock, causing a market

glut and a drop in prices. Extreme hot weather stresses cattle. This can lead to lower calving productivity and low milk production in dairy cows.

Ornamental Horticulture

Climate risks to nurseries in District V are minor, because frosts are few and the crops are irrigated. One extension agent said that climate prediction would have little impact on nursery management. Extreme storm events such as hurricanes are the major concern for ornamental horticulture. Purchases of crop insurance have increased in response to this.

Potential Responses to Improved Climate Information

Sugar

While some extensionists saw no use for climate predictions in sugarcane production, others identified some potential application. With climate prediction information sugarcane farmers could plant earlier to harvest before wet weather, but this still might result in lower growth and less profit. If a season of heavy rainfall is anticipated, farmers could better prepare to drain fields and plan fungicide treatments. Such an expectation also would affect the scheduling of fertilizer applications. All the sugarcane farmers irrigate, so no new response to lower rainfall predictions would be expected. Two agents felt that, regardless of predictions, changing the timing of sugarcane harvests is difficult, because the growers are contracted to provide the mills with a certain amount of sugarcane by a specified date.

Citrus

Because citrus is a perennial, there is little flexibility to change planting strategies or variety selection in response to weather or climate data. When growers anticipate a freeze they can flood or spray the groves so that heat is released to the trees and fruit as the water freezes. With more long-term prediction of extreme cold events, growers would ensure that their pumping and spray irrigation equipment is in working order. If growers expected an extremely wet period they could apply fungicides in advance. Beyond this, agents felt there were not many actions citrus growers could take in response to improved climate prediction.

Mixed vegetable farming

It was generally felt that vegetable growers in this District would reap greater benefit from climate predictions than other producers, especially in planning management strategies such as planting, irrigation, harvest, pest control, etc. The lead time of the prediction required would vary according to the crop and the type of operation. One agent said that 120-day climate predictions would be useful for tomatoes. As with other crops, advance knowledge of wet periods could prompt farmers to apply fungicides in a more timely way. It was also pointed out that if farmers knew about a wet season they could plant less leaf crops. However, farmers might decide that the risk of losses is outweighed by the potential gain of higher prices. This agent called farming "Vegas with a plow." Since the price of vegetables is so affected by production in competing regions it was emphasized that climate predictions in these regions would be very useful to farmers in deciding what and how much to plant.

Cattle and Livestock
If forewarned of a dry period, farmers could plant more hay in advance to maintain herds. Three-month precipitation predictions affecting pasture availability could be especially valuable for planning to sell less productive heifers. This would reduce feed and forage requirements and help avoid selling at low cattle prices. Prediction of rainfall would also be valuable for planning fertilizer applications for hay. Though frosts in District V are rare, prediction of a frost could be useful in the planning a hay harvest. Predictions of warm winters might help farmers make plans for pest control for the following season.

Landscaping, Ornamentals and Nurseries
Market issues supercede climate issues and basically determine varieties and plants grown. Due to intensive management, climate issues have minor implications for nursery products. One agent felt that, at the present, predictions do not affect crop decisions. The prediction of precipitation would be valuable for turf management, specifically in management of fertilizer applications.

Other Important Factors

In District V a number of secondary land uses mainly related to urban development are impacted by climate and could benefit from better predictions. With urbanization, storm and hurricane prediction would have increasing importance for building construction and homeowner protection, including protecting ornamental vegetation.

The trend toward conversion of agricultural land to urban development is especially prevalent in District V. Population growth leads to increased land values and taxes, which serve as great economic incentive for farmers to sell their land. Extensionists surveyed in six of the eight counties noted this situation. One extensionist stated, "Contrary to popular belief, farming is an industry which, like a factory, can be moved to other regions of the world." He predicted that in ten years agriculture would be non-existent in his county. In the past six years, the number of growers in Lee County has been reduced by more than half. In Collier County, golf courses are a major industry and a factor in the loss of agricultural land, along with urban sprawl. It was said that many farmers avoid capital gains taxes by swapping land with developers who buy cheaper land to the north. Although agriculture is declining in the western coastal counties (Lee and Collier), agriculture and cattle ranching continue to be of major economic importance in the eastern and inland counties of District V.

In Dade County there were concerns that the already high water tables in certain areas would rise further from the planned restoration of the Everglades. This would further increase the risk of flooding associated with high rainfall events. The need for a study on this issue has been expressed to water management officials.

FORESTRY

The production of pine for pulp and sawtimber is a major agricultural activity in Florida, covering the majority of the panhandle. Climate prediction clearly has applications to various aspects of both large-scale industrial forestry and non-industrial private forest (NIPF) landowners.

Plantation Establishment

Seedlings are outplanted to the field in the early spring. Ideally new plantations have an 80% survival rate of seedlings. However, lack of rainfall can lead to seedling death, requiring re-planting of the plantation, which significantly increases establishment costs. In one example from 1997, an extension agent said he would have suggested that landowners delay outplanting for a year if he would have known of the upcoming spring drought. With predictions of precipitation, agents could assist in planning of seedling outplanting.

