EXTENSION AGENT KNOWLEDGE AND PERCEPTIONS OF SEASONAL CLIMATE FORECASTS IN FLORIDA

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INTRODUCTION

El Niño-Southern Oscillation (ENSO) is one of the most important determinants of year-to-year climatic variability and severe impact around the globe (Cane, 2000). In general, El Niño brings more rainfall and cooler temperatures to Florida in the fall and winter months, while La Niña brings warmer and much drier conditions during fall, winter, and spring. After El Niño events of 1982-83 and 1997-98 detailed studies showed the effects on rainfall patterns to be stronger in the southern than the northern part of the state of Florida. However, the impact on winter and spring temperatures on agriculture is greater in the Northern counties and across the panhandle than in the south. Additionally, these effects are significantly greater during the winter and spring than during the summer (Hansen, 2002, Neelin et al., 1998). During El Niño years, hurricanes also typically make fewer landfalls in the Southeast USA.

Although the full potential of seasonal or inter-annual forecasts has yet to be realized (Mason et al., 2000,) forecasts have shown promise in supporting decisions about planting dates, irrigation needs, crop types, fertilization, and variety selections. Expected market conditions, pests and disease onset and severity, and the need for crop insurance for upcoming seasons can also be better estimated using seasonal forecast (Fraisse et al., 2004; Hansen, 2002). The Southeast Climate Consortium (SECC) involves researchers at six universities in the Southeast U.S., namely, University of Miami, University of Florida, Florida State University in Florida, University of Georgia, Auburn University, and University of Alabama-Huntsville. It provides climate forecasts and risk assessment tools via the Internet at AgClimate.org. The SECC has used focus groups, workshops, and participatory appraisal methods to elicit input into the development of Web-based decision support tools. AgClimate enables extension agents and their farmer clients to explore, for example, yield impacts of crop management responses to forecast climate scenarios (Jagtap et al., 2002).

Seasonal climate forecasts should enable farmers and other stakeholders to explore different options and choose solutions using context specific reasoning (Meinke et al., 2001;

Podesta et al., 2002) through delivery from trusted extension agents. Several researchers stress that intermediaries can play useful roles in helping farmers interpret and apply scientific forecasts (Ingram et al., 2002, Nelson et al., 2002). Several research projects have relied on agricultural extension agents (Hansen et al., 2004) to train and diffuse seasonal climate information. The SECC has chosen to work with extension agents because of the influence they are likely to have on the adoption of climate forecasts among their local clientele, and their local expertise in suggesting coping strategies or adaptations to current farm management practices to farmers in light of improved climate forecasts. Cooperative Extension Services plan their activities strategically and it is thus highly sought after partners for communication and contributions to help farmers respond optimally to climate forecasts.

An important aspect of SECC research is continuous assessment of impacts, adoption, and adaptations implemented as a result of its efforts, followed by the integration of the assessment findings to guide future work. In tandem with the initial release of the decision support system (DSS), SECC researchers conducted the survey presented in this paper. The goal was to analyze the knowledge and perceptions of extension agents of the Florida Cooperative Extension Service regarding seasonal climate forecasting, and the potential for their clientele to effectively make adaptations based on the forecasts. The objectives of the state-wide survey were:

1. To identify demographics and characteristics of surveyed extension agents
2. To determine their knowledge and perception of seasonal climate forecasts
3. To assess their confidence and willingness in use of climate forecasts
4. To explore their preferred climate forecast presentation delivery
5. To explore demographic characteristics interaction with perceptions and willingness to use climate forecasts
6. To draw conclusions with respect to potential changes to the DSS that may increase its value to extensions agents and producers.

Materials and Methods

The study population consisted of the 166 agricultural, natural resource, forage, horticultural, and livestock extension agents working for the Florida Extension Service at the time of the data was collected (Office of the Director of Extension, November 2004).

A survey instrument consisting of 36 questions was designed and uploaded on the AgClimate Web site (http://survey.agclimate.org/agsite.cgi?DATABASE=agsite). Next, a series of three emails was sent out to the target audience. The first was an alert sent by SECC researchers previous to the survey. The second was a formal request to participate in the survey sent by the Assistant Dean for Extension at the University of Florida. The third was a reminder sent jointly by SECC researchers and the Assistant Dean. Total time allotted to survey completion was two months, November-December, 2004. Participation was voluntary, anonymous, and approved by the institutional review board (IRB) at the University of Florida.

