4.10 FACILITATING USE OF CLIMATE INFORMATION FOR WILDFIRE DECISION-MAKING IN THE U.S. SOUTHWEST.

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1. INTRODUCTION

Over the past two decades, in large part due to notable advances in El Niño-Southern Oscillation (ENSO)-based forecasting, public awareness of climate forecasting has increased substantially. ENSO-based forecasts are most effective for the winter half-year in the U.S. Southwest; summer half-year forecasting, by contrast, remains less skillful. Recognizing both the potentials and pitfalls of issuing and using wildfire-based climate forecasts, the Climate Assessment for the Southwest (CLIMAS), a NOAA-funded regional integrated sciences assessment (RISA), initiated a series of workshops in February 2000 to facilitate dialogue between climatologists and fire-decision managers. CLIMAS, in collaboration with the University of Arizona Laboratory of Tree-Ring Research (LTRR), the program for Climate, Ecosystem and Fire Applications (CEFA) at the Desert Research Institute (Reno, Nevada), and the U.S. Department of Interior/USDA Forest Service (Joint Fire Sciences Program and Riverside Fire Laboratory, respectively), has held three workshops thus far. Each of these workshops has provided valuable insights into how to ensure that wildfire managers not only receive the climate information they need, as well as when and where they need it, but also that they have the basic knowledge needed to appropriately interpret and use the information provided.

In this paper we review the rationale behind the design of the workshops and summarize the outcomes to date. We evaluate the workshop process in terms of its success in establishing ongoing dialogue between the two communities, and in terms of moving both climatologists and wildfire experts along the rather steep learning curve associated with delivering, interpreting, evaluating, and using climate information for wildfire planning and management. We also provide a brief overview of current and planned research on climate and fire in the Southwest, arising from the outcomes of the workshops.

2. THE FIRE-CLIMATE WORKSHOPS

2.1 *Background and Impetus for the Workshops*

Our first workshop, *The Implications of La Niña and El Niño for Fire Management* (held during February, 2000), was prompted by the extremely dry conditions in the Southwest, beginning during the summer of 1998. By late summer 1999, it became very likely that the U.S. Southwest and Southeast would experience the second dry La Niña-spawned winter in a row. Furthermore, wet conditions during the 1997-1998 El Niño winter, combined with a very wet summer in 1999 the Southwest, had produced an abundance of fine fuels that would quickly dry out over the forecasted dry winter and present an exceptional wildfire threat during the 2000 fire season. Work by the University of Arizona's Laboratory of Tree-Ring Research Fire History Group and others (Swetnam and Betancourt 1990; 1992; Swetnam and Baisan, 1996; Swetnam and Betancourt, 1998; Grissino-Mayer and Swetnam, 2000) demonstrated that, over the past 400 years, the sequence of a wet El Niño winter followed by two dry La Niña winters is closely correlated with extensive wildfire occurrences. This was precisely the state of affairs that would emerge if the winter 1999-2000 forecast turned out to be correct.

The National Oceanic and Atmospheric Adminstration (NOAA), through its Climate Prediction Center (CPC), issued the winter 1999-2000 La Niña forecast with a high degree of confidence. This prompted us to move quickly to do something we had been talking about doing anyhow, i.e., hold a workshop that would bring wildfire managers and fire researchers together with climatologists, meteorologists, and climate impacts researchers to discuss the linkages between ENSO and wildfire regimes. We knew that the situation that year would affect fire managers' decision making in the Southeast and across the West as well.

We invited representatives of the fire management, climate science, and fire research communities in the western and southeastern U.S. The workshop represented the first time that these three communities had been brought together in one place. The meeting evolved into a lively interaction between the climate and wildfire participants. By the end of the workshop, a list of issues and recommendations had been developed and an action plan aimed at moving toward integration of climate science with fire science and management had been articulated. Participants left the workshop with high enthusiasm for holding a follow-up workshop at the end of the 2000 fire season.

