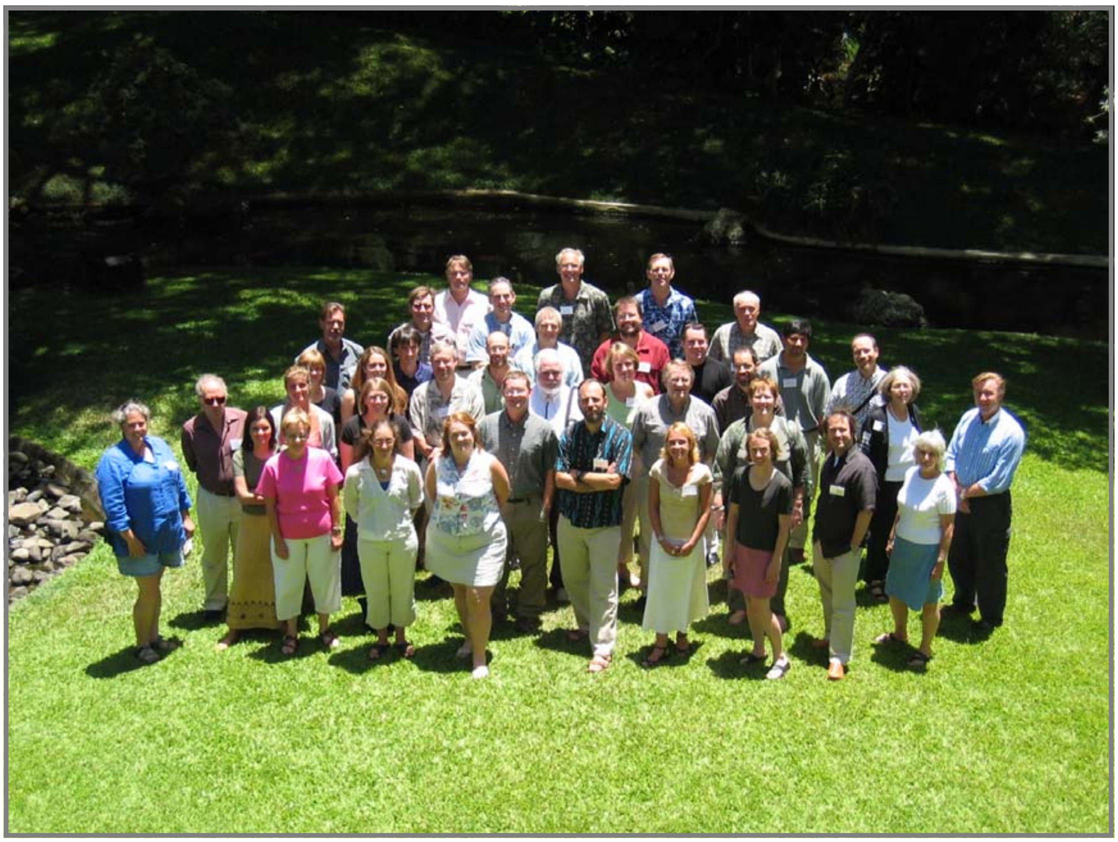
2005 SPARC Reconciling Supply and Demand Workshop:

Climate Science Policy Lessons from the RISAs

August 15—17, 2005 East-West Center Honolulu, Hawaii

Climate Science Policy: Lessons from the RISAs

Workshop Report



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26 January 2007

Final Draft

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I. Executive Summary

On August 15-17, 2005, 40 scholars convened at the East-West Center in Honolulu, Hawaii to participate in a workshop titled "Climate Science Policy: Lessons from the RISAs". The primary justification for climate research in the United States is to provide 'useful' information for decision making. The genesis of this workshop, therefore, stems from the desire to explore one overarching question:

Are US climate research efforts resulting in the production of useful, and thus policy-relevant, scientific information for decision makers? In other words, are we making the right decisions about what science to conduct, and thus what scientific information to supply to decision makers?

This workshop focused on the lessons learned from the NOAA Regional Integrated Sciences and Assessment (RISA) programs based on the fact that these programs are widely hailed as a promising means to connect decision-making needs with the research prioritization process.

In conducting this workshop and related research, we utilize a framework that we call "reconciling the supply of and demand for science" (Sarewitz and Pielke, in press). In so doing we borrow concepts from the field of economics that recognize that there is both a supply side and demand side in the marketplace, and that both sides are effectively linked, modulated, and optimized through robust communication and a variety of other mechanisms. The same can be said for climate science policy in that decisions are made regarding what scientific information to produce, or supply, while users of scientific information simultaneously have specific information needs, or demands, that inform their decisions. In an ideal situation, scientific information that is produced is both needed and used by decision makers and research efforts that result in unused information are avoided or minimized. In simple terms, for science to support decision-making, the ideal situation is one in which the supply of climate science is reconciled with the users' demands.

Research to date indicates that the 'demand side' of climate science is better understood and characterized from individual to institutional levels than the 'supply side', which eludes characterization – to date – due in part to the dispersed nature of climate research and sheer scale of endeavor. In order to understand and evaluate how climate science research priorities and production on a national scale match up with the users' information needs, one should map both the supply and demand sides of climate information. Additionally, one should also explore how these two sides are reconciled through mediating processes and institutions. Given the scope of our research project, however, we chose to examine the RISA programs, drawing lessons from their experience that may be applied to climate science policy. Of particular interest is the desire to improve research prioritization, thus expanding options afforded to climate science policy-makers in order to improve the production of policy-relevant climate information for decision makers.

During the first day of the workshop, participants discussed and characterized the demand side of climate information in their particular contexts. Generalizing demands for climate information is difficult because users of information are context dependent; for example, each RISA focuses on unique policy problems in different regions of the country. Stakeholders are identified through a variety of mechanisms, including word of mouth, through existing relationships and through targeted outreach efforts. While some RISAs elicited users' information demands through informal interactions, others employed the expertise of social scientists to conduct directed studies or other formal needs assessments. While formal evaluation of stakeholder interactions have been minimal, most RISAs cite the importance of developing social capital in the form of trusting, long-term relationships with stakeholders in order to increase the likelihood of successful co-production of climate information.

On the second day, participants discussed and characterized their experience with the supply side of climate information. The issue of context emerged as one of the most important lessons in that researchers must tailor their information not only to the physical characteristics of the different regions, but to likely events, logistical realities, and users' understanding of the issues. RISA research activities were dynamic, and often changed or adjusted based on interactions with stakeholders and improved understanding of their needs. Mechanisms for prioritizing research priorities within RISAs also varied considerably. Disseminating climate information varied widely both between the RISAs and within each RISA, in that the RISAs would often utilize a variety of methods ranging from peer reviewed publications and reports to public presentations and web-based materials. Face to face interactions with stakeholders were often cited as a more effective means of disseminating information.

The third day of the workshop focused on the issue of reconciling supply and demand. One barrier oft noted by RISAs was the problem concerning the inherent limitations of climate prediction, in that stakeholders often requested such information that was usually beyond the capabilities of the RISA researchers. Mitigating tensions between the expectations of stakeholders and the capabilities of the RISA researchers was a necessary activity with many RISAs, and most found that educating stakeholders about the capabilities and limitations of science ameliorated such tensions. Again, few RISAs formally evaluate their research and planning processes, although every RISA identified at least some informal mechanisms by which to ascertain their success.

The workshop provided many valuable lessons about reconciling supply and demand of scientific information:

- Early, iterative, sustained and two-way communication is essential for reconciling supply and demand of scientific information.
- Good relationships, that is, ones based on trust, reciprocity and respect - both intra-RISA and with stakeholders - is necessary to build healthy and collaborative dynamics. Producing good and useful information is about understanding the full scope of the problem and thus context. To identify such characteristics, RISAS must actively engage stakeholders, thus good communication and healthy relationships are necessary.
- Effective process must also be dynamic, resilient, and adaptive to challenges, events and opportunities.
- Producing useful information inevitably involves trade-offs and attempts to balance various tensions, for example, the production of knowledge vs. provision of services; public vs. private interests; public-oriented vs. peer-reviewed products; breadth of research vs. depth; demands of parent program vs. needs of stakeholder community, etc.
- RISAs utilize a variety of approaches to engage with stakeholders, suggesting that there is no single 'best approach' for this kind of work.

- Despite the compelling evidence of RISA program success in producing policy-relevant information, these experiences have had little impact on climate science policy, yet there appears to be no easy answer as how to do so.
- An important next step for the RISA program is to become institutionalized within the broader climate science community.

Our findings from the workshop indicate that there are four primary approaches to reconciling the supply of and demand for climate information within the RISA programs.

- RISAs that employ a *'stakeholder-driven research'* approach focus on performing research in both the supply side and demand side as a contribution to reconciliation. Such efforts require robust communication in which each side informs the other with regard to decisions, needs, and products. The focus here is on decisions made by stakeholders.
- RISAs that employ the *'information broker'* approach produce little or no new scientific information themselves, due either to resource limitations, or lack of critical mass in a particular area. In this approach, the RISA sees their primary role as providing a conduit for information and facilitating the development of information networks. The focus here is on integration and sharing information deemed to be relevant to the information needs of decision makers.
- RISAs utilizing a *'participant/advocacy'* approach focus on a particular problem or issue, and engage directly in solving that problem. In this sense, they see themselves as part of a learning system and promote their research to a well-defined set of stakeholders who share the RISA's conceptualization of the problem and desired outcomes.
- Sometimes RISAs must utilize a *'basic research'* approach in which the researchers recognize particular gaps in fundamental knowledge that is necessary as a prerequisite to the production of context sensitive, policy-relevant information. Researchers, therefore, often establish some basic research as a priority within the organization.

In practice, however, each RISA often utilized many or most of these approaches at different times depending upon the particular context of the problem, showing reflexivity and adaptation in organizational practice and process. One factor that appears to influence a RISA's approach is also that of organizational longevity, in that the more well-established RISAs had more formal processes and procedures in place, having had more time to map their own field and problem area.

Finally, the workshop produced several lessons for climate science policy. The RISAs have learned a tremendous amount about what is needed to produce, package, and disseminate useful climate information, and have published many of their findings. Yet lessons from the RISAs appear to have had little influence on the climate science policy community outside of the RISAs, namely, those program managers and policy makers who could otherwise support the important function that RISAs play in reconciling supply and demand. Improving feedback between RISA programs and the larger research enterprise need to be enhanced so that lessons learned can inform broader climate science policy decisions.

RISA Acronyms:

CAP: California Applications Program

CISA: Carolinas Integrated Science & Assessments

CIG: Climate Impacts Group (Pacific Northwest)

CLIMAS: Climate Assessment of the Southwest

NEISA: New England Integrated Science and Assessment

Pacific RISA: (Hawaiian and US affiliated islands)

SECC: Southeast Climate Consortium

WWA: Western Water Assessment (Interior West)

II. Purpose of the Workshop

A. Introduction

In April 2002, the House Science Committee held a hearing to explore the connections of climate science and the needs of decision makers. The hearing charter included the following question[1]: "Are our climate research efforts focused on the right questions?" By "right questions" the Committee clearly meant questions whose answers are likely to lead to useful information to decision makers. The Science Committee's hearing highlighted the role of the NOAA Regional Integrated Sciences and Assessments (RISA) as a promising means to connect decision-making needs with the research prioritization process:

> One approach to producing policy-relevant information is the regional assessment model, developed within NOAA and other agencies, that attempts to build a regional-scale picture of the interaction between climate change and the local environment from the ground up. By funding research on climate and environmental science focused on a particular region, [the RISA] program currently supports interdisciplinary research on climate-sensitive issues in five selected regions around the country. Each region has its own distinct set of vulnerabilities to climate change, e.g., water supply, fisheries, agriculture, etc., and RISA's research is focused on questions specific to each region. The regional assessments are developed in consultation with local stakeholders such as resource managers, farmers, and emergency responders. RISA has been called a step in the right direction by some, although the program is small (approximately $4 million in FY 2003), while others view it as a model that could guide some of the larger efforts within USGCRP.

The RISA program is now 10 years old and has developed a significant body of experience in working to establish a two-way connection between decision makers and interdisciplinary science and assessment[2]. This experience provides a rich resource for drawing lessons from the various RISA projects on how science priorities might be set, research implemented, and the resulting output transferred to operational agencies in support of the needs of decision makers. The purpose of the workshop, therefore, was to focus specifically on how RISAs make decisions about prioritizing and conducting research given the goal of supporting decision making, in order to extract lessons from these experiences that might inform the larger climate science program enterprise.

B. What is the problem? Reconciling Supply of and Demand for Climate Science

Our research is motivated by a simple fact: there is both a supply side and a demand side for scientific information relevant to decision making. This suggests a hypothesis that is strongly supported by results from our prior research, as well as the work and experience of many others: the capacity of scientific research to support decision making is greatly enhanced when the supply side (i.e., researchers) and demand side (i.e., decision makers) understand each other's capabilities, needs, and limits.

We are consciously using the terms "supply" and "demand" because in the economic marketplace, supply and demand are effectively linked, modulated, and optimized through many mechanisms. If there is no demand for a product, companies will not produce it (or, at least, not for long)—or perhaps they will advertise aggressively to create a demand. Producers are constantly monitoring, assessing, and responding to consumer preferences so that they can enhance sales and profits. Competition between producers of similar products (e.g., different brands of CD players or pain killers), or dissimilar products that fill similar needs (e.g., CD vs. cassette players; aspirin vs. ultrasound) leads to constant evolution of both consumer preferences and producer outputs. In the high technology sector, a considerable

1. http://www.house.gov/science/hearings/full02/apr17/full_charter_041702.htm
2. http://www.climate.noaa.gov/cpo_pa/risa/

amount of incremental innovation comes in response to specific input from consumers. Overall, a key attribute of this coevolution of supply and demand is communication: producers are constantly striving to understand, influence, and respond to the preferences of consumers; consumers are constantly making choices among options in response to their own preferences, knowledge, and experiences.

Over the past several decades, scientific information has come increasingly to play a role in decision making at every scale from the individual (e.g., a person trying to understand if recycling provides an environmental benefit) and the very local (e.g., a mayor deciding whether to order an evacuation prior to a hurricane) to the global (e.g., governments negotiating climate change agreements). Here, there is a supply side and a demand side too, but formal or informal feedbacks to enhance mechanisms to ensure compatibility between the supply of scientific information and the demands of decision makers are often lacking. In the absence of such mechanisms, there are important factors at play, which militate against alignment of supply and demand, factors that reflect intrinsic differences between research and policymaking. For example, from the scientific (supply) perspective, the types of questions and problems that scientists are able to address or are interested in addressing are not necessarily those that decision makers need to have answered. And from the policy perspective, most important policy dilemmas are almost always underlain by value disputes that science cannot resolve.