RESULTS

Demographics and Characteristics of Target Population

Demographic characteristics of respondents are shown in Table 1. Table 2 shows characteristics of agents and their clientele.

Table 1. Number and percent of respondents by gender, age, and years working in extension (N=89).

Gender	**N**	**%**
Male	58	65.2
Female	27	30.3
No response	4	4.5
Age Group		
25-35	8	9.0
36-45	19	21.3
46-55	32	36.0
55-65	25	28.1
More than 65	2	2.2
Years Working in Extension		
Less than 1	2	2.2
1-3	9	10.1
4-6	14	15.7
Greater than 6	61	68.5

Table 2. Extension agent and clientele characteristics (N=89).

Clientele average farm size (ac)	**N**	**%**
Less than 2	4	4.5
2-10	8	9.0
11-80	19	21.3
81-200	11	12.4
Greater than 200	19	21.3
Agents' personal farm size (ac)		
0	65	73.0
Less than 2	1	1.1
11-80	8	9.0
81-200	7	7.9
Greater than 200	4	4.5
Work location in Florida		
Southern	18	20.2
Central	28	31.5
Northern	31	34.8
Western (Panhandle)	8	9.0
Most relevant agent activities (all that apply)		
Water quality	37	41.6
Greenhouse or nursery production	31	34.8
Perennial fruit or nut production	29	32.6
Beef cattle	24	27.0
Vegetable production (e.g., tomato, lettuce)	24	27.0
Forage production	24	27.0
Field crop production (e.g., soybean, corn)	17	19.1
Timber production	16	18.0
Annual fruit production (e.g., strawberry)	12	13.5
Dairy cattle	9	10.1

Knowledge and perception of El Niño-Southern Oscillation climate phases

Table 3 summarizes responses to key questions about agents' knowledge of ENSO phenomena. Most extension agents believe that their work is affected by El Niño or La Niña events. Most of them identified the common climate impacts by ENSO phase.

Table 4 shows the actual use and reliance on weather (less than 2 weeks) forecasts and some perceptions of usefulness of seasonal (3-6 months) climate forecasts by extension agents. Most extension agents consult weather forecasts and rely on those forecasts on a weekly or daily basis. Most agents also reported that it is useful to know if the climate during the next season is going to have unusual characteristics.

Most extension agents believe agricultural producers would be interested in using seasonal climate information and believe other decision makers may be interested in using climate information as well. Popular forecasts used by agents are the freeze alerts from the Florida Automated Weather Network (FAWN), predictions of El Niño and La Niña phases, and risk of wildfire from the SECC. A sizable fraction of agents also mentioned forecasts of temperature patterns (growing degree days or chilling hours) as forecasts of interest. FAWN and El Niño and La Niña phases are perceived as the most useful as shown in Table 5.

Table 3. Extension agent knowledge of climate impacts of ENSO phases (N=89)

Work Affected by El Niño or La Niña Climate Events	**N**	**%**
Strongly agree	41	46.1
Agree	35	39.3
Neither agree or disagree	4	4.5
Disagree	3	3.4
Strongly disagree	3	3.4
Climate Impacts of El Niño Climate Phases (all that apply)		
More rain than usual	58	65.2
Do Not Know	21	23.6
Cooler temperatures than usual	20	22.5
Higher temperatures than usual	20	22.5
Less rain than usual	8	7.9
No changes from usual	5	5.6
Climate Impacts of La Niña Climate Phases (all that apply)		
Less rain than usual	50	56.2
Do not know	25	28.1
Cooler temperatures than usual	20	22.5
Higher temperatures then usual	18	20.2
More rain than usual	9	10.1
No changes from usual	7	7.9
Climate Impacts of Neutral Climate Phases (all that appl y)		
No changes in rain from usual	52	58.4
No changes in temperatures from usual	42	47.2
Do not know	21	23.6
Cooler temperatures than usual	6	6.7
Less rain than usual	3	3.4
Higher temperatures than usual	2	2.2

Table 4. Use and perceived reliability of weather and climate forecasts (N=89).