It is unfortunate that the 2000 fire season turned out to be even worse than we anticipated in February 2000. It would have been an exaggeration to place the entire blame on antecedent La Niña conditions for the devastation wrought; by the same token, it would have been equally erroneous to discount climatic influences. If anything, the experience of the blazing summer of 2000 strengthened the resolve of the climate/weather and wildfire/land management communities to work toward a more integrated understanding of the role of climate, as well as more immediate weather, in wildfire

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regimes. Moreover, the accelerating trend toward conflation of urban and rural land use patterns and associated increase in risk at the urban-wildland interface, as exemplified by the Cerro Grande fire near Los Alamos, New Mexico, brought the issue into sharper focus.

Such was the background for our subsequent workshops, Fire and Climate 2001 (convened February, 2001) and Fire and Climate in the Southwest 2001 (convened March, 2001). The climatic backdrop for convening of these workshops in the spring of 2001 was not as spectacular or certain as the persistent and strong La Niña conditions that prompted our February 2000 workshop, *The Implications of La Niña and El Niño for Fire Management*. However, the very uncertainty accompanying the winter-spring 2001 climate forecasts, as we transitioned out of La Niña conditions, underscored the need for further dialogue: (1) for fire managers to better understand climate forecast tools, their correct interpretation and their limitations, and (2) for climate forecasters to better understand the decision support needs of fire managers and the constraints under which they need to make decisions that affect ecosystems, property and human life.

2.2 *Workshop Design*

Our fire-climate workshops have been carefully designed to foster communication, discussion and opportunities for collaboration between the various scientific and management communities involved. We invited representatives from each of the aforementioned management, forecasting and research communities across the U.S. (including Alaska) and northern Mexico, although in practice the Pacific Northwest, Intermountain West, Southeast and Southwest have been best represented at our workshops. We also invited representatives from the California, Pacific Northwest, Southeast, and Southwest NOAA-funded RISAs. Our goal has been to maximize the opportunity for constructive dialogue and participant input.

In each workshop, thematic sessions of brief (30 minute) scientific talks were capped by opportunities for questions and group discussion. Breakout groups provided important opportunities for participants to process the information presented during workshop talks. Breakout group sessions were explicitly designed to address concerns identified by the workshop participants. Moreover, we designed the breakout groups to include members of each of the participating research and management communities. Integral to breakout group discussions were the goals of establishing of an action plan for implementation of participants' concerns, and identifying opportunities for its collaborative research, data management, monitoring and training programs. Our February 2001 workshop also included a two-hour climate forecast evaluation session, specially designed to (1) assess participants' ability to interpret official NOAA/National Weather Service climate outlooks (and by implication the success of NOAA/NWS in transmitting their climate forecast information), (2) provide training in forecast interpretation and evaluation, and (3) garner feedback on forecast format, communication, evaluation, and users' forecast accuracy requirements.

Building upon the experience of our initial workshop, we incorporated pre- and post-workshop surveys, in order to assess participants' experiences during the previous fire season, and their comments on the workshops. In our surveys of fire and land managers, researchers and decision makers, we assessed the following: (1) their use of and their perception of the usefulness of climate forecasts, (2) how they changed their management tactics, resource allocation, and training based on the availability of climate forecasts, (3) dissemination of information during the fire season, (4) fire-climate research initiatives, and (5) their major concerns and needs. In our surveys of climate/weather research and forecast professionals, we assessed the following: (1) degree of interaction with the fire community, (2) fire-climate research initiatives, (3) feedback from the fire community regarding research and forecast products, and (4) their major concerns and needs. We briefly discuss the results of these surveys, below. As mentioned above, we asked workshop participants to evaluate the workshops. Our evaluation surveys assessed (1) which programs and discussions were most and least useful to participants, (2) how we might improve the workshops, and (3) an overall rating (including interest in participating in activities to further address the issues raised at the workshops).