Science policy scholar Harvey Brooks aptly characterized the inter-relationships of supply of and demand for scientific information:

> "If the process of using science for social purposes is thought of as one of optimally matching scientific opportunity with social need, then the total evaluation process must embody both aspects in an appropriate mix. Experts are generally best qualified to asses the opportunity for scientific progress, while broadly representative laymen in close consultation with experts may be best qualified to assess societal need. The optimal balance between opportunity and need can only be arrived at through a highly interactive, mutual education process involving both dimensions." (1996 p. 33)

Policy research increasingly documents that compatibility of scientific supply and decision-maker demand can be increased through mechanisms that enhance knowledge of, and communication between, the supply and demand sectors. When scientists and decision makers understand each other's capabilities, needs, and limits, research agendas can be better designed to support decision making, and decisions can be more successfully rooted to take advantage of scientifically robust information. Despite insights gained from several decades of scholarship in this area, however, the organization of climate science in the United States evolved with weak linkages between the supply of and demand for knowledge among the broad array of potential users and desired societal outcomes. Adopting Kitcher's term, we hypothesize that climate science is very far from being "well ordered", in which science addresses both the needs of free inquiry and is responsive to societal needs and values. More importantly, we suggest both that this hypothesis is testable and that, given the scale of public investment and the potential environmental and socioeconomic stakes, the effectiveness of science policies could be greatly enhanced from testing it.

As long ago as 1992, a first (and, as far as we can know, last) step along these lines was taken in the Joint Climate Project to Address Decision Maker's Uncertainty (Bernabo 1992). The project sought to determine "what research can do to assist U.S. decision makers over the coming years and decades," it argued that "[a]n ongoing process of systematic communication between the decision making and the research communities is essential," and it concluded that "[t]he process started in this project can serve as a foundation and model for the necessary continued efforts to bridge the gap between science and policy" (p. 86). Those continued efforts did not occur.

More than a decade later, the scale of the climate research enterprise has increased enormously, along with fundamental understanding of the climate system. At the same time we observe that there is little if any evidence that this growth of understanding can be connected to meaningful progress toward slowing the negative impacts of climate on society and the environment. On the other hand, appreciation of the variety of decision makers and complexity of decision contexts relevant to climate change has greatly deepened. Understanding of this diversity should allow us to ask: what types of knowledge might contribute to decision making that could improve the societal value of climate science? Next, we outline a methodology of science policy research for assessing and reconciling the supply and demand functions for climate science information.

a) **Demand Side Assessment**. Research on the human dimensions of climate, though modestly funded over the past decade or so, has made important strides in characterizing the diverse users of climate information, be they local fisherman and farmers or national political leaders; on the mechanisms for distributing climate information; and on the impacts of climate information on users and their institutions. This literature provides the necessary foundations for constructing a general classification of user types, capabilities, attributes, and information sources. This classification can then be tested and refined, using standard techniques such as case studies, facilitated workshops, surveys and focus groups. Given the breadth of potentially relevant stakeholders, such a demand side assessment would need to proceed by focusing on particular challenges or sectors, such as carbon cycle management, agriculture, ecosystems management, and hazard mitigation.

b) **Supply Side Assessment**. Perhaps surprisingly, the detailed characteristics of the supply side—the climate science community—are less well understood than those of the demand side. One reason for this of course is that over the past decade or so there has been some programmatic support for research on the users and uses of climate science, but no similar research on climate research itself. Potentially relevant climate science is conducted in diverse settings, including academic departments, autonomous research centers, government laboratories, and private sector laboratories, each of which is characterized by particular cultures, incentives, constraints, opportunities, and funding sources. Understanding the supply function demands a comprehensive picture of these types of institutions in terms that are analogous to knowledge of the demand side, looking at organizational, political, and cultural, as well as technical, capabilities. Such a picture should emerge from analysis of documents describing research activities of relevant organizations, from bibliometric and content analysis of research articles produced by these organizations, and from workshops, focus groups, and interviews. The result would be a taxonomy of suppliers, supply products, and research trajectories. As with the demand side assessment, the scale of the research enterprise suggests that this assessment process should build up a comprehensive picture by focusing sequentially on specific areas of research (such as carbon cycle science). This incremental approach also allows the assessment method to evolve and improve over time.

c) **Comparative Overlay**. Assessments of supply and demand sides of climate information can then form the basis of a straightforward evaluation of how climate science research opportunities and patterns of information production match up with demand side information needs, capabilities, and patterns of information use. In essence, the goal is to develop a classification, or "map," of the supply side and overlay it on a comparably scaled "map" of the demand side. A key issue in the analysis has to do with expectations and capabilities. Do climate decision makers have reasonable expectations of what the science can deliver, and can they use available or potentially available information? Are scientists generating information that is appropriate to the institutional and policy contexts in which decision makers are acting? Useful classifications of supply and demand functions will pay particular attention to such questions. The results of this exercise should be tested and refined via stakeholder workshops and focus groups.

		Demand: Can User Benefit from Research? YES	Demand: Can User Benefit from Research? NO
Supply: Is Relevant Information Produced?	NO	Research agendas may be inappropriate.	Research agendas and user needs poorly matched; users may be disenfranchised.
	YES	Empowered users taking advantage of well-deployed research capabilities.	Unsophisticated or marginalized users, institutional constraints, or other obstacles prevent information use.

The 2x2 matrix shown here schematically illustrates the process. We call this the "missed opportunity" matrix because the upper left and lower right quadrants reflect where opportunities to connect science and decision making have been missed. Areas of positive reinforcement indicate effective resource allocation where sophisticated users are benefiting from relevant science. Areas of negative interference may indicate both opportunities and inefficiencies. For example, if an assessment of demand reveals that certain classes of users could benefit from a type of information that is currently not available, then this is an opportunity—if provision of the information is scientifically, technologically, and institutionally feasible. Another possibility would be that decision makers are simply not making use of existing information that could lead to improved decisions, as Callahan et al. (1999) documented for regional hydrological forecasts. Finally, research might not be well matched to the capabilities and needs of prospective users, as Rayner et al. (2002) have shown.

d. **Institutional Context for Climate Science Policy**. As we have emphasized throughout this discussion, supply and demand must ultimately be reconciled via mediating processes and institutions—in this case, science policy institutions, such as relevant federal agencies, congressional committees, executive offices, non-governmental advisory groups, etc. Institutional attributes such as bureaucratic structure, budgeting, reporting requirements, and avenues of public input, combine with less tangible factors including the ideas and norms embedded within the institution, to drive decision making (e.g., Laird 2001, Schön and Rein 1994, Keohane et al. 1993, Wildavsky 1987, Kingdon 1984). How do managers justify their decisions? Are those justifications consistent with the decisions that they actually make? What ideas or values are perhaps implicit in the analyses and patterns of decisions that the institution exhibits? These sorts of questions can be addressed through analysis of internal and public documents, interviews, and public statements. We emphasize that it is the institutional analysis that provides the basis for identifying concrete alternatives for better reconciliation of supply and demand functions.

Our analysis of the evolution of the climate science enterprise in the U.S. indicates that policy assumptions and political dynamics have largely kept the supply function insulated from the demand function except in the area of international climate negotiations. Some modest experiments, notably the RISA (Regional Integrated Sciences and Assessment) program of the National Oceanographic and Atmospheric Administration, have sought to connect scientists and research agendas to particular user needs at the local level, but these lie outside the mainstream of the climate science enterprise.

A research effort of the type sketched here can illuminate how well climate science supply and demand are aligned, highlight current successes and failures in climate science policy, identify future opportunities for investment, and reveal institutional avenues for, and obstacles to, moving forward. The value of the method will in great part depend on how receptive science-policy makers are to learning from the results of such research. We are optimistic on this front for two reasons. First, the fundamental justification for the public investment in climate science is its value for decision making. This justification, repeated countless times in countless documents and public statements, is prima fascia evidence that climate science policy makers are committed to an enterprise that creates useful information. Second, and of equal importance, the very process of implementing the method we describe will begin to create communication, reflection, and learning among decision makers who govern the climate science enterprise, and various users and potential users of scientific information hitherto unconnected to the science policy arena. The result of this dynamic process will be an expansion of the decision options available to science policy makers, and thus an expansion of opportunities to make climate science more well-ordered. Undoubtedly, institutional innovation would need to be a part of this process as well, given the scale and scope of the climate science enterprise and the potential user community.

C. NOAA Regional Integrated Sciences and Assessment (RISA) Programs

We are focusing on the RISAs as a body of experience that offers the promise of learning about successes of and obstacles to reconciling the scientific supply of and demand for science. We are not interested in evaluating the RISAs with respect to their NOAA missions. We are happy to leave that to the RISA program managers. But we do think that the RISAs can teach us, the Climate Programs Office (CPO), National Oceanic and Atmospheric Administration (NOAA) and the Climate Change Science Program (CCSP) and beyond something about the challenges at the two-way interface of the complex relationship between decision making about science and decision making about climate. The RISA program explicitly seeks to work at the boundary of science and decision making.

> "RISA projects point the way toward a new paradigm of 'stakeholder- driven' climate sciences that directly address society's needs and concerns."
>
> "What makes science useful and usable for the public? Much work has gone into answering this question, and the RISAs have been at the forefront of the effort. RISA researchers place strong emphasis on working directly with people who have an investment—a "stake"—in activities, resources, or property that may be vulnerable to climatic impacts. These stakeholders hold the key to scientists' understanding of what kinds of climate information can aid the public in coping with climate variability, and how to provide this information in forms that people can actually use."[3]

A 2005 NRC Report that looked at experience in seasonal climate forecasting found this area to be rich for understanding connections of science and decision making,

> "…crucial to the success of such systems is that they incorporate user-driven definition and framing of the problem to be addressed. "User-driven" is used here to mean that the agendas of analysts, forecasters, scientists, and other researchers are at least to some degree set by the potential users of forecasts. The process of collaborative problem definition would be user driven, but reflect input from the scientific (producer) community on what is feasible."[4]

3. From the 2005 RISA Brochure.

4. Cash and Buizer, 2005, page 9

D. Workshop logistics and details

The 2005 "SPARC Reconciling Supply and Demand Workshop" was held August 15-17, 2006 at the East-West Center in Honolulu, Hawaii. The Workshop was divided into three days. Day #1 explored the characteristics of the demand side of the RISA programs. Each RISA team was allotted about ten minutes to give a prepared presentation, followed by questions from the audience. Day #2 explored supply-side characteristics utilizing the same approach. Day #3 explored how to manage the ecology between the supply and demand sides. For this session, each workshop participant was assigned to a particular group to answer the question: "What lessons have we learned from the RISAs for Climate Science Policy in the Climate Change Science Program?" The workshop participants then reconvened and each group presented its answers to the question.

III.Summary of Findings

A. Demand side assessment

The range of stakeholders is unique to each RISA program, yet most RISA stakeholders include local, county, regional, state, and federal officials. In the CAP, researchers also work at the international level collaborating with Mexican scientists, and several RISAs also work with various American Indian Tribes. Stakeholders also represent public, private, ngo and educational organizations. Since each RISA mission is unique, each set of stakeholders varies according to the particular climate problem area in which the RISA works. For example, CIG's mission includes four sectors of research and outreach including water resources; forests; aquatic ecosystems; and coasts and consequently its stakeholders include such groups as the Portland Water Bureau, Seattle City and Light, Washington Department of Fish and Wildlife and the International Halibut Commission among others. The NEISA program, on the other hand, has a comparatively narrow focus related to the study of climate, air quality and human health, thus its stakeholders come from sectors related primarily to those issue areas such as hospitals and state departments of health and human services. For many of the RISAs, agricultural, forest and water-related groups and agencies serve as primary stakeholders. Several other RISAs identify various offices and departments of emergency planning and services as stakeholders, as well as tourism-related interests (e.g. Pacific RISA). Still other RISAs count the media and general public among their stakeholders (e.g. WWA).

RISAs employ a variety of mechanisms for identifying stakeholders, for example, through existing networks related to the particular RISA research area, word of mouth, personal relationships and through recommendations through researchers extended communities. CAP notes the importance of boundaries, in that they seek stakeholders who manage porous institutional boundaries and avoid those with institutional walls (p. 49[5]). Several RISAs identify the need to seek out and work with early adopters who have good potential to engage in new tools and approaches to their decision making processes. The Pacific RISA also suggests that the nature of the science itself influences who potential stakeholders may be, in that "ENSO-based forecasts and climate change projections tended to focus on changes in rainfall, temperature so the user communities (stakeholder) most active in the early years were those for whom changes in those parameters were most directly relevant" (p. 59). Pacific RISA's emphasis on building resiliency to climate variability and promoting sustainability also shapes decisions regarding potential stakeholders.

RISAs use a variety of means for including stakeholders in the research and planning process. Many programs rely on interaction with stakeholders at workshops, conferences, professional meetings, and the like to meet with stakeholders and to identify their science information needs. Some RISAs also utilize briefings and publicizing of research as outreach

5. Citations from these sections unless otherwise indicated come from the "2005 SPARC Reconciling Supply and Demand Workshop: Climate Science Policy Lessons from the RISAs. August 15-17, East-West Center, Honolulu, Hawaii." CAP pgs 34-42; CISA pgs 43-45; NEISA pgs 46-50; Pacific RISA pgs 51-63; CIG pgs 64-70; SECC pgs 71-72; CLIMAS pgs 73-85; WWA pgs 86-91.

mechanisms in order to elicit stakeholder needs. A few RISAs, however, utilize more directed approaches to elicit stakeholder needs such as personal contacts with key individuals, interviews, directed studies, resource planning meetings and also consulting activities. In the case of the Pacific RISA, the process for eliciting stakeholder needs grew out of previous projects such as the Pacific Assessment and the PEAC review project. Findings from these efforts informed development of the Pacific RISA research and implementation activities confirming that "the concept that sustained communication and user engagement is critical o the co-evolution of climate science, information services and climate risk management policies" (p. 54). Between 1999 and 2001, the SECC conducted several Sondeos[6] comprised of scientists, agricultural extension agents and ranchers. Over the course of four Sondeos, the SECC identified several opportunities in which climate information could improve ranchers' decisions (Vedwan et al., 2005). The CLIMAS group describes two processes that contribute to stakeholder participation in research planning, that is, "dialogue development, and taking advantage of events and opportunities." They describe a process of information exchange as well as acculturation in which scientists and stakeholders "learn each other's vocabulary". Through an iterative process, both groups identify and refine specific research problems and questions. This iterative process continues through the research and reporting phase whereby stakeholders could be invited to collaborate on white papers or reports.

RISA programs identified several important strategies for eliciting stakeholder research needs and wants. The CISA, NEISA and CIG programs found that tapping into, and utilizing existing networks aided in outreach and helped foster relationships through which stakeholders could be identified and their needs elicited. The CISA program also engaged stakeholders who expressed early interest in long-term relationships. Other RISAs also identified developing relationships with stakeholders as important foundational steps prior to, and concurrent with, eliciting their needs. The WWA has found that personal relationships between researcher and stakeholder increases their ability to elicit stakeholder needs, and the Pacific RISA suggested that mutual respect is essential for healthy relationships. The CIG not only utilizes annual meetings to exchange information between researchers and stakeholders, but also takes advantage of these opportunities to "introduce the 'targeted' users of their research products to the specific CIG team members working in their area of interest" (p. 67). The CIG program works at developing and maintaining relationships with users, but these relationships avail the program of numerous opportunities for eliciting stakeholder needs, and indeed, for stakeholders to approach the CIG team members on their own initiative. The CIG suggests that producing useful information and products for users requires understanding the users' decision context, but cautions that "you can't rely on users to set the research agenda". CLIMAS seeks out 'early adaptors' and 'key informants' in order to leverage the multiplier effect, in that such stakeholders will disseminate information and products and thus broaden the CLIMAS audience. They also have a better understanding about research project selection recognizing the inherent tradeoffs between the size of the project and time constraints. The Pacific RISA also identified institutional and technical constraints as a conditioning factor in research and project design. The CLIMAS program utilizes a process that combines "supply and demand or push and pull" to elicit stakeholder information. At times, CLIMAS may "push information and research that we suspect stakeholders need. In other cases, things develop 'organically', out of explicit or implicit stakeholder articulation of needs" (p. 75). Unique among the RISAs is the CLIMAS approach to utilizing "rapid rural multi-sector assessments of vulnerability to climate variability and change…[utilizing] snowball sampling techniques, repeated intensive visits that include extensive ethnographic interviews, and interrogation between CLIMAS social and physical scientists" (p. 75).