Frequency of consulting weather forecasts	**N**	**%**
At least daily	61	68.5
At least weekly	20	22.5
At least monthly	1	1.1
Seasonally	3	3.4
When extreme events occur	1	1.1
Frequency of reliance on weather forecasts		
At least daily	21	23.6
At least weekly	40	44.9
At least monthly	5	5.6
Seasonally	11	12.4
When extreme events occur	7	7.9
Rarely or never	2	2.2
It is helpful to know if the climate during the next season will be different.		
Strongly agree	44	49.4
Agree	34	38.2
Disagree	2	2.2
Strongly disagree	4	4.5

Table 5. Use and reliability of weather forecasts and perception of climate forecast usefulness (N=89).

Agricultural producers are interested in using climate information	**N**	**%**
Strongly agree	42	47.2
Agree	35	39.3
Neither agree or disagree	9	10.1
Other decision makers, eg. water managers and government officials, are interested in using climate information		
Strongly agree	36	40.4
Agree	33	37.1
Neither agree or disagree	14	15.7
Disagree	2	2.2
Strongly disagree	1	1.1
Forecasts used in the past (all that apply)		
Florida Automated Weather Network (FAWN) freeze alert	58	65.2
El Niño, La Niña phase	32	36.0
Southeast Climate Consortium (SECC) wildfire risk	18	20.2
Chill hours accumulation	18	20.2
Growing degree days	17	19.1
Farmers Almanac	17	19.1
Plant moisture stress	7	7.9
Cattle heat stress index	4	4.5
Other	8	9.0
Forecasts you found useful (all that apply)		
Florida Automated Weather Network (FAWN) freeze alert	63	70.8
El Niño, La Niña phase	53	59.6
Plant moisture stress	49	55.1
Growing degree days	43	48.3
Chill hours accumulation	38	42.7
Southeast Climate Consortium (SECC) wildfire risk	31	34.8
Cattle heat stress index	21	23.6
Other	7	7.9

Confidence in and willingness to use seasonal climate forecasts

Table 6 shows information about confidence and willingness of use of seasonal climate forecasts by extension agents. Most extension agents showed confidence in seasonal climate predictability: about half of them believed extreme dry events can reliably be predicted and two-thirds believed freeze events can reliably be predicted. Fewer expressed confidence in the ability of climate forecasts to predict crop failures or yield losses. Most extension agents indicated that they would be willing to use and recommend adaptations to farming practices based on seasonal climate forecasts only if these are correct at least 75% of the time.

Most extension agents expressed a willingness to provide advice to producers based on climate forecasts (Table 7), but those forecasts would have to be delivered in lay terms and as management options rather than simple prediction of climate variables such as rainfall or temperature. In their opinion, the most likely clientele to use forecasts successfully would be vegetable farmers, nursery operators, and orchard growers. These groups would benefit mostly by improving planning planting schedules, irrigation and nutrient management, and selection of crop or varieties.

Table 6. Confidence in predictability of seasonal climate (N=89).

Extreme dry events can be predicted reliably	**N**	**%**
Strongly agree	7	7.9
Agree	37	41.6
Neither agree or disagree	25	28.1
Disagree	16	18.0
Strongly disagree	1	1.1
Freeze events can be predicted reliably		
Strongly agree	11	12.4
Agree	49	55.1
Neither agree or disagree	11	12.4
Disagree	13	14.6
Strongly disagree	0	0.0
Climate forecasts can reliable predict crop failures or low yields		
Strongly agree	4	4.5
Agree	27	30.3
Neither agree or disagree	34	38.2
Disagree	20	22.5
Strongly disagree	4	4.5
To use climate forecasts they must be correct at least		
25% of the time	2	2.2
40% of the time	0	0.0
50% of the time	1	1.1
60% of the time	11	12.4
75% of the time	47	52.8
80% of the time	21	23.6
To be used to recommend management practices to clientele forecasts must be correct at least		
25% of the time	1	1.1
40% of the time	0	0.0
50% of the time	0	0.0
60% of the time	7	7.9
75% of the time	37	41.6
80% of the time	31	34.8

Table 7. Willingness and characteristics of use of seasonal climate forecasts (N=89).