3. OUTCOMES

3.1 *Pre-Workshop Survey Results*

Prior to our 2001 workshops, we surveyed all of those invited (n = 270) regarding their experiences during the 2000 fire season. Paper copies of the surveys were provided along with invitations to the workshops, and online forms were made available through the CLIMAS website. We received 29 responses to our surveys for Fire and Land Managers, Researchers, Decision Makers (henceforth, *fire survey*) and 9 responses to our surveys for Climatologists and Meteorologists (henceforth, *climate survey*). (Note: 100 people attended our 2001 workshops). General findings from categorical questions are summarized below, along with qualitative insights gained through analysis of open-ended questions.

As expected, most fire professionals felt that their jurisdictions were either vulnerable or very vulnerable to the effects of climate (86%), and none of those surveyed felt that they were not vulnerable to climate. 80% of respondents to the fire survey described the 2000 fire season as above-average and only 10% described the 2000 fire season as below average. We queried fire professionals about what they did differently during the 2000 fire season. A majority of the respondents (52%-62%) allocated more resources for firefighting, requested additional funding for resources and/or gathered additional science data during the course of the 2000 fire season. Most notably, 41% of respondents carried out fewer than usual prescribed

fires; only 7% carried out more prescribed fires during the 2000 fire season.

Given the impetus for our 2000 fire-climate workshop, i.e., a high probability of climate-driven fire danger for much of the southern tier of the U.S., some of our key interests were how fire professionals used seasonal climate forecasts, their perceptions of how useful the forecasts were, and their experiences regarding contacts with climate/weather professionals. For the purpose of the survey, we distinguished climate from weather by defining climate as anything occurring for periods of one month or longer. 97% of respondents used seasonal climate forecasts in their decision-making and 89% found climate forecast useful during the course of their fire management activities. Some respondents expressed some confusion regarding where to draw the line between weather and climate forecasts. This point was reinforced by the result that of the 86% of respondents who said that they initiated contacts with climatologists or climate forecast agencies, 75% identified local NWS offices as their contact, and only 39% identified NOAA/CPC (i.e., the source of official climate forecasts) as their contact. Table 1 shows the aspects of decision-making to which fire professionals applied climate forecast information. A majority of respondents used climate forecasts for long-term planning activities, such as resource allocation, risk assessment, support planning and long-range fire behavior prediction. It is interesting, however, that climate forecasts were relatively seldom used for determination of preparedness levels, community education and in prevention efforts (including, to a certain degree, management of prescribed fire programs).

Table 1. Fire survey responses to the question: In what aspect of decision making did you use seasonal climate forecasts? Respondents were asked to "check all that apply."

72%	Support planning
72%	Long-range fire behavior prediction
66%	Regional fire behavior outlooks during high fire activity
62%	Prioritizing allocation of firefighting resources
62%	Risk assessment
52%	Justifying additional funding needed to respond to above-normal fire danger
52%	Management of prescribed fire programs
45%	Prevention
38%	Determination of preparedness levels
34%	Community education
21%	Selection of strategies and cost estimates associated with WFSA development
14%	Determining the number of incidents

Open-ended responses (not shown) confirmed that fire management preparation tactics have been or will be changed by the use of climate forecast information for resource allocation, prepositioning of resources, preparedness, prescribed fire decisions, and severity funding requests. For example,

- "Increase lead time for severity funding requests (get personnel on early when an early season is anticipated). Adjust expected burn season for prescribed fires. Provide heads up for managers when wildland fires may be used to accomplish resource objectives, and also when conditions are expected to be too harsh to allow fire use (i.e. all wildland fires need to be suppressed)."
- "Will get a better idea of when to initiate prescribed burning; greater awareness of fire hazard risk."
- "I believe we are talking about strategy and not necessarily tactics. Climate forecasts provide an opportunity to identify where additional resource may be needed and provide time to execute spending authority and prepare to move resources in a timely manner. Quite often, these days, we are concerned with the magnitude of the fire problem and if it exists in more than one geographic area. Because we have a limited number of resources, we are constantly allocating and reallocating resources based on the need. This is an expensive operation so we need the best information possible at the earliest possible time."