Working with and engaging stakeholders has taught the RISA programs several important lessons necessary for effective production of useful information. Perhaps one of the most common exhortations by the RISA workshop participants

6. From Vedwan et al., 2005, p 5: "A *Sondeo* [italics in original] refers to a series of open-ended, interactive discussion among specialists from various disciplines and farmers or another target group (Hildebrand, 1981)."

was to develop relationships with stakeholders early and be prepared to develop the relationships over time, or as the NEISA program explains, develop engagement early and engage often. The CAP program concurs and includes the need to be responsive to the stakeholders and be attentive to effective outreach activities. The Pacific RISA explains that developing credibility and trust between scientists and users is "a long term endeavor", and CLIMAS explains that developing trust is "fundamental to building sustainable stakeholder relationships". The CLIMAS program suggests that "stakeholder interaction requires iterativity, which Lemos and Morehouse (2005) defined for integrated assessments as achieving three objectives: a good fit between knowledge production and application, disciplinary and personal flexibility, and availability of resources. Achieving iterativity requires ongoing collaboration, time, persistence, and identification of areas of mutual concern and interest" (p. 74).

Another important lesson learned from stakeholder engagement is "to take advantage of windows of opportunities!" (p. 87), or, in other words, "be ready to strike" (p. 36). The CAP explains it this way: "Agencies, especially local agencies, are buffeted by many stresses each year and often place climate issues low among their priorities. When climate rises towards the top of their priorities, however they are eager for help, advice, and hard facts; during these intervals, much progress can be made in establishing connections and in developing long-term users of climate services" (p. 36). Several RISAs have adjusted their strategies of engagement or have adjusted the products they produce as a result of lessons learned. The Pacific RISA, on the other hand, has responded to the lessons learned from experience, recognizing that their users need continuous climate support as opposed to specific event-based products and consequently, the Pacific RISA has adjusted its priorities accordingly. Additionally, they understand that that forecasts and climate problems must be anchored to the specific context of the problem and of the long-term benefits of providing outreach and education. In providing information to stakeholders, the CAP makes sure to use clear and simple examples in order to convey their research. These examples offer compelling evidence of the importance for RISAs to respond to the particular context of their stakeholder's problems, underscoring the fact that there is no single 'best approach' to engaging with stakeholders.

B. Supply side assessment

The issue of context plays an important role in how RISAs set their research priorities. While users' expressed needs and desires definitely contribute to shaping research priorities, these needs constitute only a small part of the suite of characteristics that inform such priorities. For example, several RISAs explain that users' desired research must 'fit' with the research qualifications of the team of researchers. Other RISAs indicated the need for research to fit within the context of the larger research questions they explore as part of their organizational mission. For example, the CIG identifies how research opportunities fit with "knowledge relative to the regional climate system, linkages to sectoral impacts via environmental sensitivities, the level of understanding achieved within and across sectors" among others (p. 67). Other RISAs orient their research toward likely events (e.g. CLIMAS) and "the tractability of problems and issues" (e.g. CAP). Consideration of past research also influences research priorities. The Pacific RISA sets research priorities based on problems and needs identified through PEAC, and the NEISA program explored past research on asthma to inform research priorities. Mechanisms for deciding what research to prioritize varies considerably between RISAs, from less formal, ad hoc discussions among the RISA researchers, to more formalized procedures that link the organization's goals, mission and strategic plans to research selection. For example, the CIG utilizes an executive committee, comprised of PIs, to make such decisions.

Every RISA reports that at least some of their research priorities have evolved based both on feedback from stakeholders and on experienced gained from previous research, recognizing the need to deepen, broaden, or otherwise refine their existing research priorities. For example, both the CAP and CIG noted the need to change the scale of their research. NEISA expanded its notion of air quality to include "biological, chemical and physical properties of air" (p. 47). CLIMAS describes its approach to evolving research priorities as one based on "'adaptive management' in response to recognized opportunities" (p. 77; see also WWA). CLIMAS cites two examples of the need to respond to and leverage specific opportunities, such as the onset of drought in the southwest, and the research project 'life cycles'. In so doing, CLIMAS can "optimize [their] activity with stakeholder needs". CAP notes that some of its research is evolving in some areas from a more climate variability-oriented approaches to one that explores larger climate change issues. WWA reported significant "innovation and maturation" in its process of research prioritization, from one driven largely by researcher desires to one driven by stakeholder's needs and specific events that open opportunities for research (p. 89). Most RISAs have maintained their research programs, but lack of funding has lead to the termination of some, while lack of stakeholder interest led to the elimination of others. Balance between research on new subjects and compilation and dissemination of existing materials varies between RISAs.

Utilizing multiple methods and fora for disseminating information about their research and findings are common characteristics among RISAs. Examples include peer reviewed publications, reports and white papers, guest lectures, workshops, public presentations, brochures, PowerPoint presentations, reports written for public consumption, consultancies, email list-serves, trade journal articles, professional conferences, meetings with stakeholders and users, newsletters and web-based information exchanges such as each RISA's program web page. The Hawaii RISA emphasizes the importance of "eyeball - to - eyeball" interaction as a critical component to its process of information dissemination, particularly given some of the regional limitations associated with electronic transfer of information (p. 57). Several RISAs also use the media as a mechanism for dissemination such as issuing press releases, writing editorials and even writing the occasional article. While peer-review publications offer less value to stakeholders, RISAs note the importance of such publications in terms of establishing and maintaining professional credibility, not to mention the value that such publications contribute to tenure, retention and promotion considerations. Nevertheless, most RISAs note that some of the most effective mechanisms for information dissemination include direct contact with stakeholders, whether through workshops, meetings or face – to – face interactions. Additionally, many of the programs provide at least some introduction to climate science to their stakeholders, such as 'climate 101' (p. 78) type material and educational outreach programs (e.g. CISA, WWA, etc.).

C. Reconciliation/Managing the Ecology of Supply and Demand

Several factors shaped RISA research priorities. For some RISAs, the lack of fundamental knowledge about scaling down climate modeling, for example, compelled them to undertake additional research in more fundamental science, a necessary step prior to producing policy-relevant information. The Pacific RISA recognizes explicitly the role that both supply of scientific research and demand for information by stakeholders influences research priorities. In response to this view, the Pacific RISA actively engages both scientists and stakeholders as partners in the process of reconciling the supply of scientific information with user demands and then communicates these needs to the scientific research community with whom they collaborate (p. 58).

One of the most often cited sources of conflict between stakeholder needs and the scientific capabilities and priorities of the RISAs is that of climate prediction, in that stakeholders often request information about future climate variability in temporal, spatial or other scales that science just can't produce (e.g. CISA). CIG responded to such demands by refocusing stakeholder's attention and understanding from prediction to resilience (p. 69). Some 'tensions', RISAs note, cannot be resolved given funding limitations. The Pacific RISA notes that funding limitations may have precluded the rise of potential tensions, in that they have had to evolve primarily as an "information broker – facilitating the dissemination of scientific information developed by the broader scientific community and supporting the user interactions that will help guide future climate research …" (p. 58). CLIMAS resorts to educating users to diffuse some tensions, in that when stakeholder demands are unrealistic, CLIMAS explains the nature and limitations of research to stakeholders. They also note that stakeholders often demand information on very short time scales that CLIMAS finds difficult to meet. Consequently, they reduce potential tensions by "identifying value-added information that we can provide in a short time span, while keeping the stakeholder group engaged in the long-term effort" (p. 81). They also shift emphases from solely providing information to including information on implementation of potential options. CAP identified success in avoiding tensions by making explicit to their stakeholders the limitations of their research if user expectations "seemed too wildly optimistic" (p. 40). For their part, NEISA emphasizes their role as 'partners' in the process rather than 'experts' in order to dampen unrealistic stakeholder expectations (p. 48). NEISA also responded to user expectations by bringing in scientists with appropriate backgrounds to address stakeholder expectations.

Few RISAs have an explicit plan or approach to evaluating the appropriateness of stakeholder engagement from the standpoint of public/private sector roles and responsibilities. Yet many integrate such concerns into their organizational plan or mission. CIG developed a very clear guideline for engagement and, "refuse[s] to engage in proprietary work and require[s] openness of information/data produced in research" (p. 69). CLIMAS notes that in its major sectors of research (water, drought, fire), little private sector input or services are offered to users, thus creating opportunity for CLIMAS to fill that need. They also explicitly avoid participating in consulting work, due to the fact that equity is a foundational value of the organization whereas consulting inevitably favors some stakeholders over others. WWA set rules of engagement that shape how and with whom they engage, for example, "we make it clear that we are not consultants, and a primary WWA goal is to help NOAA learn how to provide and implement Climate Services" (p. 90) and enter into stakeholder relationships under the assumption that WWA products will be publicly available.

D. Evaluating Outcomes

Only a few of the RISAs have conducted formal evaluation of the stakeholder interactions and have instead relied on more informal evaluatory mechanisms. To our knowledge there have been no external, independent appraisals of the RISAs (i.e., non-RISA, non-NOAA). In order to assess its climate dissemination efforts, the SECC conducted a "first-order assessment of FLC [Florida Consortium] impacts, including assessment of specific climate information products that the FLC introduced from 1999 through 2002." Evaluation methods included the use of semi-structured interviews either in person or over the phone with people within the Consortium (N = 13), the Florida Cooperative Extension Service (FCES) (N = 5) and FCES personnel who underwent specific in-service training related to agriculture and climate (N = 24). The evaluation utilized several proxies in order to determine what impact the FLC efforts had on its stakeholders. CLIMAS also conducts evaluations to "prioritize research initiatives, to assess success in knowledge transfer and exchange, and to assess the utility, usability, and timeliness, of specific products or suites of products" (p. 73). An additional metric for evaluation is the degree of "sustained interaction" with stakeholders, recognizing the importance of social capital in the production of useful information. Indeed, several other RISAs also utilize the frequency, duration and continued interaction with stakeholders as a proxy for success (e.g. NEIS, WWA). Many of the RISAs also seek immediate and informal feedback at meetings or workshops and query stakeholders directly regarding the utility of specific products.

IV. Few of the RISAs have formal processes for evaluating their research and planning processes, yet several engage in more informal ad-hoc approaches. NEISA for example, communicates with stakeholders and seeks input from its advisory committee (p. 50) and the Pacific RISA seeks informal feedback from stakeholders regarding "information gaps and research needs" (p. 60). One example of what appears to be a rather robust evaluation is that which CLIMAS undertook in the context of writing its proposal for renewal of the RISA grant. Specifically, they sought to discover "the extent to which we had been able to deliver on the objectives articulated in the original proposal, the history of how we came to work on particular initiatives, the types of information and products that we were providing (or in the process of developing) to stakeholders, our internal success in achieving integration as an interdisciplinary team, and our progress integrating stakeholders into our research process" (p. 82). WWA views the evaluation process as involving two steps. First, they evaluate the criteria used to judge projects and then evaluate these criteria against project results, in which "ongoing stakeholder interactions and support are an obvious sign of success" (p. 91).

IV. Analysis

A. RISA approaches to Climate Science Policy

The workshop provided an opportunity to uncover and explore the variety of approaches used by each of the eight RISA programs. For purposes of analysis, it may be useful to explore the various processes that RISA programs use to reconcile supply and demand. We have identified four different approaches: stakeholder-driven research, information broker, participant/advocate, and basic research.

The *'stakeholder-driven research'* approach focuses on performing research in both the supply side and demand side in order to reconcile the two. Such efforts require robust communication in which each side informs the other with regard to decisions, needs, and products. Central to this approach is the process of identifying stakeholder's science information needs. This process is best done through an ongoing combination of formal mechanisms such as surveys and through personal queries to stakeholders. For example, SECC utilizes multiple feedback mechanisms to stakeholders not only to determine their needs, but also to inform them how SECC can meet those needs. The CLIMAS group employs social science researchers, particularly anthropologists, to assist in the needs assessment process. Additionally, they recognize the need to identify users' needs not only in terms of data, but to understand their needs with regard to the full context of the problem. Furthermore, through their experience they have come to realize that two-way, iterative, and long-term communication is essential for this process to be effective, and view their role as one of bridge-building. The dynamic of RSD is further buttressed by the recognition that this process is dynamic, or fluid. Consequently, many RISAs make explicit the need to 'capitalize on events' with regard to research decisions, and also be flexible in the roles they play depending on the situation. Intra-RISA decisions also reflect a more dynamic approach, such as with CIG, which employs a democratic process for decision making as well as consensus building among program members.

RISAs that employ the *'information broker'* approach have made the decision not to produce the scientific information themselves, either because of resource limitations, or because of lack of expertise in a particular area. Consequently, much of their efforts concentrate on providing information service support. The Hawaii RISA embodies this approach in that they are constrained by both a limited budget and the fact that program members' areas of expertise does not include production of climate science information. The program members nevertheless have a strong breadth of knowledge in the area of climate variability, resiliency and sustainability. Indeed, programs that utilize the information broker approach need members with knowledge in these areas for the simple reason that a significant amount of their time involves communicating with both science producers and stakeholders. Cultural acuity is also required in order to forge relationships across the groups. Limited resources may also drive the development of team-oriented, networking strategies they often utilize. Underlying this approach is the need to build both trust among and between groups, and credibility that comes through long-term, sustained engagement.

RISAs utilizing a *participant/advocacy* approach do so largely based on a desire to engage in a particular problem, joining with other stakeholders who are similarly engaged in advocating for solutions to that problem. For example, the NEISA program engages in the participant approach with regard to the INHALE project. They explicitly defined their roles in the group not as experts, but as participants and view their contributions as that of academics with a purpose, or as 'interested academics' who practice engaged scholarship. They also describe the process not in terms of the RSD model posited herein, but as a learning community that utilizes a dynamic of collaborative problem formulation and problem solving in a more holistic approach. Implicit in this approach is also a desire to change 'the system' and transform institutions as a means of ameliorating problems related to their area of interest. Their research priorities therefore, reflect the needs of a narrower group of stakeholders. Participation in this approach, however, still includes an iterative approach of identifying what information would be useful to solving the problem, and in designing research agendas that will facilitate solution to the problem.

At times, RISAs utilize a *'basic research'* approach, in which their research priorities are aligned more with basic research activities than with the production of applied research that can be readily used by stakeholders. This approach stems from the fact that researchers may find they are unable to produce the useful information needed by users due to the lack of fundamental knowledge about the problem. For example, the CAP identified gaps in climate modeling capabilities as a limitation to their ability to provide useful information for stakeholders, and consequently adjusted some of their research toward more fundamental endeavors.