Would like to provide advice based on climate forecasts	**N**	**%**
Strongly agree	21	23.6
Agree	44	49.4
Neither agree or disagree	9	10.1
Disagree	8	9.0
Strongly disagree	3	3.4
To be able to use climate forecasts clients need (all that apply)		
Forecasts delivered in lay terms	43	48.3
Forecasts delivered as management options rather than simple forecasts	29	32.6
Some help from agents	27	30.3
Significant help from agents, including training	17	19.1
Little or no help from agents	13	14.6
What type of clients are more likely to use climate forecasts successfully (all that apply)		
Vegetable farmers	69	77.5
Nursery operators	65	73.0
Orchard growers	58	65.2
Emergency planners	56	62.9
Row crop farmers	54	60.7
Water resource managers	52	58.4
Livestock producers	46	51.7
Landscapers	46	51.7
Tourist industry	43	48.3
Forest managers	39	43.8
Aquaculture producers	37	41.6
Clientele Can Use Climate Forecast to Improve (all that apply)		
Planting schedules	61	68.5
Irrigation management	58	65.2
Nutrient management	47	52.8
Crop or variety selection	41	46.1
Harvest planning	41	46.1
Labor management	28	31.5
Allocation of land to activities	27	30.3
Marketing	21	23.6
Spacing or stand density	14	15.7
Waste management	11	12.4

Table 8 shows potential uses of seasonal climate forecasts expressed by the extension agents. Most of them believe climate forecasts may help enhance the economic situation of farmers by either reducing the risk of economic losses or increasing profitability. However, few believed climate information would not be useful to their clientele. Agents believed livestock producers may benefit from forecasts by improved planning of feed purchases or field rotations. The main uses growers may have for forecasts in the perception of extension agents were planning irrigation activities, planting dates, or changing varieties.

Table 8. Potential uses of climate forecasts (N=89).

Clientele can use climate forecasts to (all that apply)	N	%
Reduce risk of economic losses	66	74.2
Increase profitability	43	48.3
Reduce expenditures	42	47.2
Select correct insurance products	33	37.1
Take greater advantage of market changes	33	37.1
Modify insurance coverage	30	33.7
Gain an edge over competing producers	22	24.7
Climate forecasts will not impact clientele	9	10.1
Livestock producers can use climate forecasts to (all that apply)		
Time feed purchases	39	43.8
Improve field rotations	36	40.4
Adjust stocking rate	34	38.2
Improve herd size management	32	36
Adjust storage planning	28	31.5
Improve Marketing strategies	20	22.5
Reduce Labor costs	14	15.7
Climate forecast are not useful to livestock producers	6	6.7
Crop Growers Can Use Climate Forecasts to (all that apply)		
Improve irrigation planning	66	74.2
Better allocate planting dates	63	70.8
Tailor variety selection	50	56.2
Improve Land allocation	36	40.4
Reduce Labor costs	30	33.7
Adjust Storage planning	29	32.6
Improve Marketing strategies	27	30.3
Better plan input purchases	27	30.3
Climate forecasts are not useful to crop growers	6	6.7

Preferred climate forecasts format and delivery

Table 9 summarizes extension agents' preferences of forecast formats. Most extension agents prefer forecasts to predict with high likelihood when conditions will be substantially different average. They preferred forecasts that interpret available data presented as text describing the most likely events. The graphic presentations of forecasts preferred by the most extension agents were frequency distributions and probabilities of exceedance.

Table 10 summarizes information regarding preferences of extension agents to forecasts delivery. Agents prefer to receive forecasts by e-mail and would disseminate forecasts to their clientele by e-mail and bulletins. Only 20% of extension agents preferred to make their own interpretation whereas half did not.

Table 9. Preferred climate forecast format (N=89).

Preferred statement for forecast for a county with average monthly precipitation of 5 inches in January	N	%
There is 70% probability that precipitation will be greater than 8 inches	31	34.8
There is a 70% probability that precipitation will be greater than average	15	16.9
There is 85% probability that precipitation will exceed 2 inches	15	16.9
There is a 80% probability that precipitation will be less than last year	11	12.4
There is a 30% probability that precipitation will exceed 5 inches	7	7.9
Preferred format forecasts for a county		
Text with the most likely events and their likelihood described	35	39.3
Probability graphs and tables showing all likely climate behaviors	25	28.1
Tools that show likely impact of different climate scenarios	24	27
Preferred graphic presentation of forecasts		
Frequency distribution	35	39.3
Probability of exceedance	17	19.1
No preference	15	16.9
Neither frequency distribution or probability of exceedance	19	21.3

Table 10. Preferred climate forecast dissemination (N=89).