Several respondents noted the need for a change from reactive to proactive management strategy. The following comments are illustrative:

- "With rare exception, fire managers are reactive rather than pro-active. We desperately need 3- and 6-month projections for planning, allocating resources, prepositioning, etc. These needs are national and regional (and probably local)."
- "Currently management is somewhat reluctant to react to long-range forecasts --- even forecasts out 5 days or more, relying heavily on the today and up to 5 days before committing to moving resources. Once these longer range forecast start showing some consistent reliability there will be a change from reactive to proactive actions."
- "Climate forecasts could change the way fire agencies plan strategically for wildfire resource allocation and fire use opportunities. Currently the agencies are unable to plan more than a few days in advance."

Another key interest of ours was discerning how fire professionals define a "good climate forecast." Such information is particularly important to CLIMAS researchers involved in the evaluation and improvement of long-range climate forecasts (Hartmann et al., 1999; Pagano et al., 2000). The information in Table 2 was particularly useful in preparation for the climate forecasts and evaluation session at the February 2001 workshop. Fire professionals want to know why or how a forecast was made; i.e., they show a strong preference for the inclusion of as much forecast information as possible, in order to make informed decisions. These decision-makers indicate a preference

for a reasonable probability of detecting that a climate event will occur, but they are flexible with regard to the accuracy of forecast information. For example, 83% of the respondents agreed or strongly agreed that it is OK for climate forecasts to change direction as forecast lead-times get shorter, and a majority (60%) felt that climate forecasts could be useful even if they didn't indicate a strong probability for an event to occur. Nonetheless, fire professionals indicated that climate forecast probability must be at least 62% (average of all respondents) for the forecast to be useful to them. Perhaps most important for issuers of climate forecasts, 64 percent of respondents believe that "a low rate of incorrect forecasts is more important than a high rate of correct forecasts," i.e., fire professionals require a low *false alarm* rate.

Table 2. Responses to questions about "what makes a good climate forecast?"

Note: All values are expressed as percentages (n=29).	Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
Prefer forecasts to include discussion about why or how forecast was made.	61	29	4	0	6
OK for forecasts to change direction (e.g., wet then dry) as lead-time gets shorter.	29	54	11	3	3
A low rate of incorrect forecasts is more important than a high rate of correct forecasts.	18	46	11	14	11
Forecast is "bad" if event was given low chance of occurrence, then actually happened.	15	25	7	32	21
More important to know event not likely to happen, than to know event likely to happen.	0	15	33	37	15
Forecasts are not useful unless they show a strong chance for an event to occur.	11	11	18	42	17

During the 2000 fire season, 87% of fire survey respondents disseminated weather or climate information along with their fire reports, which indicates the importance of such information for their operations, as well as in order to educate the public about the fire situation in the field. A majority of respondents (68%) disseminated information about fire through the Internet. The next most important means of disseminating information about fire during the 2000 fire season was through printed materials, e.g., newspapers/weekly magazines (39%), pamphlets/information sheets (32%). Other traditional media were used less frequently; e.g., radio and television were used equally (29%).

Nine climatologists/meteorologists (of 18 that attended) responded to our brief survey. Most of them (7/9) initiated contact with fire managers/researchers and the same number were contacted by fire managers/researchers with regard to providing a variety of services, such as long-range forecasts, information about weather parameters and fire/climate indices, information for smoke management, and remote weather station (RAWS) data. Three of respondents indicated that for the 2000 fire season they either provided or were requested to provide information on the following: climate change, long-range climate variability, assessment of climate for the year 2000, and products regarding the likelihood of a "severe, extended fire season." Six out of eight respondents tailored their climate and meteorological forecast/research products for use by the fire and land management communities. Five out of eight respondents went on to assess the effectiveness of their products. The following comments indicate insights from climate/weather forecast providers:

- "Managers continually affirm that even marginally-accurate 10-90 day weather forecasts/outlooks can be of use in planning, logistical preparations, and in some cases tactics used in their land management operations."
- "We've tried to use the experience of numerous past encounters to guide the development of web products and how they look and work. The best feedback comes from constant daily usage and interaction. It also makes a lot of difference to solicit input before and during development, rather than waiting for critiques after the fact."
- "Feedback on our weekly climate forecasts was limited and not helpful. We hope to improve on this…"

3.2 *Breakout Group Suggestions and Action Plans*

The most salient suggestions from three workshops' worth of breakout groups are summarized below (Table 3). Our qualitative analysis is based on common themes and concerns enumerated in all three workshops. The most important themes articulated by participants in all three workshops were with regard to the following topics: Databases and Observation Networks, Decision Support Tools, Education/Training/Outreach, Information Transfer, Long-Range Land Management (within the context of climate and wildfire management), Research, and the Use of Climate Forecasts.

Data

One of the key points during the workshop was that fire danger in the western U.S. is often dependent on winter precipitation; thus, participants recommended an increase in the number of *all-weather* observation stations. Workshop participants identified wind as a key variable for further analysis, and stressed the need for easy access to data on wind speed and direction. Participants suggested that variables such as precipitation, relative humidity, stability and wind were more important for fire management than was

temperature. Moreover, they recommended that climatologists include fire and land-use related variables such as buildup index, energy release component (ERC), and vegetation health parameters in their analyses. A key organizational concern was that there were far too many individual databases, spread among many agencies; participants recommended the formation of an interagency data group in order to coordinate data access for fire management decision making.

Table 3. Selected recommendations and needs.

Data/Observational Networks
Increase all-season observation stations
Increased access to historical data, "non-standard variables"
Data quality: fire detection reporting
Decision Support Tools
Climate-fire regime modeling, including social factors
Dynamic decision-making capability
Climate trigger points and ensembles of analogs
Education/Training/Outreach
Climate primer; fire management primer
Training courses (like S190-S590)
Outreach to Congress and the public
Information Transfer
Web-based, one-stop shopping
Regionally-specific products
Include all temporal and spatial scales
Long-Range Management
Integrate climate into EIS, NEPA, fire planning
Budget constraints: 10-yr. Horizon, 1-yr. Budgets
Include climate and climate variability in planning
Research
Climate-fire links, including atmospheric circulation
Relationships between climate and fire indices
Institutional barriers, community factors
Use of Climate Forecasts
What are the institutional barriers to climate forecast use?
What is geographical, seasonal, regime skill?
Poor federal-level support for use by fire managers

Decision Support

One of the most important needs voiced by workshop participants was for the development of tools to integrate climate into environmental impact statement (EIS) processes and large-scale NEPA (National Environmental Policy Act) process planning efforts. The recommended decision support tools would involve taking into account factors such as regulatory agencies and policies, homeowners and others, political-jurisdictional factors, social factors, as well as climate, vegetation and fire history. Participants recommended a nested design for decision support tools and climate information, such that all spatial and temporal scales are represented. They highlighted the need for tools and information that emphasize on operational contexts (e.g., district scale) and planning contexts (e.g., regional-scale for proactive/strategic planning). Another class of decision support tools recommended by workshop participants would identify so-called "trigger points" in the regionally-specific historical relationships between climate and fire (see *Research*, below).

Education/Training/Outreach

Improved training for both fire professionals and climate researchers was probably the most important goal identified by workshop participants. A theme common to all three workshops was the development of a primer for fire professionals on climate-fire relationships, written by instructional and design experts (in consultation with climatologists and meteorologists); a similar primer for climate researchers on fire management procedures and needs was also recommended. Fire management professionals suggested that this information be presented in a range of training courses similar to the S190-S590 training series. In addition, participants recommended that agencies hire a group of meteorology/climatology specialists to serve as *translators* of climate/weather information to fire managers. New hires, fire behavior analysts and incident meteorologists were identified as key recipients of this training, as well as personnel at the Geographic Area Coordination Centers (GACCs) and National Interagency Coordination Center.