One factor that appears to shape RISA approaches is that of institutional longevity. That is, the older RISAs appear to have more well-defined processes, guidelines, and strategies for performing their mission. For example, older RISAS such as CIG, CLIMAS and SECC have the most elaborate and involved processes for identifying and refining stakeholder's needs, and often include social scientists in this process. Younger RISAs, however, are still involved in mapping their field, so to speak, in that they are still in the process of identifying potential stakeholders, problem areas, and strategies that may work best for them. To some degree, utilizing an ad-hoc approach may well suite the younger RISA programs in that they are both searching out opportunities but also testing what approaches may work best within their organization and with stakeholder communities as a means to learn and guide future strategies. The Hawaii RISA, also young, is constrained significantly by limited resources and thus is compelled to adopt a more information broker approach rather than others. Such variation comes at no surprise given research in organizational life cycles and organization dynamics. But this does open up questions as to how the mature RISAs evolved as institutions, and of the consideration given to organizational design and management.

Perhaps the most apparent gap in the ability of the RISA programs to effectively reconcile the supply of and demand for science is that of evaluation. Only a few of the RISAs employ formal evaluations of programs and services, although some do utilize more informal, ad-hoc approaches and have gleaned valuable stakeholder feedback. Even more apparent through the course of the workshop was how little we actually know regarding the formal decision-making process regarding how RISAs set their research agendas, and whether such decisions are effective in terms of desired outcomes.

Additionally, one overarching questions remains, that is, what constitutes useful information? And, how do stakeholders utilize information? As with so many other characteristics of the RISAs, the evaluation approaches vary and indeed some RISAs have undertaken more formal surveys. However, what is needed at this juncture in the RISA history is a more systematic and comprehensive evaluation of both programs and services, and of science policy decision making.

B. Learning from the RISAs: Lessons for Climate Science Policy

The various RISA programs provide considerable evidence that the human dimensions research community has both strong theoretical and practical understandings of how to conduct research that results in the production of information considered to be useful by stakeholders. While it is clear that substantial climate science data has been produced, and has been placed in what can be thought of as a reservoir of knowledge, much of this information is not policy-relevant or useful in its present form. RISAs provide valuable services in conducting additional research and give consideration as to how best to package, present, and disseminate such information. Indeed, the RISA experience provides numerous practical lessons about how to produce useful climate science information, thus responding to the call by the US Congress and others to provide policy-relevant information for decision makers. Such lessons from the RISA programs could help expand options and choices regarding how to do climate research, and thus inform climate science policy. According to anecdotal data from RISA participants, it appears that the lessons learned from the RISA experience are not informing science policy decisions at NOAA or elsewhere. One proxy for this metric is the climate science budget that allocates just a fraction of a percent to efforts engaged in the production and dissemination of policy-relevant information. This fact illustrates that RISAs, or the RISA approach more generally, have not yet become institutionalized within the climate research community. At present, however, there appears to be only minimal momentum toward this goal, but not for the lack of effort put forth by RISA programs and its supporters in the climate science community.

V. Summary and Next steps

The RISA program experience provides valuable lessons for the larger climate science policy community. First and foremost, effective production of useful information for decision makers is about process, and several aspects of this emerged from the RISA workshop. First, early, iterative, sustained and two-way communication is essential for reconciling supply and demand of scientific information. Second, good relationships, that is, ones based on trust, reciprocity and respect - both intra-RISA and with stakeholders - is necessary to build healthy and collaborative dynamics. Third, producing good and useful information is about understanding the full scope of the problem and thus context. To identify such characteristics, RISAS must actively engage stakeholders, thus good communication and healthy relationships are necessary. Fourth, effective process must also be dynamic, resilient, and adaptive to challenges, events and opportunities. Fifth, producing useful information inevitably involves trade-offs and attempts to balance various tensions, for example, the production of knowledge vs. provision of services; public vs. private interests; public-oriented vs. peer-reviewed products; breadth of research vs. depth; demands of parent program vs. needs of stakeholder community, etc. Sixth, RISAs utilize a variety of approaches to engage with stakeholders, suggesting that there is no single 'best approach' for this kind of work. Seventh, despite the compelling evidence of RISA program success in producing policy-relevant information, these experiences have had little impact on climate science policy, yet there appears to be no easy answer as how to do so. Finally, an important next step for the RISA program is to become institutionalized within the broader climate science community.

Lessons from the RISA experience also raise further questions:

- Several different approaches exist for reconciling supply and demand, yet we know little about their relative strengths and weaknesses. What approaches work best under what conditions?
- The RISA programs explored here suggest two primary approaches to knowledge production and dissemination: do it yourself or be a broker of information. Both approaches appear to be effective, but this begs the question: what are the comparative advantages and disadvantages of each?
- Climate science policy, or the setting of climate science research agendas, is about making decisions. Yet, we know very little about the formal decision processes utilized in the RISA program for setting such agendas. How do RISAs decide what research agenda to adopt? What research to disseminate?, etc.
- Is the RISA research agenda effective and how do we know if it is?
- RISAs exhibited a wide variety of approaches to setting and implementing strategy and organizational management. What strategies do RISAs utilize to run effective organizations?
- RISA operations are often about balancing tradeoffs and tensions. How do RISAs manage these tensions and make decisions about tradeoffs?
- How can the success of the RISA program better inform science policy decisions at NOAA or at within the USGCRP?

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Background: Our NSF SPARC Project

In 2004 we received funding from the National Science Foundation for a project titled "Science Policy Research and Assessment on Climate" or SPARC. One component of this project is an effort focused on understanding and assessing mechanisms/institutions that oversee the interconnections of the supply of and demand for research. Our research acknowledges is motivated by a simple fact: there is both a supply side and a demand side for scientific information relevant to decision making. This acknowledgement suggests a hypothesis that is strongly supported by results from our prior research, as well as the work and experience of many others: The capacity of scientific research to support decision making is greatly enhanced when the supply side (i.e., researchers) and demand side (i.e., decision makers) understand each other's capabilities, needs, and limits.

We are consciously using the terms "supply" and "demand" because in the economic marketplace, supply and demand are effectively linked, modulated, and optimized through many mechanisms. If there is no demand for a product, companies will not produce it (or, at least, not for long)—or perhaps they will advertise aggressively to create a demand. Producers are constantly monitoring, assessing, and responding to consumer preferences so that they can enhance sales and profits. Competition between producers of similar products (e.g., different brands of CD players or pain killers), or dissimilar products that fill similar needs (e.g., CD vs. cassette players; aspirin vs. ultrasound) leads to constant evolution of both consumer preferences and producer outputs. In the high technology sector, a considerable amount of incremental innovation comes in response to specific input from consumers. Overall, a key attribute of this coevolution of supply and demand is communication: producers are constantly striving to understand, influence, and respond to the preferences of consumers; consumers are constantly making choices among options in response to their own preferences, knowledge, and experiences.

Over the past several decades, scientific information has come increasingly to play a role in decision making at every scale from the individual (e.g., a person trying to understand if recycling provides an environmental benefit) and the very local (e.g., a mayor deciding whether to order an evacuation prior to a hurricane) to the global (e.g., governments negotiating climate change agreements). Here, there is a supply side and a demand side too, but formal or informal feedbacks to enhance mechanisms to ensure compatibility between the supply of scientific information and the demands of decision makers are often lacking. In the absence of such mechanisms, there are important factors at play which militate against alignment of supply and demand, factors that reflect intrinsic differences between research and policy making. For example, from the scientific (supply) perspective, the types of questions and problems that scientists are able to address or are interested in addressing are not necessarily those that decision makers need to have answered. And from the policy perspective, most important policy dilemmas are almost always underlain by value disputes that science cannot resolve.

Science policy scholar Harvey Brooks aptly characterized the inter-relationships of supply of and demand for scientific information:

> "If the process of using science for social purposes is though of as one of optimally matching scientific opportunity with social need, then the total evaluation process must embody both aspects in an appropriate mix. Experts are generally best qualified to asses the opportunity for scientific progress, while broadly representative laymen in close consultation with experts may be best qualified to assess societal need. The optimal balance between opportunity and need can only be arrived at through a highly interactive, mutual education process involving both dimensions."[1]

Yet policy research increasingly documents that compatibility of scientific supply and decision maker demand can be increased through mechanisms that enhance knowledge of, and communication between, the supply and demand sectors. When scientists and decision makers understand each other's capabilities, needs, and limits, research agendas

[1] Brooks, Harvey, The Evolution of U.S. Science Policy, in B. Smith and C. Barfield (eds.), Technology, R&D, and the Economy, Washington, DC: Brookings Institution, 1995, p. 33.

can be better designed to support decision making, and decisions can be more successfully rooted take advantage of scientifically robust information.

Our Focus is on the RISA's as a Place to Learn

We are focusing on the RISAs as a body of experience that offers the promise of learning about successes of and obstacles to reconciling the scientific supply of and demand for science. We are not interested in evaluating the RISAs with respect to their NOAA missions. We are happy to leave that to the RISA program managers. But we do think that the RISAs can teach us, OGP, NOAA and the CCSP and beyond something about the challenges at the two-way interface of the complex relationship between decision making about science and decision making about climate. The RISA program explicitly seeks to work at the boundary of science and decision making[2].

> "RISA projects point the way toward a new paradigm of 'stakeholder- driven' climate sciences that directly address society's needs and concerns."
>
> "What makes science useful and usable for the public? Much work has gone into answering this question, and the RISAs have been at the forefront of the effort. RISA researchers place strong emphasis on working directly with people who have an investment—a "stake"—in activities, resources, or property that may be vulnerable to climatic impacts. These stakeholders hold the key to scientists' understanding of what kinds of climate information can aid the public in coping with climate variability, and how to provide this information in forms that people can actually use."

A 2004 NRC Report that looked at experience in seasonal climate forecasting found this area to be rich for understanding connections of science and decision making,

> "…crucial to the success of such systems is that they incorporate user-driven definition and framing of the problem to be addressed. "User-driven" is used here to mean that the agendas of analysts, forecasters, scientists, and other researchers are at least to some degree set by the potential users of forecasts. The process of collaborative problem definition would be user driven, but reflect input from the scientific (producer) community on what is feasible."[3]

In April, 2002, the House Science Committee held a hearing to explore the connections of climate science and the needs of decision makers. The hearing charter included the following question: "Are our climate research efforts focused on the right questions?"[4] And by "right questions" the Committee clearly meant questions whose answers are likely to lead to useful information to decision makers.

The Science Committee's hearing highlighted the role of the NOAA Regional Integrated Sciences and Assessments (RISA) as a promising means to connect decision making needs with the research prioritization process:

> "One approach to producing policy-relevant information is the regional assessment model, developed within NOAA and other agencies, that attempts to build a regional-scale picture of the interaction between climate change and the local environment from the ground up. By funding research on climate and environmental science focused on a particular region, [the RISA] program currently supports interdisciplinary research on climate-sensitive issues in five selected regions around the country. Each region has its own distinct set of vulnerabilities to climate change, e.g., water supply, fisheries, agriculture, etc., and RISA's research is focused on questions specific to each region. The regional assessments are developed in consultation with local stakeholders such as resource managers, farmers, and emergency responders. RISA has been called a step in the right direction by some, although the program is small (approximately $4 million in FY 2003), while others view it as a model that could guide some of the larger efforts within USGCRP."

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[2] From the 2005 RISA Brochure

[3] NRC Seasonal Climate Lessons Workshop Report

[4] http://www.house.gov/science/hearings/full02/apr17/full_charter_041702.htm

The RISA program is now 10 years old and has developed a significant body of experience in working to establish a positive feedback between decision makers and interdisciplinary science and assessment.[5] This experience provides a rich resource for drawing lessons from the various RISA projects on how science priorities might be set, research implemented, and the resulting output transferred to operational agencies in support of the needs of decision makers.

Our workshop, to be held 15-17 August 2005, hosted by the Hawaii and Pacific Islands RISA in Honolulu, HI, that will bring together ~40 participants, including representatives from each of the RISA teams, to address the questions such as the following:

- How are stakeholders' needs reflected in the research prioritization process?
- How are stakeholders' needs assessed and evaluated?
- How does each RISA prioritize areas of research and assessment to which to it devotes its resources?
- How does each RISA evaluate its resource allocation decisions?

Participants will come from each of the NOAA RISA projects, the SPARC team, as well as others with expertise in science policy and climate.

The overarching goal of the workshop is to distill from the RISA projects those understanding of processes, institutions and other conditions that facilitate making decisions about climate science research priorities that lead to useful information for decision makers. We will evaluate the extent to which climate science policy in the RISAs can serve as "a model that could guide some of the larger efforts within USGCRP."

In addition to the workshop itself, products will include a report and preparation of at least one article for submission to a peer-reviewed journal.

[5] http://www.risa.ogp.noaa.gov/index.html

The Neglected Heart of Science Policy: Reconciling Supply of and Demand for Science

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Most scientific research, whether funded by public or private moneys, is intended to support, advance, or achieve a goal that is extrinsic to science itself. While some research is not expected by anyone to have a result other than the advance of scientific knowledge, such work is an extremely small portion of the overall science portfolio. Funding for research generally considered to be "basic" by those who perform it is usually justified by the expectation that the results will contribute to a particular desired outcome. For example, much of the research supported by the U.S. National Institutes of Health (NIH) is considered "basic" by medical researchers, in that it explores fundamental phenomena of human biology, but robust public support for NIH is explicitly tied to the expectation (and legislative mandate) that research results should end up improving human health.

In pursuing a particular societal goal or set of goals, how do we know if a given research portfolio is more potentially effective than another portfolio? This question would seem to lie at the heart of science policy, yet it is almost never asked, much less studied systematically. Given the complexity of the science enterprise, of the processes of resource allocation, knowledge creation, and knowledge application, it would be very surprising indeed if the organization of the existing enterprise was in any way close to "optimal" in terms of its capacity to advance desired outcomes. Of course to some extent the very notion of an optimally organized research portfolio is nothing more than an abstraction, and perhaps an incoherent one at that, because recognizing optimality would demand not only complete agreement about what social outcomes are desired, but also comprehensive prior understanding of what lines of research would have to be pursued, in what institutional settings, with what results, and how the results of that research would actually be used.

On the other hand, the lack of such comprehensive understanding is not an obstacle to recognizing conditions under which the organization of research is more or less likely to support desired ends. Some research portfolios are clearly better than others from the standpoint of the potential to contribute to societal goals. For example, it is broadly accepted that current global priorities in biomedical research are very poorly aligned with global health priorities, a problem commonly termed the "10/90 problem," in reference to the observation that only about 10 percent of the global biomedical research budget is allocated to diseases accounting for about 90 percent of the worlds' health problems (ref, GFHR).

This sort of analysis is incomplete, of course. A major commitment to AIDS research starting in the late 1980s led in fairly short time to antiretroviral drugs that are, thus far, quite effective in the treatment of AIDS sufferers. Yet 90 percent of AIDS sufferers have no reasonable prospect of ever receiving this treatment, largely because they (or the societies in which they live) cannot afford it. The potential for science to contribute to societal goals depends critically on factors well beyond science. So just "doing research" on an issue of societal importance says nothing directly about whether or under what conditions that research can effectively contribute to addressing that issue (Sarewitz et al, 2004; Bozeman and Sarewitz, 2005).

Moreover, doing research still begs the question: "what research?" Looking again at biomedicine, the question of how much emphasis should be placed on exploring the molecular genetic origins of disease, versus environmental, behavior, nutritional, cultural, and other origins, is strongly debated. [cite malaria papers in Science] Similar tensions flare up in debates over the appropriate balance between treatment (e.g., drugs) and prevention (e.g., vaccinations). Genetics and treatment often win out, not necessarily because they are always the best routes to advancing human health, but because they lie at the confluence of advanced technology, high prestige science, market incentives, and even ideology (e.g., genetic determinism; Lewontin, 19xx).