Preferred way to receive forecasts	N	%
E-mail	54	60.7
Internet Web site	21	23.6
Television	4	4.5
Phone	3	3.4
Extension bulletins	3	3.4
Preferred way to disseminate forecasts (all that apply)		
E-mail	60	67.4
Mailed newsletter (bulletin)	48	53.9
Meetings	44	49.4
Phone	38	42.7
Site visits	35	39.3
Internet Web site	28	31.5
Radio	10	11.2
Preferred to make own interpretation of potential forecasts impacts in working area		
Strongly agree	4	4.5
Agree	14	15.7
Neither agree or disagree	22	24.7
Disagree	33	37.1
Strongly disagree	12	13.5

Demographic characteristics of extension agents and perceptions and willingness to use climate forecasts

Figure 1 shows the interaction of age and gender of extension agents in their perception of usefulness of knowing the climate of the next season. Numerical measurements in Figure 1 represent an average response by category (5 = strongly agree); thus, larger numbers represent a more positive perception of knowing seasonal climate forecasts. Younger males and the oldest cohort of females are the agents with the most positive perceptions, whereas middle-aged females and the oldest cohort males had the most negative perceptions of climate forecasts.

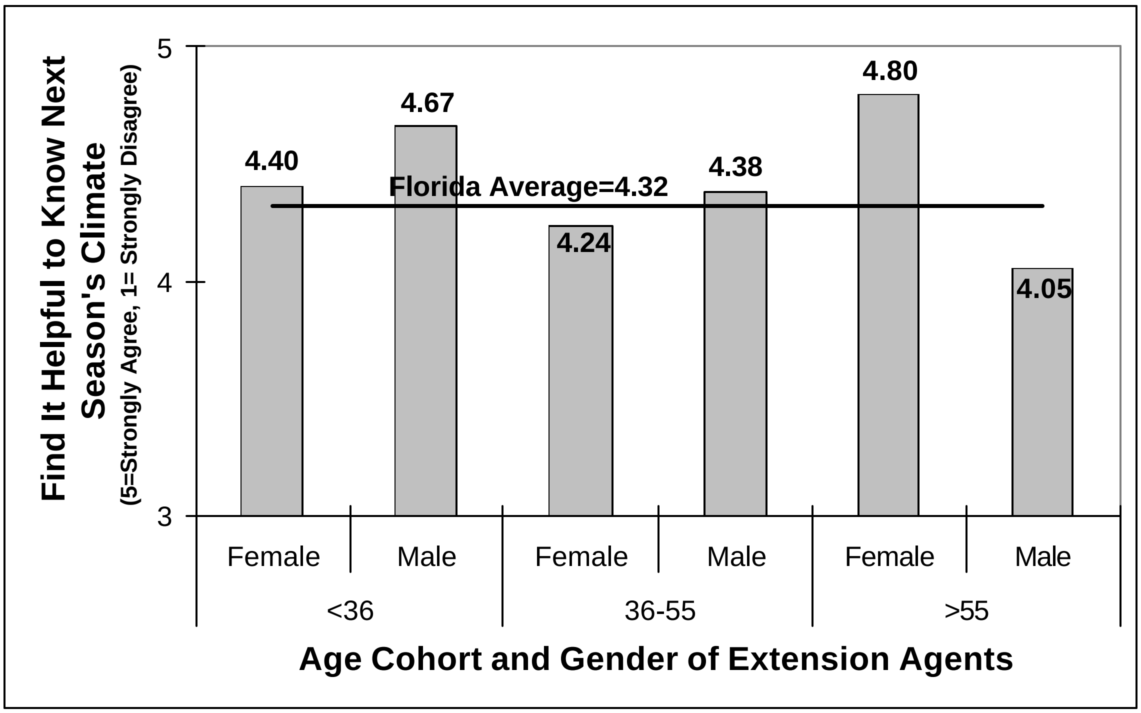

Figure 1. Perception of usefulness of knowing next season climate by age and gender of extension agents.

Figure 2 also shows perceptions regarding usefulness of knowing climate forecasts, categorized by location or area of influence of extension agents. Extension agents in southern and western Florida appear to consider climate forecasts more useful than agents in central and northern Florida.

Figure 3 shows the interaction of age and gender of extension agents on their willingness to provide clientele advice based on ENSO events forecasts. As in previous figures, higher numbers represent higher willingness. Younger males expressed the least willingness to use ENSO-based climate forecasts in their recommendations.

Figure 4 shows the interaction of area of influence of extension agents in their willingness to provide clients with advice based on ENSO climate forecasts. While extension agents in Southern and Central Florida responded similarly, agents in Northern Florida have the lowest willingness of all (3.68) and Western Florida agents have the highest willingness (4.25).