Participants also emphasized that agency officials and Congress need to hear about the synergy between long-term climate conditions and the ability of the fire and ecosystem managers to achieve land management objectives. They noted that, with regard to the ability of land managers to implement prescribed burn and restoration plans within short time frames, the expectations of agency officials and Congress are often unrealistic. In order to remedy this situation, they recommended that congressional aides be invited to attend future fire-climate workshops.

Information Transfer

In order to make the aforementioned data, information, and decision support tools most useful to fire managers, participants expressed a strong preference for *one-stop shopping* using the Internet. Participants pointed out that graphical and map presentation is far more useful than data tables and lists. They stressed that products need to have *telescoping* or *layering* features, in order to give users the ability to move up and down a wide variety of temporal and spatial scales with ease, and to give users the ability to specify levels of complexity. In addition, participants expressed a need for products that incorporate interaction and dynamic decision-making. Participants also recommended that many more local and regional National Weather Service meteorologists

attend fire-climate workshops, in order to facilitate the integration of short-term weather and long-term climate information in fire management and fire weather forecasting.

Long-Range Management

A key point to surface from workshop discussions is that climatology considerations are not integrated into land management planning. Moreover, climate and fire regimes are assumed to be stationary, even though current research suggests regionally specific climate effects associated with low-frequency variations in ocean-atmosphere circulation (e.g., ENSO, Pacific Decadal Oscillation). There is also a perception that the effects of management activities far outweigh climate effects. Indeed, NEPA processes give no consideration to climate and changing fire regimes. Participants recommended that such considerations should be incorporated into management of endangered species, high-investment areas, aquatic life, protected areas, wilderness, and urban-wildland interface areas.

Many participants noted that fire management protocol requires management decisions to be made based on data from the previous 20 years; they suggested, however, that data from an *analogous* 20 years would be more appropriate for their decision-making needs. Arizona and New Mexico fire managers emphasized the need for sustainable multi-year budgets in order to carry out objectives associated with long-range planning horizons (e.g., the 10-year planning horizon of the Western Governors' Association and the 20-year retrospective period to suggested by the National Fire Management Analysis System). They noted that budgets are only allocated one year at a time; consequently, unused funds cannot be accrued in order to achieve the mandated longer-term objectives.

Research Issues

Workshop participants recommended research initiatives in the physical, natural, and social sciences, as well as research that integrates the three. Foremost is a better understanding of the dynamic links between climate and fire. Participants noted that synoptic scale weather sequences are the most important influence on wildfires in many parts of the country. They suggested research to determine whether the synoptic scale climate patterns correlate with long time-scale processes, and with short-term processes such as locally extreme outbursts of wind. Participants suggested further research into relationships between climate and fire/drought indices, forecasted values (such as burn index and ERC) and National Fire Danger Rating System data.

Participants suggested that one way to present historical climate and fire data would be to show them as a time series of recent conditions coordinated with a time series ensemble of past analogous years. Thus, managers could trace recent conditions and then see a range of possible future conditions. Expanding on this idea, participants suggested that review of past climatic conditions would enable the identification of *trigger points* during the fire season that would serve as prompts for fire managers to make key decisions. Participants also recommended biophysical research on the impact of climate on factors such as plant and fuel flammability, curing, drying, etc. Participants noted that there is a need to address issues associated with data quality, arising from inconsistencies over the decades in collection and maintenance of data.

Social science research recommendations included analyses of regional and community sociocultural differences, in order to better understand the tolerance of certain communities to smoke associated with prescribed fire, political power relations (in terms of preparedness and receptivity to forest health and restoration programs), and analyses of human-caused risk factors. Moreover, participants suggested studies of the institutional barriers to the use of climate forecasts by fire managers.

Use of Climate Forecasts.