The point is that given how little attention is paid to understanding the relationship between alternative possible research portfolios and stipulated societal outcomes, there is no a priori reason to expect that existing research portfolios aimed at a given social goal necessarily are more effective than other possible research portfolios. This being the case, the key question—the neglected heart of science policy—is how one might approach the problem of rigorously assessing the relationship between a research portfolio (or a set of alternative portfolios) and its potential societal outcomes.

Some would argue that this problem simply cannot be usefully approached. The connections between research and societal outcomes cannot be accurately predicted in detail, therefore, the argument would go, predicting the differing outcomes of an array of hypothetical or counterfactual research portfolios is not feasible. Obviously, we think such arguments (which are common in science policy debates) are wrong-headed and wrong. Wrong-headed because science policy decisions are constantly being justified on the basis of putative linkages between research investments and desired outcomes. If such justifications cannot be supported analytically or logically, then they should not be asserted in the first place. Wrong because contingency, complexity and non-linearity (i.e., in the relations between science policy decisions and societal outcomes) are obstacles to accurate predictions, but they do not prevent improved decision making (various refs—Lasswell, Lindblom, etc.), where "improved" means more likely to achieve desired outcomes.

Our approach in this paper is to conceptualize "science" in terms of a "supply" of knowledge and information, and "societal outcomes" in terms of a "demand" function that seeks to apply knowledge and information to achieve specific societal goals. In the next section we develop this conceptualization, drawing briefly from many areas of science policy scholarship. The core of our argument is that "better" science portfolios (that is, portfolios viewed as more likely to advance desired societal outcomes, however defined) would be achieved if they were informed by knowledge about the supply of science, the demand for science, and the relationship between the two. We will provide a general method for pursuing such knowledge, using the specific example of climate change science to illustrate how research on science policy could be organized to support improved decisions about the organization of science itself.

Understanding and Mediating the Supply of and Demand for Science in Science Policy

We borrow from economics the concepts of "supply" and "demand" to discuss the relationship of scientific results and their use for several reasons (cf. Broad, Darymple). First, the analogy is straightforward. Decisions about science (i.e., science policy decisions) determine the composition and size of research portfolios which "supply" scientific results. People in various institutional and social settings who look to scientific information as an input to their decisions constitute a "demand" function for scientific results. Of course, the demand function can be complicated by many factors, e.g., sometimes a decision maker may not be aware of the existence of useful information or may misuse potentially useful information. But there is reasonable conceptual clarity between people, institutions, and processes concerned with the supply of science, and those concerned with its use. Indeed, conventional notions of science policy exclusively embody the former.

Nonetheless, a second reason for characterizing scientific research in terms of supply and demand is to recognize that, just as in economics, in the case of science supply and demand are closely interrelated. Science policy decisions are not made in a vacuum but with some consideration or promise of societal needs and priorities. Thus there is a feedback between the (perceived) demand for science and the (perceived) characteristics of supply. People with spinal cord injuries or type II diabetes, influenced by the rhetoric of scientists studying embryonic stem cells, in turn create an enhanced demand for such research. However, whether embryonic stem cell research is itself the "right" path to achieving the desired goals (in this case, presumably cures for the injuries or diseases) is not necessarily apparent. Numerous alternative paths may be available (Garfinkel et al., in press).

Some think the right science is, by definition, being done, so long as scientists are freely pursuing knowledge with minimal external interference. This position, most rigorously espoused by Michael Polanyi (1962), views the scientific community as an autonomous, self-regulating market organized to identify and pursue the most efficient lines of knowledge generation. Any "attempt at guiding scientific research toward a purpose other than its own is an attempt to deflect it from the advancement of science" (p. 62). From this perspective, the supply of scientific knowledge is best generated without any connection or attention to demand for particular types of knowledge.

The apparent logical and practical weakness of this perspective—that knowledge, efficiently pursued, may or may not be knowledge that has any utility in the world—has been answered in two ways. First, basic knowledge is conceived as accumulating in a metaphorical reservoir from which society can draw to solve its multifarious problems. The reservoir is filled most rapidly and effectively through the advance of science independent of considerations of application. Second, application of basic knowledge to real world problems is often serendipitous, so there is no way to predict the connection between a given line of research and a given social goal. Chemistry (or, one supposes, solid earth geophysics or cosmology) is as likely to help cure a certain disease as is molecular genetics. Numerous anecdotes are offered up to illustrate the significance of serendipity in connecting inquiry to utility (ref anecdote in FOI).

Of course no one really advocates this model in its extreme form. Certainly, if the time scale is long enough (decades and beyond), fundamental advances in knowledge may have broad application beyond anything that could be anticipated, but on the time scales that motivate support for research, strategic investments in basic understanding are invariably conceived in the context of related areas of potential application. This reality has given rise to a weaker version of the science-as-a-self-regulating-market argument, where the need to make strategic investment choices among disciplines and research topics is tacitly acknowledged, but scientists and science advocates still argue that they are best positioned to contribute to social goals if they are given autonomy to pursue knowledge in directions guided by the logic of nature, not the exigencies of social need ("Press report;" cf., Pielke and Byerly 1998).

The idea that the creation of scientific knowledge is a process largely independent from the application of that knowledge within society has had enormous political value for scientists, because it allows them to make the dual claims that a) fundamental research divorced from any consideration of application is the most important type of research (ref: Weinberg, axiology of science) and b) that such research can best contribute to society if it is insulated from such practical considerations, thus ensuring putative freedom of inquiry, but also political control over public resources devoted to science. The continued influence of this perspective was recently asserted by Alan Lesnher (2005), Chief Executive Office of the American Association for the Advancement of Science, "… historically science and technology have changed society, society now is likely to want to change science and technology, or at least to help shape their course. For many scientists, any such overlay of values on the conduct of science is anathema to our core principles and our historic success."

Empirical studies of the complex connections between research and societal application give little support to the foregoing conceptions. One of the richest areas of scholarship in this domain has focused on the origins of technological innovation, where case studies and longitudinal surveys have revealed networks of continual feedbacks among a large variety of actors, including academic scientists, industrial scientists, research administrators, corporate executives, policy makers, and consumers. The resulting picture is complex and yields no single, straightforward model for how knowledge and application interact; yet one feature that invariably characterizes successful innovation is ongoing communication between the producers and users of knowledge. Moreover, historical studies of innovation typically show precisely the opposite of what one would expect from the autonomous science argument. Emerging technological frontiers typically precede deep knowledge of the underlying fundamental science. It is precisely the demand for better theoretical foundations among those worried about applications that has driven the growth of fundamental science in many areas (e.g., Rosenberg, 1982).

As economist Richard Nelson (unpublished ms ?now published?) writes: "for the most part science is valuable as an input to technological change these days because much of scientific research is in fields that are oriented to providing knowledge that is of use in particular areas."

If this seems spectacularly circular, then that is precisely the point: science agendas are closely aligned with areas of application because certain areas of science demonstrate themselves to be of particular value to some groups of users. This is a very different view of the world than one in which science advances independently of subsequent applications. Research on the relations between industry and universities, for example, strongly demonstrates that the priorities of so-called pure science have long been aligned with the needs of industry (e.g., Crow and Tucker; Mowery and Rosenberg, etc.). Such alignment is not a result of serendipity, but of the development of networks that allow close and ongoing communication among the multiple sectors involved in technological innovation. Thus, fundamental research relevant to innovation does indeed go on in universities where scientists have considerable autonomy to pursue basic knowledge, but the priorities and directions of this fundamental work are strongly influenced by collaboration with scientists, engineers, and managers working closer to the actual point of product development and application (and they, in turn, are influenced by a variety of end-users or consumers). In the useful term introduced by Donald Stokes (199x), this type of fundamental science is "use-inspired," and it is central to the successful functioning of modern, high technology economies. More generally, the generation of knowledge in the broader context of applications has been termed Mode 2 science by Gibbons et al (1994), to distinguish it from the traditional insistence on "pure" science as the ultimate source of social value.

Two attributes of this discussion bear emphasis. The first is that, in contrast to the canonical portrayal of fundamental science contributing to application because it is free to advance in isolation from consideration of application, studies of technological innovation have often shown exactly the opposite—that it is the awareness of potential application and utility that ensure the contribution of fundamental research to innovation. Second, in contrast to the portrayal of scientific advance as something that is unpredictable and therefore beyond planning or control through influences beyond the scientific enterprise, the history of post World War II science and technology policy is one of successful strategic decisions about investments in particular areas of science and engineering in support of specific areas of societal application, such as communications, computing, advanced materials, aviation and avionics, weapons systems, and biotechnology. From the creation of agricultural research stations in the mid 19th century, to the advent of the transistor shortly after World War II, to the continued advance of human biotechnologies today, strategic decisions to focus public sector resources in particular areas of science have consciously and successfully linked research portfolios to technological advance and such societal outcomes as economic growth, agricultural productivity, and military power.

Such outcomes are themselves highly complex, of course. In the past several decades, other lines of scholarship (e.g., Handbook of STS) have recognized that the more detailed societal consequences of scientific and technological advance also bear clear evidence of a dynamic relationship between the producers and users of knowledge and innovation, and that this relationship itself is strongly conditioned by broader contextual factors.

For example, the natural, cultural, and political attributes of the United States in the 19th century gave rise to an organization of agricultural science closely tied to the practice of farming and the needs of farmers (and strongly resisted, at first, by scientists seeking to preserve their autonomy), including the development of institutional innovations—the agricultural research station and extension services—to bring supply and demand sides together (e.g., C. Rosenberg; Cash). The inextricable linkages between science, technology, and the geopolitics of the Cold War drove the institutional symbiosis of universities, corporations, and the military that dominated the demand-supply relation in U.S. science for half a century and motivated President Eisenhower's famous warning about the overweening power of the "industrial-military complex" (ref and expand quote?) Feminism and the growing political power of the women's movement in the U.S. eventually led to an understanding that a health research system run by males was often biased toward males in its priorities, practices, and results. Such insights, which were at the time controversial but are now widely accepted, led to significant changes both in the conduct of science and its application in ways that benefit women. (refs) Similarly, the political empowerment arising from the gay rights movement in the U.S. ultimately influenced the course of AIDS research in ways that directly benefited AIDS sufferers in the U.S., for example through more rapid clinical testing and approval of treatments (Epstein). Based on these successes, "disease lobbies" in the U.S. have become a significant factor in determining biomedical research priorities.

Such examples illustrate that the supply of science is often responsive to the presence of a well articulated demand function. Put somewhat more bluntly, scientific research priorities trajectories are often decisively influenced through the application of political pressure by groups with a stake in the outcomes of research. Obviously, this does not mean that science can produce whatever is asked of it. Moreover, groups lobbying for one type of research or another may or may not actually understand how best to advance their interests. For example, it might be the case that health care delivery reform or changes in behavior would return greater benefits to some disease lobbies than funding for a particular type of research.

More significantly, there is no reason to think that the influence of particular political interest groups (whether they be disease lobbies or pharmaceutical corporations) on the supply of science will yield outcomes that are broadly beneficial to society; they may, on the contrary, lead to the preferential capture of benefits by certain groups (Bozeman and

Sarewitz, 2005). For instance, the very fact that most health research is carried out in affluent societies and responds to the health needs of affluent people has resulted in an increasingly wide gap between science agendas and global health priorities. Scientific opportunities that are likely to yield the greatest return in terms of social benefit (e.g., through vaccine development) are widely neglected. Nonetheless, politics provides a key mechanism for mediating the relationship—for reconciling—supply of and demand for science.

The philosopher Philip Kitcher (2001) has identified an ideal, which he terms "well-ordered science," that describes an optimal relationship between supply and demand (though he does not articulate it using these terms), achieved through an ideal process of representative deliberation.

> For perfectly well-ordered science we require that there be institutions governing the practice of inquiry within society that invariably lead to investigations that coincide in three respects with the judgments of ideal deliberators, representatives of the distribution of [relevant] viewpoints within society. First, at the stage of agenda-setting, the assignment of resources to projects is exactly the one that would be chosen through the process of ideal deliberation . . . Second, in the pursuit of the investigations, the strategies adopted are those which are maximally efficient among the set that accords with the moral constraints the ideal deliberators would collectively choose. Third, in the translation of results of inquiry into applications, the policy followed is just the one that would be recommended by ideal deliberators . . ." [122-123]

Well-ordered science, like all ideals (democracy, justice, freedom), sets a standard that cannot be met but toward which aspirations can be aimed: science that is maximally responsive to the needs and values of those who may have a stake in the outcomes of the research; the complete reconciliation of supply and demand. This philosophical ideal adds a normative overlay to what has been demonstrated empirically. Not only are the supply of and demand for science related to each other through a process of politically mediated feedbacks, but in a democracy it is desirable that this feedback process be maximally responsive to the negotiated common interests of relevant stakeholders, rather than captured by particular special interests. Indeed, as Kitcher (2003, p. 218) asserts: "The current neglect of the interests of a vast number of people represents a severe departure from well-ordered science."

Kitcher's notion of "well-ordered science" is procedural; it describes a well-informed process of defining research agendas and practices that reflects the priorities and norms of relevant stakeholders (including, of course, scientists involved in the research). In the real world, intermediary institutions—sometimes called boundary organizations—may enhance the pursuit of well-ordered science by mediating communication between supply and demand functions for particular areas of societal concern (refs., see McNie for a comprehensive review). Again, this is not a matter of asking scientists to "cure cancer" or "end war," it is a process of reconciling the capabilities and aspirations of knowledge producers and knowledge users.

Even if the procedural ideal were achieved, it would not guarantee the achievement of a particular stipulated social outcome. Many of the goals of science—curing a given disease, for example—may be difficult to attain for a variety of reasons, ranging from intrinsic scientific difficulty to cultural or institutional complexities. But the key point is that departures from well-ordered science are inherently *less* likely to achieve such outcomes, because research agendas will not reflect the priorities, needs and capabilities of the broadest group of constituents that could potentially make use of the resulting knowledge and innovation.

Supply of and Demand for Science in Decision Making

Our discussion so far has aimed at building a conceptual foundation for assessing the relations between supply of and demand for science as input to science policy decisions. We have shown: 1) that the notion of supply and demand functions for science helps to clarify the dynamic role of science in society; 2) that supply of and demand for science are reconciled in various ways, with various degrees of success (depending in part on who defines "success"), and 3) an ideal reconciliation of supply and demand would match the capabilities of science with the needs of those who could most benefit from it. We now address what logically ought to be the most obvious—and tractable—problem of supply-demand relations in science: the use of science to support decision making in public affairs.

With the end of the Cold War, science has increasingly been called upon to provide information that can improve decision making in public affairs (Ehlers report, Millennium Development S&T report). This relatively new role for science in part reflects the increasing capacity of scientific methods and tools to study complex systems ranging from genes to climate. But it also reflects the rapidity of societal evolution that results from the increasing power and global reach of science and technology. That is, science is called upon as a tool to monitor and assess the changes that science itself helps to induce (see Beck, 1992). The expectation that science can help inform human decisions about societal change has been especially strong in the area of the environment, and we focus on discussion on the problem of climate change.