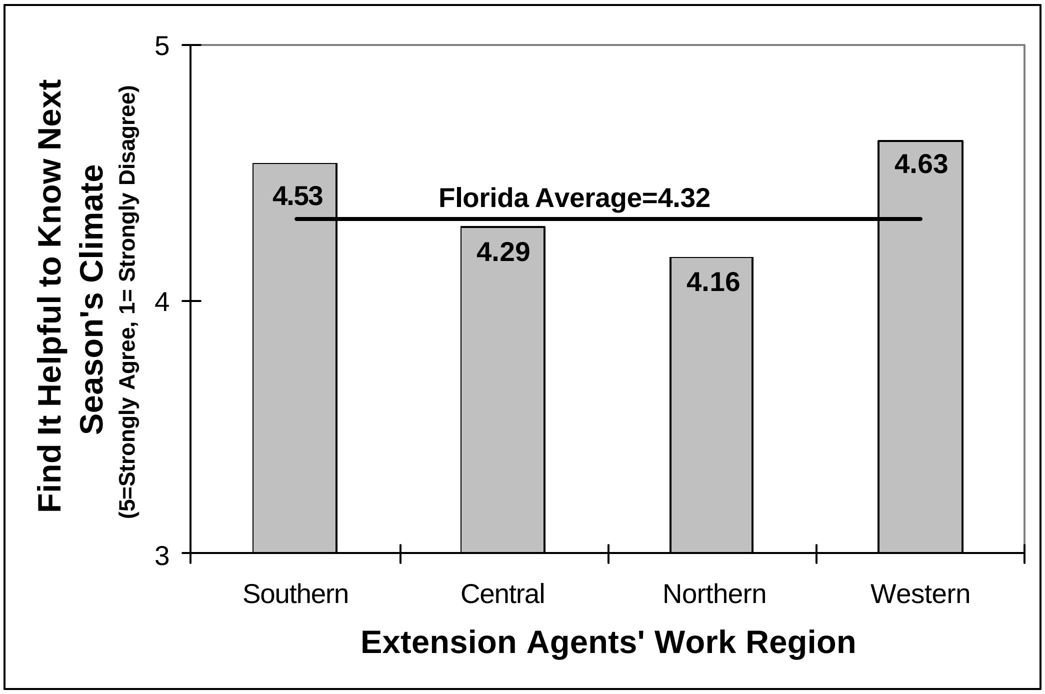

Figure 2. Perception of usefulness of knowing next season climate by location of extension agents.

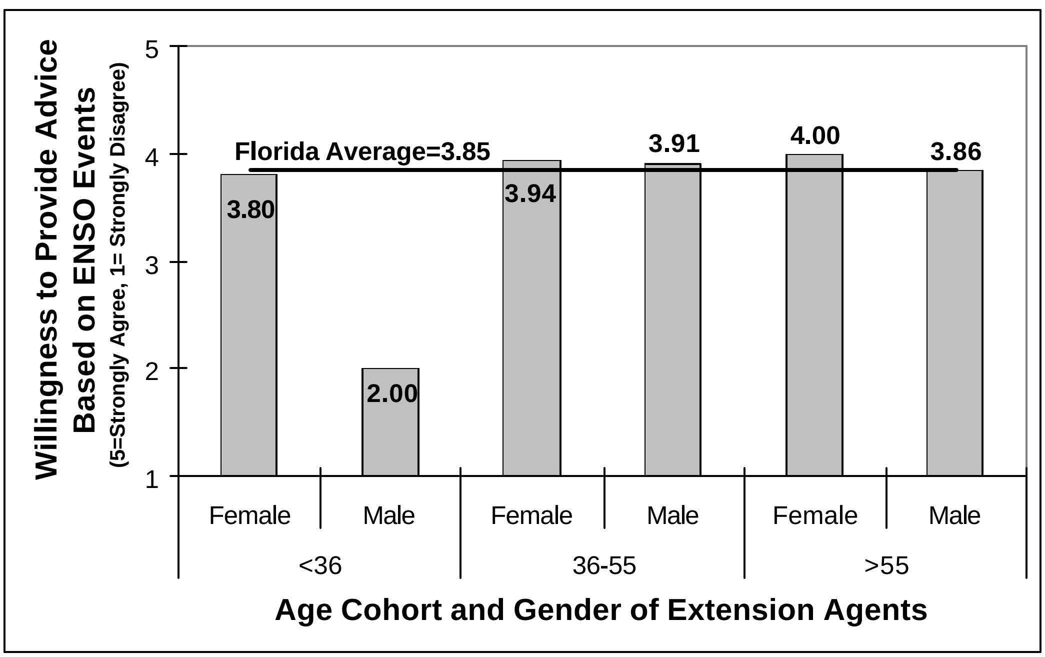

Figure 3. Willingness to provide advice based on ENSO events by age and gender of extension agents.