Prescribed burning

Periodic burning keeps forest fuel levels low by avoiding the buildup of vegetation, which can lead to intense, stand destroying fires during droughts. The practice of prescribed burning requires great attention to details of wind, precipitation, and temperatures. While predictions of weather conditions are needed for burn execution, climate prediction would be valuable for long-term scheduling of controlled burns. For example, prediction of a period of heavy precipitation followed by drought would indicate a buildup of vegetation followed by extreme stand flammability. This information would be useful in the scheduling of burns to control fuel levels.

Pest control

Drought stressed trees are made vulnerable to infestations of the southern pine beetle, a major pest of commercial pine species. Trees damaged by the southern pine beetle are in turn more vulnerable to drought and fire. Aerial photographs are used to identify infestation. Infested stands can be salvage harvested to prevent spread of infestation. We speculate that with the prediction of drought, efforts to counteract the attack of southern pine beetle would be reinforced.

Harvesting and Thinning

Climate prediction can be used in harvest scheduling, an important part of forestry. Excessive precipitation can limit access to stands for harvest, especially in cypress and other lowland stands. One agent suggested that with prediction of a wet season, extensionists could recommend that owners of high stands hold their timber until supply drops to take advantage of higher prices. With drought prediction, recommendations

could be made for an early harvest to avoid the market glut. While a thinning executed during drought can stress the residual stand due to mechanical damage, prediction of a drought can encourage landowners to thin before the drought, thus reducing competition for water and nutrient resources during the drought.

Competing Markets

Forest products of Florida compete with pulp and paper from other parts of the country. If an extension agent had the time and knowledge to analyze climate predictions of competing regions, decisions could be made to improve the profitability of forestry in Florida.

Pine Straw Harvesting

With the prediction of drought, landowners may decide to delay harvesting of pine straw to help maintain soil moisture.

It was noted that large-scale forestry operations would be better able to use climate prediction, and that small-scale landowners were often constrained by the FIP and CRP program requirements.

OTHER USERS

Though not directly related to the agricultural focus of this project, other potential applications of climate prediction were identified through the sondeo process. These include: disaster aid, watershed management, forestry and wildlife, marine management, tourism and recreation, the pest control industry, the insurance industry, transportation, and exotic plant invasions.

Disaster Prevention and Aid

Clearly one of the most broadly used applications of weather and climate forecasting is the anticipation of storms. As forecasting of bad weather allows preparation to minimize negative effects, prediction of a season of bad climate can give the opportunity for long term preparation. In relation to urban development, storm and hurricane prediction would have increasing importance for building construction and homeowner protection, including protecting ornamental vegetation.

Water Management Districts

Climate predictions could be very valuable for the water management districts of Florida. In some instances it was noted that water management districts already have excellent information. Reportedly, however, this information is not always shared freely with the extension offices. Potential applications for watershed management encompass many demands, such as urban water supply, wetlands restoration, and aquifer management.

The South Florida Water Management District currently restricts but does not yet enforce water use.

Marine Management

The link between climate and marine resources was mentioned as an area that needs further research. References were made to the effects of climate on access to fishing and on algal blooms.

Tourism and Recreation

Extension agents mentioned both the effects of tourism on weather reporting and the effects of prediction on tourism and recreation. In an effort to retain the tourist population, weather or climate extremes are under reported. Conversely, unfavorable weather or climate predictions could seriously damage this industry. Land previously used for agriculture is being converted to golf courses and development. Golf courses demand expanses of turf, requiring intensive management. Precipitation prediction would be very valuable for the management of golf course turf, specifically fertilizer applications and the control of algal blooms. This is an industry with lots of money demanding exacting management.

Agrochemical and Insurance Industries

Extensionists noted that agrochemical and insurance industries already use climate forecasting in an effort to maximize profits. One extensionist stated that these industries obtain this information through commercial or in-house research. Open access to climate prediction information would affect both providers and users of agrochemicals and insurance services.

Exotic plant species, diseases, and insects

Ocean currents can introduce non-native plant species. In the Keys, low-pressure systems have introduced non-native insects and associated diseases. Climate prediction could be used in efforts to counteract these invasions.

INFORMATION DISSEMINATION

Current Practices

Currently, extension agencies and farmers rely on some sources of weather information. This information is more related to short-term forecasts. Farmers use this information in farm management for fast responses.

Data Transmission Network (DTN) is considered a relatively accurate source of information. The system provides not only 15-minute weather updates but also price and market information for farm commodities. Large-scale farmers and county extension

agencies most commonly count on this private system. Farmers without direct access to the system sometimes call the agents for DTN-provided information. It is also common to find this system at distributors' and dealers' stores where the farmers generally can have free access. Although DTN provides mostly five-day weather forecasts, it also presents general 30 and 90-day forecasts.