Research on decision making has long recognized that there is no simple connection between "more information" and "better decisions" (e.g., March and Feldman; Clark and Majone, Sarewitz et al.), and that, to the extent "more information" does not solve a problem, the fault cannot simply be located with the decision maker (i.e., in the demand function). More information may not lead to better decisions for many reasons, e.g., the information is not relevant to user needs; it is not appropriate for the decision context; it is not sufficiently reliable or trusted; it is unavailable at the time it would be useful; it is poorly communicated. Also, of course, the idea of "better decisions" depends on who stands to benefit from which decisions. Some types of information may support decisions that benefit some people but adversely affect others.

Apparently commonsensical ideas, for example, that climate forecasts would be valuable to people who make decisions related to climate behavior (e.g., water managers, emergency managers, agricultural planners) turn out to be very complex, as such factors as institutional structures, prior practice, socioeconomic conditions, and political stakes, strongly influence the types of information that decision makers need and use, and the array of stakeholders that might benefit from such decisions (e.g., Rayner et al; Broad; NRC; Lemos; Lahsen in review, etc.)

Scholars striving to understand the behavior of scientific information in complex decision contexts (especially those related to the environment and sustainability) have converged on the recognition that the utility of information depends on the dynamics of the decision context and its broader social setting (e.g., Jasanoff and Wynne, 19xx; Pielke et al., 2000). Utility is not immanent in the knowledge itself. For example, Michael Gibbons (1999) describes the transition from a gold standard of "reliable" knowledge as determined by scientists themselves, to "socially robust" knowledge that "is valid not only inside but also outside the laboratory. Second, this validity is achieved through involving an extended group of experts, including lay 'experts'. And third, because 'society' has participated in its genesis, such knowledge is less likely to be contested than that which is merely reliable." (p. C82).

Arriving at a similar set of insights, Cash and others (2003) have shown that information capable of improving decisions about the management of complex environmental systems must have the three attributes of credibility, salience, and legitimacy, attributes which can only emerge from close and continual interactions among knowledge producers and users. Pielke and others (2000) similarly recognized that effective integration of science and decision making required a tight coupling among research, communication, and use. Guston (1999) pointed to the value of boundary organizations at the interface between science and decision making for helping to ensure that such integration can occur. Funtowicz and Ravetz (199x) coined the term "post-normal science" to describe the complex organization of knowledge production necessary to address problems of decision making, in contrast to older notions of autonomous—"normal"—scientific practice.

Despite these conceptual advances—derived, in part, from studying relative successes in such areas as international agricultural research and weather forecasting—the overall picture is neither clear nor encouraging. While the rich world spends billions annually on research aimed at supporting environmental policy, there is not much evidence that significantly enhanced decision making capabilities or environmental outcomes have resulted (Cash et al, 2003; Lee, 1993; ds 2004; Millennium ecosystem report?). To suggest that "politics" has prevented progress on such issues is merely to restate the problem. Indeed, the recent spate of media and public attention focused on the problem of the "politicization of science" (e.g., UCS report; Hoover Inst. book) reflects the persistent notion that the contribution of science to decisions is mostly a process of delivering facts to users, and that failure to attend to facts reflects problems in the demand function (i.e,. "politics"). This debate is oblivious to the sorts of insights summarized above, which teach us that science is always politicized, and that the real-world challenge is to ensure an inclusive and non-pathological process of politicization (Sarewitz 2004; Pielke, in prep) leading to an appropriate reconciliation of supply of and demand for information or knowledge.

While there are many complex reasons why it is difficult to generate "socially robust knowledge," scholarly attention has focused principally on the dynamics of interactions between knowledge producers and decision makers, and on the need for institutional innovation to enhance such interactions, as briefly summarized above. Very little consideration has been given, however, to science policy—that is, to the decision processes that strongly determine the priorities, institutional settings, and metrics of success for the supply of scientific research (Marburger 2005). Correspondingly, very little consideration has been given to the types of information or knowledge that science policy decision makers could use to improve the reconciliation of supply and demand.

The neglect of science policy is problematic because science policy decisions, especially at the macro level, are likely to be made by people, and in institutions, that are distant from the interface between research and its use. Indeed, the complex interactions among knowledge producers, knowledge users, and intermediaries that characterize post-normal science often takes place within a context of scientific research agendas whose main characteristics have already been determined. This problem is particularly acute for large scale, long-term research efforts, such as global climate change science.

Origins of the Climate Change Supply Function

In 2003, seven national leaders in climate science wrote (in response to an article by the authors of this paper (Pielke and Sarewitz, 2003): "The basic driver in climate science, as in other areas of scientific research, is the pursuit of knowledge and understanding. Furthermore, the desire of climate scientists to reduce uncertainties does not . . . arise primarily from the view that such reductions will be of direct benefit to policy makers. Rather, the quantification of uncertainties over time is important because it measures our level of understanding and the progress made in advancing that understanding" (Wigley et al, 2003). This argument restates the traditional logic for public support of science, discussed at the beginning of our paper: that the exploration of nature, motivated by the desire for understanding, is the best route to beneficial social outcomes. It is consistent with (though more extreme than) the original rationale for the U.S. Global Change Research Program (USGCRP), under whose aegis more than $25 billion were spent on climate research between 1989 and 2003. While the USGCRP was intended by policy makers to provide "useable knowledge" for decision makers, its structure and internal logic reflected the belief that the best route to such useable knowledge was via research motivated predominantly by a desire to expand fundamental understanding. The USGCRP was also motivated by the belief that decision making would be improved simply by providing additional scientific information (with a particular focus on predictive models) to those making decisions (Pielke, 1995; 1999a; 1999b).

To the extent that the USGCRP's science priorities were responsive to a particular decision context, this context was the international assessment and negotiation process aimed at arriving at a global regime for stabilizing greenhouse gas emissions. To the extent that scientists and users of science were interacting, they were doing so mostly as part of the process of developing this regime. The key point here is that the science agenda (i.e., supply function) was linked to an extremely restricted expectation of what sorts of policies would be necessary to deal with climate change (i.e., global policies that governed greenhouse gas emissions), via intellectual primitive but politically powerful notions about how those policies would come about (i.e., through increased scientific knowledge about climate change). In this highly restricted, supply-dominated context, the Intergovernmental Panel on Climate Change (IPCC) issued reports throughout the 1990s and early 2000s, written by teams of scientists that assessed the state of expanding knowledge about climate, while the U.S. National Research Council (NRC) issued reports, written by teams of scientists that analyzed research needs and priorities in the context of pursuing a comprehensive understanding of climate behavior. These expert-driven, supply-focused processes were the controlling political influences on the evolution of the climate research agenda (Pielke 2005).

The fact that so many billions have been spend on climate research, not just in the U.S. but in other developed countries as well, in turn suggests that there is a demand function which is being served by this research (otherwise, why would policy makers keep spending the money?), although in fact very little is known about the structure and objectives of that demand function. To the extent that the IPCC can be viewed as a sort of boundary organization aimed at connecting the science to its use in society, then the demand function seems mostly to be embodied in the international process for negotiating and implementing climate treaties under the U.N. Framework Convention on Climate Change, especially the Kyoto Protocol. Politicians and policy makers in the U.S. have, over the years, justified their support of the USGCRP largely in terms of the need to have better information before making decisions about climate, where decisions about climate has generally meant decisions about emissions reductions.

Yet the problem of climate change implicates a much broader array of potential decision makers in the climate change arena than those with a stake in international negotiations (e.g., see Rayner and Malone, 19xx; Sarewitz and Pielke, 2000), and would include farmers and foresters, local emergency managers and city planners, public health officials, utility operators and regulators, and insurance companies, among many others. At the same time, the evolving agenda for climate research has been driven almost exclusively by scientific organizations such as the IPCC and the NRC. In 2003 an exhaustive strategic planning process aimed at refining the USGCRP was dominated by scientific voices plus civil society groups advocating action on the Kyoto Protocol, with little input from actual decision makers who influence, are influenced by, and must respond to, climate change and climate impacts. The resulting *Strategic Plan for the U.S. Climate Change Science Program* (2003) contains comprehensive recommendations for continuing and expanding climate research, but little information about the needs and capabilities of the potential users of that information (though the report does highlight the importance of such users).

Meanwhile, relatively sparse but consistent research conducted under the category of "human dimensions of climate change" (mostly focused on annual to interannual climate variability) has shown that available information on climate is in some cases not deemed useful by decision makers (e.g., NRC, Rayner, Miles), in other cases benefits particular users at the expense of others (e.g., Broad, Lemos), and in yet other cases is misused and contributes to undesired outcomes (e.g. Pielke, Broad), and in all cases depends for its value on the types of institutions that are making the decisions (Cash et al). Overall, however, the institutional structures and feedback processes that lead to increased understanding between supply and demand sectors in areas of research such as high technology innovation and biomedicine are largely absent from the climate research enterprise, especially in the United States. The *U.S. National Assessment of the Potential Consequences of Climate Variability and Change* (2001) did encompass a series of regional meetings involving, with various degrees of success, certain stakeholders, but this process has not been institutionalized; rather, it culminated in a several reports whose purpose was "to synthesize, evaluate, and report on what we presently know about the potential consequences of climate variability and change for the US in the 21st century." The question of whether "what we presently know" is what we need to know to act effectively was not addressed.

Reconciling Supply and Demand in Climate Science: A Proposed Method

The insights derived from several decades of scholarship on the relationship between the production and use of knowledge in many domains of research and application suggest that the organization of climate science in the United States is unlikely to have evolved in a manner leading to a strong alignment between the supply of and demand for knowledge among a broad array of potential users and contributing to a broad array of desired societal outcomes. Adopting Kitcher's term, we here hypothesize that climate science is very far from being "well ordered." More importantly, we suggest both that this hypothesis is testable and that, given the scale of public investment and the potential environmental and socioeconomic stakes, the effectiveness of science policies could be greatly enhanced from testing it.

As long ago as 1992, a first (and, as far as we can know, last) step along these lines was taken in the *Joint Climate Project to Address Decision Maker's Uncertainty* (Bernabo 1992). The project sought to determine "what research can do to assist U.S. decision makers over the coming years and decades," it argued that "[a]n ongoing process of systematic communication between the decision making and the research communities is essential," and it concluded that "[t]he process started in this project can serve as a foundation and model for the necessary continued efforts to bridge the gap between science and policy" (86). Those continued efforts did not occur.

More than a decade later, the scale of the climate research enterprise has increased enormously, along with fundamental understanding of the climate system. At the same time we observe that there is little if any evidence that this growth of understanding can be connected to meaningful progress toward slowing the negative impacts of climate on society and the environment[1]. On the other hand, appreciation of the variety of decision makers and complexity of decision contexts relevant to climate change has greatly deepened. Understanding of this diversity should allow us to ask: what types of knowledge might contribute to decision making that could improve the societal value of climate science? Next, we outline a methodology of science policy research for assessing and reconciling the supply and demand functions for climate science information.

A. <u>Demand Side Assessment</u>. Research on the human dimensions of climate, though modestly funded over the past decade or so, has made important strides in characterizing the diverse users of climate information, be they local fisherman and farmers or national political leaders; on the mechanisms for distributing climate information; and on the impacts of climate information on users and their institutions. This literature provides the necessary foundations for constructing a general classification of user types, capabilities, attributes, and information sources. This classification can then be tested and refined, using standard techniques such as case studies, facilitated workshops, surveys and focus groups. Given the breadth of potentially relevant stakeholders, such a demand side assessment would need to proceed by focusing on particular challenges or sectors, such as carbon cycle management, agriculture, ecosystems management, and hazard mitigation.

B. <u>Supply Side Assessment</u>. Perhaps surprisingly, the detailed characteristics of the supply side—the climate science community—are less well understood than those of the demand side. One reason for this of course is that over the past decade or so there has been some programmatic support for research on the users and uses of climate science, but no similar research on climate research itself. Potentially relevant climate science is conducted in diverse settings, including academic departments, autonomous research centers, government laboratories, and private sector laboratories, each of which is characterized by particular cultures, incentives, constraints, opportunities, and funding sources. Understanding the supply function demands a comprehensive picture of these types of institutions in terms that are analogous to knowledge of the demand side, looking at organizational, political, and cultural, as well as technical, capabilities. Such a picture should emerge from analysis of documents describing research activities of relevant organizations, from bibliometric and content analysis of research articles produced by these organizations, and from workshops, focus groups, and interviews. The result would be a taxonomy of suppliers, supply products, and research trajectories. As with the demand side assessment, the scale of the research enterprise suggests that this assessment process should build up a comprehensive picture by focusing sequentially on specific areas of research (such as carbon cycle science). This incremental approach also allows the assessment method to evolve and improve over time.

C. <u>Comparative Overlay</u>. Assessments of supply and demand sides of climate information can then form the basis of a straightforward evaluation of how climate science research opportunities and patterns of information production match up with demand side information needs, capabilities, and patterns of information use. In essence, the goal is to develop a classification, or "map," of the supply side and overlay it on a comparably scaled "map" of the demand side. A key issue in the analysis has to do with expectations and capabilities. Do climate decision makers have reasonable expectations of what the science

Information Being Produced?		Demand: Can User Benefit from Research?	
		YES	NO
	NO	Research agendas may be inappropriate.	Research agendas and user needs poorly matched.
	YES	Sophisticated users taking advantage of well-deployed research capabilities.	Unsophisticated users, institutional constraints, or other obstacles prevent information use.

[1] This is not the place to flesh out this argument, but see, e.g., [list various refs]. While some would regard the coming-into-force of the Kyoto Protocol as evidence of progress in this realm, no responsible scientific voices are claiming that Kyoto will have any discernible effect on negative climate impacts.

can deliver, and can they use available or potentially available information? Are scientists generating information that is appropriate to the institutional and policy contexts in which decision makers are acting? Useful classifications of supply and demand functions will pay particular attention to such questions. The results of this exercise should be tested and refined via stakeholder workshops and focus groups.

The 2x2 matrix shown here schematically illustrates the process. We call this the "missed opportunity" matrix because the upper left and lower right quadrants reflect where opportunities to connect science and decision making have been missed. Areas of positive reinforcement indicate effective resource allocation where sophisticated users are benefiting from relevant science. Areas of negative interference may indicate both opportunities and inefficiencies. For example, if an assessment of demand reveals that certain classes of users could benefit from a type of information that is currently not available, then this is an opportunity—if provision of the information is scientifically, technologically, and institutionally feasible. Another possibility would be that decision makers are simply not making use of existing information that could lead to improved decisions, as Callahan et al. (1999) documented for regional hydrological forecasts. Finally, research might not be well matched to the capabilities and needs of prospective users, as Rayner et al. (2002 NOAA rept) have shown.

D. Institutional Context for Climate Science Policy. As we have emphasized throughout this discussion, supply and demand must ultimately be reconciled via mediating processes and institutions—in this case, science policy institutions, such as relevant federal agencies, congressional committees, executive offices, non-governmental advisory groups, etc. Institutional attributes such as bureaucratic structure, budgeting, reporting requirements, and avenues of public input, combine with less tangible factors including the ideas and norms embedded within the institution, to drive decision making (e.g., Laird 2001, Schon and Rein 1994, Keohane et al. 1993, Wildavsky 1987, Kingdon 1984). How do managers justify their decisions? Are those justifications consistent with the decisions that they actually make? What ideas or values are perhaps implicit in the analyses and patterns of decisions that the institution exhibits? These sorts of questions can be addressed through analysis of internal and public documents, interviews, and public statements. We emphasis that it is the institutional analysis that provides the basis for identifying concrete alternatives for better reconciliation of supply and demand functions.