According to workshop participants, federal-level administrators have been slow to adopt the use of climate information in scheduling controlled burns. Participants suggested that in order to change bureaucratic culture at this level, a well-packaged presentation regarding strengths and weaknesses of climate forecasts is needed. The use of climate forecasts needs to be tied to other institutional and policy factors such as protection of endangered species. The goal should be to create an environment where the value of climate forecasts can be demonstrated. Workshop participants highlighted the fact that if accurate climate forecasts information is available by January, then sufficient time is available for additional severity funding to be requested.

Climatologists stressed that forecast users must keep in mind that forecasts are not always going to be correct, and that seasonal climate forecasts have known regional and seasonal strengths and weaknesses. For instance, whereas winter forecasts have been fairly reliable for parts of the western and southern United States, summer precipitation forecasts still lack reasonable skill. Forecasters recommended that fire managers could take advantage of the high level of skill during extreme phases of ENSO. Perhaps most important was the sentiment that present-day climate forecasting is approximately as well-developed as weather forecasting was in the 1960s; thus participants agreed that there is cause for optimism with regard to the future of long-term climate and associated fire forecasting.

3.3 *Post-Workshop Evaluations*

For the 2001 workshops, we instituted a brief workshop evaluation form. The small sample of respondents (n = 10) unanimously agreed that the workshops were of the value, and 9 out of 10 respondents indicated interest in planning subsequent workshops. Workshop presentations and breakout groups were identified consistently by evaluation respondents as highly valuable workshop activities, whereas opinion was mixed with regard to the climate

forecast and evaluation session. In open-ended comments, respondents' expressed agreement regarding the value of the workshops as a way for researchers and managers to express their concerns and learn about each others' perspective. In response to the question "how can we improve the workshop?" respondents indicated the need for an expanded and better balanced spectrum of participants and presenters, continued communication, and improved communication. The following remarks are illustrative:

- "Communication is fundamental -- we need more communication and cooperation at all levels, interagency, intra-agency, from the field to D.C."
- "Currently the participants include climate researchers, climate-ecology-biogeography researchers, high-level public agency fire managers, and lower level fire managers. I recommend the next round you consider adding "fire community" folks such as those targeted by FIREWISE."
- "Try to get presentations by more of the users (i.e., users of climate forecasts)... we, the research and forecasting community, cannot understand their needs enough."
- "Consider providing a glossary with definitions of [climate] terminology, like: ensemble, reanalysis, synoptic, coupled, 500 mb height..."

4. PROGRESS AND FUTURE DIRECTIONS

The recommendations and ambitious action plans established by participants at the three workshops, have resulted in a variety of actions. For example, CEFA has established a *one-stop shopping* web site, with a comprehensive array of links to historical climate data, climate forecasts, fire index data, fire weather forecasts, climate analyses and other operational and research products. CLIMAS has developed a fire-climate web site with background information on the fire-climate relationships in the southwestern U.S., a fire-climate online bibliography, and links to fire and climate research and general information for the Southwest. CEFA and the National Interagency Fire Center (NIFC) have collaborated to develop climate/weather training courses for fire managers in the western U.S. As a result of NIFC Joint Fire Science Board (JFS) members' participation in our workshops, the recent JFS Program request for proposals included initiatives for research on climate and fire relationships, and improved fire prediction capabilities based on long-term relationships between fire and climate. Moreover, several workshop participants have combined forces, and the auspices of an EPA Star Grant funded project, to develop a decision support system for fire management, which includes fire history, climate, remotely sensed, and social science data.

CLIMAS, with the support of NOAA, the JFS Program, the USDA-Forest Service Riverside Fire Laboratory, the University of Arizona Institute for the Study of Planet Earth, and the collaboration of CEFA will continue to host future climate and fire workshops. We expect that ongoing contact between CLIMAS, CEFA, NWS offices, NIFC and other state and federal fire and land management agencies will fulfill workshop action plan goals, such as:

- Identification of the best way to conduct educational/training activities
- Development of climate and fire management primers
- Development of a five-year plan to establish of an ongoing, dynamic assessment process and form a permanent fire-climate expert group
- Form an ongoing working group to move forward on integrated land management planning

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