Local television, newspapers, extension newsletters, the Farmer's Almanac, trade publications, The Weather Channel, and NOAA radio are other sources of weather prediction on which farmers and extension agents rely. These sources are free and acceptably accurate, although they deal mostly with short-term forecasts.

Extension agents mentioned that farmers also obtain weather or climate information through their own experience. Agents also believe that farmers' meetings serve as an important exchange of weather and climate information.

In recent years, the Internet has emerged as an accessible and increasingly used medium for farmers, but the degree to which it is relied upon is not clear in many counties. All the extension agencies have Internet access and WebPages. Many extension agents currently use this medium to obtain and/or deliver weather and climate information. A newsletter survey revealed that 54% of the farmers in Citrus County prefer to get data about weather on the Internet. A large number of web pages provide information of relevance to agricultural decision-making, including FAWN, University of Florida, and Auburn University.

Potential Practices

Some agents believe that the Internet is very appropriate for disseminating climate forecasts because it provides easy access, particularly for computer owners, and the information can be quickly updated. Some agents already present weather information through their county WebPage.

Other means of possible climate forecast delivery mentioned by the agents were quarterly newsletters, annual or semi-annual growers' meetings, and CD-ROM creations. It was also proposed that guest speakers be invited to the growers' meetings. These guest speakers would be specialists in climate forecasts.

Improved climate information from NOAA and agents could be directly provided to local TV, radio stations, and newspapers for dissemination.

In some counties on-farm trials were suggested as a means of validating the use of climate forecast information for cropping strategy.

One extension agent mentioned that how the climate information is disseminated should not be a big issue. The more important concern is that the farmers obtain the information, regardless of the source.

CONCLUSIONS

Florida is a very diverse agricultural state with a range of climate conditions. Moreover, the characteristics of weather and climate of primary interest to farmers vary geographically. In north Florida and the Panhandle for example, late hurricanes, timing of frosts, and drought are most important while in central Florida it is the occurrence of frosts and water allocations, and in south Florida it is flooding and hurricanes.

In the north, farms more commonly engage in a number of activities that may include traditional row cropping along with the cultivation of vegetables, fruits, livestock, and forest products. In the south, large-scale plantations and ranches specializing in single commodities are more prevalent. In general, it appears that the more diverse operations in the north, which are often smaller than many in the south, are in a better position to respond to climate predictions. The ability to respond also depends on the commodities a farmer is producing.

Different attitudes were found among extension agents about their willingness to disseminate climate information and recommend strategies and practices based on climate predictions. This may be a reflection of the agents' perceptions regarding both reliability and the ease with which farmers could respond to such information.

At a local scale, market was found to be a more important factor than climate. However, since climate conditions in competing supply regions have a profound impact on prices, climate predictions in these areas would be very important in farmers' decision-making process.

It should be noted that competing producers and other stakeholders such as chemical suppliers, insurance companies, produce buyers, relief aid agencies, and banks would also benefit from climate prediction, and often to the detriment of farmers.

Climate prediction can be used either to compete with or cooperate with producers of other regions.

Most farmers already use weather predictions for short-term decision making. More widespread use of climate prediction by farmers depends on accurate and reliable predictions.

Farmers would prefer a more localized rather than regional forecast because microclimatic variability even within a single farm is often very high.

As with any new technology, it may take a number of years and successful application before agricultural strategy is altered in response to climate forecasts. Farmers will have to see better crops and better profits from using improved climate prediction before it is

adopted. Farmers with the most limited resources and income may be less able to alter their strategies.

Some of the more notable potential uses of climate prediction for farmers include:
-Cropping strategy (species, maturity, variety, timing, and location)
-Pest management
-Irrigation/drainage management
-Herd size and composition management
-Pasture management
-Forestry (plantation establishment, controlled burning, harvest planning, pest management)
-Facilities and infrastructure management and development
-Fire regime management

Crops that are most flexible in response to climate prediction include row crops and forestry in the north, vegetables in the center, vegetables in the south, and cattle throughout the state.

Through the sondeo it became clear that the management of cattle, pasture and hay would have fairly similar responses to climate predictions throughout the state. In contrast, other potential agricultural responses would be more localized.

RECOMMENDATIONS

There is a need for coordination among public agencies in disseminating climate prediction information.

NOAA should work closely with and provide training to extension agents to ensure that the generated information becomes increasingly useful to local agricultural needs and compatible with local agricultural conditions.

Extension personnel should be involved in the crop modeling efforts to make the results more useful to the extension services.

Farmers who produce crops for which the crop models are being developed are more likely to benefit from improved information. Therefore, modeling should concentrate on crops raised by many farmers. To be most useful, these models should focus on crops for which climate-responsive alternatives in management strategy are feasible, for example, because of more flexible marketing windows.

To the extent possible, climate models should be more specific spatially and temporally because variability within a region is an obstacle to the use of climate predictions.

Information on how to *directly* access NOAA's weather and climate forecasting should be made available to extension agents and farmers. The same information source ideally should provide links to global and historic climate data.

REFERENCE

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