Our analysis of the evolution of the climate science enterprise in the U.S. indicates that policy assumptions and political dynamics have largely kept the supply function insulated from the demand function except in the area of international climate negotiations (various RP/DS refs). Some modest experiments, notably the RISA (Regional Integrated Sciences and Assessment) program of the National Oceanographic and Atmospheric Administration, have sought to connect scientists and research agendas to particular user needs at the local level, but these lie outside the mainstream of the climate science enterprise.

A research effort of the type sketched here can illuminate how well climate science supply and demand are aligned, highlight current successes and failures in climate science policy, identify future opportunities for investment, and reveal institutional avenues for, and obstacles to, moving forward. Consistent with our perspective throughout this paper, the value of the method will in great part depend on how receptive science policy makers are to learning from the results of such research. We are optimistic on this front for two reasons. First, the fundamental justification for the public investment in climate science is its value for decision making. This justification, repeated countless times in countless documents and public statements, is prima fascia evidence that climate science policy makers are committed to an enterprise that creates useful information. Second, and of equal importance, the very process of implementing the method we describe will begin to create communication, reflection, and learning among decision makers who govern the climate science enterprise, and various users and potential users of scientific information hitherto unconnected to the science policy arena. The result of this dynamic process will be an expansion of the decision options available to science policy makers, and thus an expansion of opportunities to make climate science more well-ordered. Undoubtedly, institutional innovation would need to be a part of this process as well, given the scale and scope of the climate science enterprise and the potential user community.

As a first step toward testing both this method (which should, of course, have broad applicability beyond climate change science) and the specific hypothesis that climate change science is far from well-ordered, we convened a workshop to consider supply of and demand for science related to the global carbon cycle. Carbon cycle science is a high priority area of focus in climate change science (ref), with annual public expenditures in the U.S. of about $xxx million. Research priorities have been established largely in the manner described above, with little engagement between supply and demand sides (Dilling, workshop paper). Nevertheless, the importance of carbon cycle science is explained in terms of its value for a variety of information users in industry, agriculture, government, and other sectors (Dilling et al, 2003).

Our workshop (for more information, go to: http://sciencepolicy.colorado.edu/carboncycle/workshop/.) brought together leading carbon cycle researchers, science policy decision makers, and users representing "carbon cycle management" decision contexts such as urban environmental planning, energy production, agriculture, and emissions trading. Perhaps not surprisingly, most users reported that they benefited little, if at all, from recent advances in carbon cycle science (the single exception being the user engaged in developing emissions trading schemes), and, importantly, that they would greatly welcome specific types of knowledge and information that could enhance their capacity to make effective "carbon management" decisions. The extent to which this poor reconciliation between supply and demand reflected the inability of users to take advantage of relevant available information, versus a failure to generate relevant information (i.e., lower right vs. upper left quadrants in the matrix, above), awaits further analysis and a more rigorous implementation of the method described above (guided by what we learned during the workshop). But the larger point is that this level of reconnaissance supports the hypothesis that the science is not well-ordered, as well as the prospect that a better reconciliation of supply and demand is both possible and desirable.

Conclusion: Enhancing Public Value in Public Science

In the public sector, science policy decision making is mostly about how to allocate marginal increases in funding among existing programs. Consideration of how alternative research portfolios might better achieve stipulated societal outcomes is not a regular part of science policy discourse or decision processes. There are several reasons for this, including:

1. The widespread belief that more science automatically translates into more social benefit;
2. The insulation of science policy decision processes from the contexts within which scientific knowledge is used;
3. The capture of science policy decision process by narrow political constituencies (drawn from either the supply or demand side);
4. The natural resistance of bureaucratic decision processes to changes inside the margins;
5. The absence of analytical frameworks and tools that can reveal connections among science policy decisions, the supply function for science, the demand function for science, and the effective pursuit of stipulated societal outcomes.

Much of our work (as well as that of a number of colleagues) in recent years has begun to consider how to develop such analytical frameworks and tools (various refs on PVM, RTTA, prediction, health outcomes, SA, etc.) This work is stimulated by the possibility that scientific priorities and societal needs are sub-optimally aligned in a number of critical areas. The challenge for scholarship, in our view, is a) to identify particular cases where the promises upon which scientific funding are predicated are not being effectively met, and, more importantly, b) to show that plausible alternative research portfolios might more effectively meet these promises.

In this paper we have outlined one way to conceptualize a desirable connection between science policy decisions, science, and social outcomes: via a reconciliation of the supply of and demand for science. We have offered a method for developing knowledge that could facilitate such a reconciliation, and an example—climate change research—where there are good reasons to believe that condition a), above, pertains, and that condition b), above, can be fulfilled. In doing so, our larger purpose is to challenge science policy researchers and science policy decision makers to seek ways to formalize and to make analytically tractable the neglected, researchable question that must lie at the heart of a meaningful science policy endeavor: how do we know if we are doing the right science?

RISA DOCUMENTS

CALIFORNIA APPLICATIONS PROGRAM

http://meteora.ucsd.edu/cap/

CAP response prepared primarily by
Randy Hanson (USGS), Dan Cayan (Scripps), and Kelly Redmond (WRCC/DRI)

Demand Side Assessment

- **Who are the major stakeholders for your RISA?**

  Major stakeholders for the California Application Program (CAP) include international, federal, state, county, and local agencies that provide regulatory, public safety, and resources to the public.

  A few examples:

  - Tony Westerling and Tim Brown are working with federal fire agencies (USDA Forest Service, BLM, National Park Service as well as State and local agencies).
  - Kosta Georgakakos and group are working with Army Corps of Engineers, US Bureau of Reclamation, National Weather Service, and the State of California Department of Water Resources, to develop a better forecast system (days to months lead times) for water resources management, and in particular reservoir management, in central and northern California.
  - Kelly Redmond is working with federal and state officials on methods for drought assessment and monitoring, within the state and for dealing with waters that cross state boundaries. He is also working with the California Energy Commission and other state agencies in an effort to develop and better disseminate climate information, and to improve climate monitoring for California and the surrounding region.
  - Alexander Gershunov is working with Mexican scientists to elucidate effects of climate variability and climate change as they affect water and other resources in Mexico and the US/Mexico border region.
  - Mike Dettinger is working with a collective of state and federal team members to provide science based guidance to the CALFED Bay-Delta program, a state/federal partnership to develop and implement a long-term comprehensive program to restore ecological health and improve water management in the San Francisco Bay and upstream Sacramento/San Joaquin delta region.
  - Randy Hanson is working with a group of water purveyors in the Ventura and Monterey Bay areas and with the state (California Department of Water Resources) in the Central Valley to develop ways of providing simulations and related forecasts of conjunctive ground-water/surface-water use needed for water-resource management and guidance for water transfers, sales and purchases.
  - Dan Cayan is working closely with the California Energy Commission in conducting a physical climate science program to explore potential impacts of climate change and variability in California. He is also working with a team of university and state scientists and public health officials to understand climate linkages to encephalitis and West Nile virus and the mosquito populations that transmit these diseases.

- **What processes are used to include stakeholders in the research planning process, the research implementation process, and the research reporting process?**

  In several cases an ongoing research interaction was already present. In others, new topics were selected such as vector-born diseases transmitted by Mosquitoes such as Wes Nile Virus and Encephalitis; Kawasaki disease that may be transmitted by an unknown infectious agent, and lilacs as a nation-wide precursor to global climate change. Much of current CAP work has sprung from stakeholders expressing an interest in a climate related issue, and seeking to contact or interact with those in the climate community. Another method has been the publicizing of results (e.g., Sierra Snowpack prospects with climate change) that have led stakeholders to identify themselves because of their intense interest in the implications. Other CAP projects have been the outgrowth of ongoing research that stakeholders are involved in to varying degrees where the stakeholder is interested in a more rigorous assessment of climate in their resource management issues.

Occasional briefings have been arranged for state agency personnel: both technical staff and mid and upper level policy makers. Also there have been a number of briefings to state legislators, through hearings, individual discussions, and at meetings or conferences, in both university and government venues.

- **How are stakeholder interactions evaluated?**

In this particular RISA project, there has not been so much a formal evaluation of interactions, but rather, through routine conversation and other feedback, a continual process of adjustment to needs and directions, expressed by both sides of the interaction.

One measure of stakeholder interest has been the degree of enthusiasm for engaging in mutual projects and for assisting with leveraging of additional funding, and for adoption of findings in policy and procedures. In this regard, the CAP project seems to have met with abundant success.

- **What has your RISA learned from the process of stakeholder interaction, and how have its decision processes changed as a result?**

All of the standard issues that have arisen in other RISAs have been present in this one, including the need for sustained long-term interactions, and the necessity of maintaining close contact. Also, responsiveness and outreach are qualities highly valued by the particular constituencies that CAP has chosen to address, many in the political arena or in the public eye, and this RISA has paid a lot of attention to this.

In California, CAP has been instrumental in raising the awareness of climate change and variability as issues of concern to the state, and can claim considerable responsibility for the high profile that climate now has in this state. These include likelihoods, magnitudes, impacts, uncertainty, and especially vulnerability. Another key factor is the credibility of the institution, a factor that is hard to overestimate, and that helps open doors and keep them open, with people who are difficult to reach. Finally a listing of links to resent newsworthy articles are also provided for stakeholders that want to keep abreast of the latest societal impacts of climate (http://meteora.ucsd.edu/cap/reading_room.html).

Wild Fires -- Wildfire suppression and management are expensive; over $1,000,000,000 is spent every year on suppression. Often influenced by local to regional climate, wildfire forecasts are plausible and of great economic benefit. Forecasts for 2004 were provided along with analysis of the relations between climate and wild fires throughout the Western United States.

Reservoir Operations -- demonstrating the utility of modern hydrologic forecasting and water resources management concepts and ideas are combined with climate information for the improved management of the Folsom Lake waters. The demonstration of the feasibility and utility of climate-hydrology forecasting and water resources management is accomplished by inter comparing retrospective studies results for current historical practices, as well as with operations adjusted with historical hydrology and hindcasts with GCMs.

Water Resources Management -- The potential impacts of Global warming on California's water resources were addressed through the simulation of changes in snow pack. Under warmed conditions these simulations depict a severe loss of snow as indicated by changes in the snow water equivalent (SWE). By 2030, under the "business-as-usual" scenario, temperature is projected to rise about 0.6 degree Celsius, resulting in a minor decrease in April snow pack at lower elevations. However, by 2060 a temperature rise of 1.6 degree Celsius results in a loss of one-third of the total snow pack. This loss is focused in mid to lower elevations since the snow pack there is more sensitive to temperature changes than at higher, colder elevations. Regionally, this means that the northern Sierra and Cascades experience the greatest loss. These results indicate that potential global warming may result in a profound impact on a operation of reservoir systems in the Central Valley that were constructed to capture and distribute snow-melt runoff and less capable of managing additional non-snowmelt runoff.

Groundwater -- For example, for the ground-water analysis of future water availability in the Mojave River Basin was determined on the basis of climate variability cycles as opposed to indiscriminant use of historical hydrology. Similarly, the future water availability and potential effects of seawater intrusion and subsidence have been assessed for the Ventura area that incorporates climate variability.

Public Health -- In collaboration with several groups of outstanding doctors and scientists, CAP/CCCC are exploring how variations in our medium-range weather patterns to long-range climate patterns may play a role in the onset, frequency and longevity of human health problems. Vector borne diseases and Kawasaki Disease are two areas CAP/CCCC are currently researching. However, despite the existence of a state-wide surveillance system and the combined control efforts of 52 agencies with a combined budget of >$60,000,000, the activity of mosquito-borne encephalitis viruses has increased in California during the past decade. The incorporation of more recent climate models and climate data will enhance the surveillance system and related use of resources.

Different facets of the CAP project have had different reactions from stakeholders and some influence on stakeholder decision making. For example in Fire Prediction both short-term and interannual assessments are needed to help prepare for the redistribution of fire-protection resources. Similarly for Reservoir Operations the use of climate assessment by stakeholders can take on a wide spectrum of reaction that include considerations of power generation, flood control, and the sale of state and federal water For stakeholders involved with ground-water/surface-water resources, the managers are more prone to including climate data as part of their analysis of short-term decisions and are trying to align their longer-term decisions with recognized climate cycles such as ENSO and PDO. Overall, the interest in climate change (detectability, magnitude, impacts, etc) and it's relation to climate variability has become much more acute in California by State as well as by sectored interest groups. Therefore, having a sustained interest and presence in regional climate matters is critical to develop meaningful connections with stakeholders. Practitioners or specialists in other disciplines respect science partners who are respected by other scientists; this is an especially important characteristic for them to evaluate experts who are in field outside of their own.

Interest level of public and private sectors varies; RISA investigators must be ready to strike when iron is hot

The interest level of state officials in California in topics relating to climate change has increased markedly over the last year, and this RISA has positioned itself very well to respond.

On seasonal/interannual scales, stakeholders "care" about forecasts quite intensely in some years when it is perceived that climate anomalies would produce a large effect (e.g., after two years of drought). However, in other years when conditions are thought to be more "normal", there is not as much interest. Given developments in the California energy sector over the past two years, temperature is always of interest. But, not a lot can be said, typically, except for the effects of trend forcing temperatures more toward the positive than the negative anomalies.

The process of assessing and integrating climate services and forecasts into local resource management procedures and agencies requires much luck and patience. Agencies, especially local agencies, are buffeted by many stresses each year and often place climate issues low among their priorities. When climate rises towards the top of their priorities, however they are eager for help, advice, and hard facts; during these intervals, much progress can be made in establishing connections and in developing long-term users of climate services. The timetable for such advances, however, is most often set by the user, and not the purveyor, of climate services.

Simple, clear illustrations are needed

Simple, clear illustrations of model results that translate atmospheric changes into regional hydrologic changes have been important "props" that have been key elements in conveying to state agencies and the public some likely impacts of climate change in the region. The estimated loss of spring snow pack has been singularly important in this regard. Also, the observed trend over recent decades toward earlier Sierra runoff and the diminishing percentage in late spring, whether caused by global human activity or not, have at the very least given to water managers a tangible face to what is often considered a hypothetical possibility. Several sectors have expressed interest: the State Resources Agency (which encompasses water, forests, wildlife), the California Environmental Protection Agency (water and air quality), and the California Energy Commission have been quite prominent, as well as legislators who are interested in impacts in their own districts. Since we are a coastal state, the potential for accelerated sea level rise and the potential for accelerated seawater intrusion are important issues. Having a credible climate simulation model(s) at our disposal 1) to make such estimates and, perhaps as important, 2) present the results using formats and techniques more readily understood by practitioners, has been invaluable in supplying information. For example, coupling GCMs with coastal ground-water/surface-water flow models provides a mechanism to assess the impact of these changes.

We found that temperature indicators other than thermometer readings are quite effective in translating the meaning of climate change to the public or to decision makers. Phenological stages (e.g., first bloom of lilacs) and spring snowmelt runoff timing have furnished important, entirely independent and mutually corroborative evidence that spring has been arriving earlier across the West for the past three decades.

Relationships with end-users need to be cultivated

In some sectors like water resource management, in order to convince operational institutions that there is value to be gained from only modestly skillful climate forecasts, it is crucial to work closely with agencies over an extended period. It may be necessary to run their operational models side-by-side with alternative new models to demonstrate utility. It is not enough to simply provide forecasts of precipitation or streamflow; the user needs to be involved and engaged interactively throughout the various steps from climate model output to his particular application/decision.