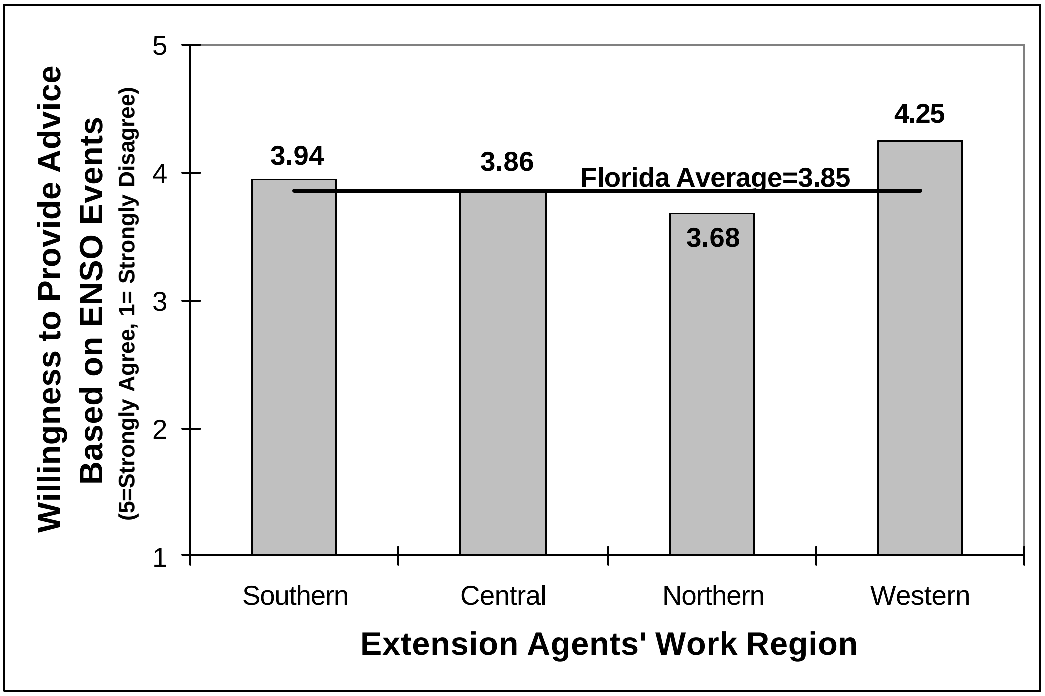

Figure 4. Willingness to provide advice based on ENSO events by location of extension agents.

Conclusions and Implications

Because of the nature of the innovation (ENSO-based climate forecasts and applications) and its specific impacts and geographical connotations, findings cannot be broadly extrapolated to extension organizations elsewhere. However, the results offer interesting insights that may be useful to extension researchers working on similar projects in other areas.

First, we can characterize our targeted extension group. This is predominantly male, middle age, and working in extension for more than six years. They typically do not own farms of their own and their clientele have farms above 11 acres in size. They work predominantly in Central and Northern Florida and besides agricultural activities they also work with decision makers on water quality issues and timber production.

Extension agents in Florida are aware of the existence of an inter-annual climate phenomenon called El Niño, Neutral, or La Niña years and its potential impacts on their area of work. Awareness is an important first step in any diffusion process. However, a large fraction of respondents were unaware of the specific impacts of the individual ENSO phases, particularly for the temperature impacts where 41 to 45 % of respondents did not correctly identify the effect (Table 3). While a majority of respondents were correctly aware of the ENSO impacts on precipitation, it is clear that agents could benefit from additional knowledge of recent advances in climate forecasting and its impact on regional conditions. Combined with the already high levels of awareness of some climate impacts, additional explanatory information and effective dissemination will likely expand the potential for adoption of seasonal ENSO-based forecasts and applications, as well as their willingness to recommend adaptations based on climate forecasts.

We distinguish climate from weather by its duration, climate being longer than the 2-week time frame. Nevertheless, the use and reliability of weather forecasts may be an indicator of potential use and reliability of climate forecasts. Most extension agents consult weather forecasts on a daily basis and rely on them on a weekly basis. The habit of forecast consultation and reliability could be transferred to climate forecasts. This fact along with majority agreement about usefulness of climate forecasts indicates extension agents in Florida are highly likely to use climate information. While responders were clear about their need for highly correct forecasts, further work is required to meet their expectations.

There is some degree of skepticism among extension agents about the predictability of seasonal climate events and, even more, about the practical applications for their clientele. They request forecasts to be accurate at least 75% of the time before they will use them and before they can feel confident enough to make recommendations based on them. A process of several years will likely be needed to demonstrate extension agents the validity and the value of ENSO-based seasonal climate forecasts and its practical applications. Agents expressed particularly strong perceptions of the reliability of crop yield forecasts based on seasonal climate expectations. Currently, forecasts are provided as probabilities of potential occurrences which are implicitly correct. Additional consideration must be given to the magnitude of the forecast event, the degree to which it is predicted to differ from historical conditions, the likely impact of the event if correctly forecast and adverse impacts associated with forecasts that fail to suggest the eventual occurrence.

Extension agents prefer translated applications of climate forecasts rather than pure forecasts of climate variables, although they perceive that reliability of predictions may decrease in the translation process. For example, extension agents prefer ENSO-based crop yield predictions rather than seasonal climate patterns, but they would trust them less than the actual climate forecasts. Extension agents will require clear and concise forecasts with clear numbers expressing likelihoods and measurements, if the forecasts are to be adopted and used routinely in their work. The higher the percentage of likelihood, the better the forecasts would be. The preferred format for forecasts is as written interpretations and, as probability frequencies and exceedance charts if graphical presentations are required.

ENSO-based forecasts of both climate variables and of application impacts should be distributed primarily by e-mail and secondarily by the Internet. This suggests that effective integration of climate forecast information with other agricultural management tools will be primarily a push approach. While in-depth collaboration with application specialists to develop the content, format, and timing of forecasts is necessary, ultimately the deliver will be an active process lead by climate extension specialists. This contrasts with more typical climate forecast systems where information is made available and users are expected to seek the needed information. The extent to which a perceived increase in forecast usefulness and value over the life of the SECC project modifies the demand for source driven information is of particular interest and will be addressed by later studies.

Extension agents would prefer to disseminate the information they receive to their clientele by e-mail, newsletter/bulletins, and/or meetings. Extension agents would prefer forecasts that have already been interpreted rather than purely climatic predictions. It appears likely that efforts to present the initial forecasts, whether of climate variables or interpreted statements, in a form that can readily be incorporated in other electronic documents and with content format appropriate for end users such as producers or decision makers will enhance the degree to which agents are able to consider climatic variability in their overall extension programs.

Extra effort to disseminate ENSO-based climate forecasts and its applications to promote their adoption and their applicability in adaptations to management practices should be targeted to young male, middle-aged female and older cohort male extension agents, who seem to have a lower perception and willingness to use the climate forecasts. Special work has to be done with the older male cohort who represent 24% of the population, and with middle-aged females who represent 16% of the population. Young males make up only 3% of the population studied.

Similarly, an extra effort has to be undertaken with extension agents located in Central and Northern Florida who showed less positive perceptions and willingness to use ENSO-based forecasts in their work. This might be because of weaker real or perceived ENSO effects in these areas or because of differential dissemination of climate forecasts; or a combination of both. In addition, extension agents working in Central and Northern Florida substantially outnumber those working in Southern and Western Florida. This issue requires further research and likely more geographically comprehensive dissemination

More than 50% of respondents said ENSO-based climate forecasts have potential to benefit livestock producers. Yet, only one third were able to mention specific management options or adaptations that livestock producers might apply. This suggests that the knowledge base on potential adaptations to climate forecasts in livestock and pasture is insufficiently developed and this should be a Southeast Climate Consortium priority.

This survey serves as baseline to compare future surveys within Florida and surveys in other states. A similar survey has recently been completed in Georgia and another is in preparation in Alabama. These three states are the current geographical area of work of the Southeast Climate Consortium. Findings of this survey are going to be a structural part of the strategic plan of the Southeast Climate Consortium for future research, development, and dissemination to stakeholders.

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