Communication enhances credibility

ENSO has become accepted as a major driver of western weather and climate patterns. However, the "flavors" of different ENSO events and the uncertainty associated with ENSO forecasts is still not well understood and needs to be clarified. We have spent (and will continue to spend) considerable time in explaining this to media, the general public and agencies.

The memorable winter precipitation season of 2004-05 is a case in point. The extraordinary amounts of precipitation, the extended duration from early fall into late spring, the cool and extended spring, and the warm conditions in coastal waters, were not forecast, and from a physical standpoint do not seem to have much to do with ENSO, although there are a few intriguing connections.

We have a much improved understanding of wildland fire management decision-making and a much improved understanding of wildland fire mangement information needs. Climate information, though used in some strategic planning, is still not fully utilized in wildland fire management practices; especially at time scales of decades and longer. When climate forecasts are utililzed in some management applications, however, forecast skill causes many managers to be skeptical of prediction usefulness. We are convinced, though, that there are a range of forecast products beyond the short range time scales that can be of benefit to fire management. For example, statistical seasonal fire forecasts can be made with modest skill using prior years' moisture indices. The fire community has been somewhat skeptical of the value of this tool but is beginning to pay more attention. The Climate-Fire Workshops held by Climas (usually jointly with CAP fire-climate specialists) have been instrumental in promoting dialogue with the fire community. Allied with this issue, it is clear that a better organized central fire data facility would be invaluable to understand and predict climate links to anomalous fire activity across the West. The Climate, Ecosystems and Fire Applications (CEFA) group headed by Tim Brown at DRI has very much adopted a

RISA-like approach, and this has been a key factor in its success.

More focus is needed on non-winter seasons and broader regions

Much of our seasonal forecast attention has been placed on winter season issues (precipitation, temperature), and we have often confined our attention to regions the scale of large watersheds (Sacramento/San Joaquin). But, climate anomalies are not confined to one season, and the footprint of climate anomalies is often super-regional in scale. For example, California draws water and power from the Colorado River system as well as from Northern California watersheds. Also, summer climate anomalies impact summer electrical air conditioning demand, and their cross-regional interconnections have not received much attention. CAP, UW, and NOAA CDC have begun to discuss this issue and how this should be dealt with in a whole-West perspective.

Collaborations with large institutional programs are key

California has begun the largest restoration program in the world, CALFED. This $30 billion 30-year effort is an attempt to involve a broad range of stakeholders in a comprehensive plan to restore the Sacramento / San Joaquin delta and San Francisco Bay and improve water quality and ecosystem function. Climatic processes are the most important external driver of these hydrologic systems, and climatic variability can be expected to cause myriad consequences. CAP has been quite influential in raising the climate connection to a significant level of visibility within the CALFED program. We have used a unique biological indicators of winter precipitation, blue oaks, to discover that wet and dry episodes of 6 to 8-year and approximately 15-year duration are a significant feature in the Central Valley climate of the past 400 years. These heretofore largely unrecognized shorter periods are familiar to those who have recently lived through the late 1980s/ early 1990s drought, and the subsequent very wet six years of the mid 1990s. CAP and collaborators have been commissioned by CALFED to summarize the role of climate variability and change in CALFED issues and to propose areas that need dealing with by CALFED science activities. We have also provided input to the current update of the California Water Plan to guide and coordinate beneficial use of California's water resources. Gaining the notice and trust of key individuals has enormous importance in our ability to inject scientific information into institutional decision making processes.

Climate data needs to be updated and maintained

Climate data archives are struggling to keep up with volumes of data that are collected by an assortment of observational networks. There is a new generation of remote sensing and numerical model data that needs to be properly archived and made accessible. In addition there is a need for integration of data bases and a continual need to disseminate, utilizing technological advances as well as other methods.

Better monitoring is critical to present and future needs

On the other hand, crucial parts of the western climate (broadly interpreted from atmosphere, ocean, hydrology and ecology) are very poorly monitored. For example, we know that spring snowmelt runoff is occurring earlier in recent decades but don't have the fundamental information to elucidate how this is occurring in mountain snow zones. Often there is little support for these measuring and monitoring activities even though these are resources that are critical for making decisions of ours and of future generations. During a series of visits to the major California agencies affected by climate, it became clear that the state, with the 7th largest economy in the world, has poor access to its own climatic history, and in particular to carefully de-biased diagnostic measures of recent climatic trends in temperature and precipitation, and how these vary on a seasonal basis and geographic basis within this extremely diverse state. We have taken preliminary first steps to develop a suite of such indicators in a new effort coordinated by the California Environmental Protection Agency. Also, together with Henry Diaz (CDC and Western Water Assessment RISA Program in Boulder) and others, we have crafted a plan to organize a high elevation monitoring and research across the West (acronym "CIRMOUNT") and have arranged for the inaugural meeting of key investigators and agency officials this fall. In California, we have also used seed funds from CAP to build up a high elevation climate monitoring network for the Sierra Nevada, along its 400 mile length, and several cross-range transects at different latitudes. Such information is crucial to the state for present and future decision making.

Global and regional models are crucial tools

Global model runs for both long (seasonal-decadal) and short (1-4 week) forecasts are needed to investigate predictability and process-related questions relating to climate impacts. CAP is working with J. Whittaker at CDC to run and assemble a historical medium range forecast dataset and has achieved approximately 10 years of 10+ member ensemble forecasts for 1-15d time leads, but this requires a lot of computer resources, considerable data management and progress is incremental.

Regional numerical models are still in a state of development, but are beginning to provide information at the regional and local scales. More work is needed to produce simulations and interpolations at the local and regional scale fidelity necessary for managers and policy makers.

Modelers are increasingly moving to smaller scales. As an exercise in applied climatology, there is a strong need to develop gridded versions of observed data sets that are both accurate and that are suitable for comparing retrospective model results with reality.

Crossing disciplines between climate science and human dimensions requires meaningful collaborations

One of our greatest challenges is to forge links between climate science and social science, policy and health science communities. Human health data is available for analysis related to climate effects, but in many cases is short duration, parochial, embargoed because of confidentiality issues, and difficult to acquire. It is almost essential to work with experts in the medical or epidemiological area to provide meaningful advice and collaboration in this area.

- **How did you develop your process for eliciting stakeholder needs/wants?**

  This has evolved somewhat through time. Initially, most research topics stemmed from ongoing interactions between the research community and local stakeholders. We also tried to concentrate on topics of wide interest. Not too many of these efforts have "run their course" and most of them are expected to remain as significant issues for the foreseeable future. With resource limitations we have been careful to select new topics and areas on a case by case basis.

Supply Side Assessment

- **Briefly describe the research agenda for your RISA.**

  Four primary thrusts:

  Providing improved forecasts and other climate information for 1) water resources, 2) wildfire and 3) human health concerns and to 4) develop an improved climate data and monitoring capacity for the California region. Problems addressed involve synoptic to climate change time scales. Collaboration with key stakeholders who represent interest of broader stakeholder groups and have needed expertise in "foreign" disciplines is a key aspect of our strategy. These thrusts are collectively building a capability to apply quantified climate services such as precipitation, temperature, wind, and humidity to reservoir operation, snow pack evaluation, fire prediction, vector-disease assessment, air quality assessment, and ground-water/surface-water flow simulations.

- **How does your RISA set its own research priorities?**

  Stakeholder interest, "tractability" of problems and issues, and the likely quality of science are key criteria. As a team largely of university or federal/nonprofit scientists who are evaluated by our published, creative output, so quality of science problems is a necessary component of our work, even if it is very applied. Also, CAP has a modest budget so is only able to sustain a relatively small core team. Thus we must exercise restraint in taking on problems and have been selective in focusing on problems that are suited to some core disciplinary strengths.

- **How has this agenda evolved over the duration of the RISA? What new projects have been started that were not anticipated at the beginning of the RISA? What projects have been terminated, and why?**

  Our initial intuition of three key study areas (water, fire, health) has proved to be on target in terms of stakeholder interest and has provided fertile and societally useful problems. The feedback we receive from stakeholders backs this up. As CAP has matured, through interactions w a variety of stakeholders we have recognized the gap between a) the need for high resolution and high quality climate information and b) our community's ability to deliver it, so we have added an emphasis on climate observation and climate data, which transcends locales and sectors.

- **In your RISA, what is the balance between research on new subjects, and assessment/compilation of existing knowledge? How is this balance determined?**

  In California, interest in potential climate change impacts turns out to be very strong and appears to be growing. Consequently, some work that initially was more focused on seasonal-interannual variability has shifted focus toward climate change time scales. We have shifted attention in climate-health from Kawasaki's disease to a new effort involving air quality; however, our longstanding work with a group studying vector borne disease remains. Ground water efforts are now migrating regionally, from coastal California aquifers in the south-central portion of the state to the central valley.

- **Please describe the specific ways that knowledge is disseminated from your RISA. How would you assess the relative importance of various dissemination mechanisms, such as peer-reviewed publications, other types of publications, web-based presentations, public fora, etc.?**

  This has been in the form of peer-reviewed publications, presentations at conferences, workshops, and meetings with stakeholders and related citizen groups, along with numerous responses to news organizations. There has also been interaction with influential NGOs. As a leveraged outgrowth of CAP there has been a concerted attempt to reach the public directly with such efforts as the California Climate Data Archive and a monthly newsletter for the state, with articles and data (www.calclim.dri.edu). Many of these efforts are interlinked with national and regional synthesis activities, in part through presence on high level advisory committees and in program management activities are also quite important. A few examples: Dettinger is on Calfed Water Science Committee; .Redmond is on National Academy teams, Cayan is on California Climate Change committee for California Energy Commission and directs the physical science component of the state-supported California Climate Change Center. We maintain a CAP web site http://meteora.ucsd.edu/cap/.

Reconciliation/Managing Ecology of Supply and Demand

- **In what ways have considerations of supply for research shaped the evolution of your research agenda?**

  Because we have chosen topics that are related to ongoing applied research we have developed a list that is related to topics recognized by CAP members as areas where climate services could make a difference. We feel it would be counterproductive to select topics where there was little chance of offering anything very new, even if there were a demand for such information. We do not want to get stretched too thin, so we have restricted the primary thrusts to 3-4 main topics.

- **What tensions have arisen between stakeholder needs, demands, and expectations, and the scientific capabilities and priorities of the RISA? How have those tensions been addressed or resolved?**

  We seem to have been lucky or prescient in this regard. We do not seem to have been exposed to strong tensions between unrealistic expectations and what can be delivered. Also we have tried to proactively defuse such expectations if they seemed too wildly optimistic.

We have, however, dropped further investigations in the Ventura area for now because local water purveyors have control issues over the analysis and distribution of information that may affect their ability to buy and sell water as well as intermittent litigation that preclude the pursuit of additional research in a more open or public arena.

- **How does your RISA evaluate the appropriateness of stakeholder needs (e.g., from the standpoint of public/private sector roles and responsibilities)?**

  There are regional differences in how the public conducts its business. In many ways the success that CAP has enjoyed is because this is California, and the state has a different mode of operation, and philosophical background, than do other areas. There is greater predilection for state agencies to cooperate, and there has traditionally been a high degree of openness and transparency in state government, and more particularly, at the mid-levels of government institutions. Also, there has been a strong technical component to many state activities. Finally, just for shear scale, even the smallest of these groups are working with sizeable resources. It is telling that the state expenditures just for mosquitoes is about $100 million a year. There is a widespread sense that government and public agencies, and the state educational system, have a strong role to play in addressing common problems, and CAP directly taps into that.

- **How are stakeholders identified? Which stakeholder groups are most important in influencing your RISA research agenda? Why? Which stakeholder groups are least important? Why?**

  In the arid West, and in California as well, water is pretty much king (though there are many princes). So anything that relates to water commands immediate attention. We could not afford to not address this issue. Also (on clear days) much of the state can look up and see that white mass of snow draping the mountains to the east. With all its connections, though, there are ample opportunities to link to related problems. State and other public agencies have certainly been the most influential stakeholders, because they have huge issues to wrestle with, and because the CAP participants have a solid reputation in these areas, and the host institution is well regarded throughout the state.

- **How does your RISA evaluate its research planning process?**

  We have not developed a formal process in the manner that some other RISAs have. There are many opportunities for discussion through the course of a year among subsets of investigators, and we usually try to meet as a larger group in association with some other meeting, or assemble at Scripps. A smaller circle of co-investigators notes areas that do not seem to be as productive. This group in turn leaves most of the final decisions regarding directions and funding in the hands of the PI. Disruptions, uncertainties, and extended delays in the annual funding cycle have made systematic approaches much more difficult in the last year or two.

- **What lessons in the process of the reconciliation of supply of and demand for science are relevant to the broader implementation of the CCSP?**

  Many new forms of analysis are not readily accepted by some sectors that have a long tradition of using historical climatology as the basis for forecasting or planning, such as ground-water/surface-water purveyors. Melding results from these traditional forms of analysis with those from the more recent approaches, centered around physically based modeling, is a considerable challenge.

  The biggest challenge remains finding a match between that which we do know or which we can know, and what others want to know. The biggest need in keeping this tension as low as it can be is for constant communication between the two sides of the ledger. Each side must understand the operating environment of the other side, the imperatives at work, the constraints faced, the audiences they must react to, the cultural landscape, the huge role of non-climatic issues, the ways in which information is processed, the uncontrollable forces that are at work, the role of groupthink, attitudes about knowledge and knowing, and most especially how decisions get made and how judgments are formed afterward about the correctness of those decisions.

  A very large lesson for the demand side seems to be that one cannot expect instant answers, Answers will likely not be definite but probabilistic, and that patience is needed to develop these approaches, educate the stakeholders on their usefulness and perhaps how to apply them and demonstrate the marginal benefits of these probabilistic estimates. The discovery process can only be forced so much. The equivalent large lesson from the supply side is that users must be engaged early on and taken seriously, and that this takes significant time and energy and resources, and a willingness to think in more than engineering terms.

For this interplay to be productive, there must be a greater and improved societal understanding of how science and the discovery process works, what science is and what it is not. The biggest misconception in this regard is that science is about certainty, whereas in truth doubt plays the central role, and our goal is to reduce the attendant uncertainty wherever we can, acknowledge that this cannot be reduced to zero, and yet strongly reiterate that knowledge that is uncertain is not useless.

RISA Documents

Carolinas Integrated Sciences & Assessments

http://www.zebra-baker.com/CISA/

Demand Side Assessment

- ***Who are the major stakeholders for your RISA?***

Our stakeholders include a wide variety of public and private water users, governmental agencies, and other organizations interested in water resources. Federal and state agencies include the US Geological Survey, US Fish and Wildlife Service, Environmental Protection Agency, South Carolina Department of Health and Environmental Control, the SC Department of Natural Resources, the SC Forestry Commission, and the North Carolina Department of Environment and Natural Resources. In the private sector, we consult with heavy water users such as the pulp and paper industry and utilities (e.g. Duke Power, SC Electric and Gas). Involvement in the Federal Energy Regulatory Commission (FERC) dam relicensing process has contributed to the expansion of our local stakeholder base. We have built upon previous work with community water system managers by making contacts with city and county governments, recreational users groups, and homeowners' associations.

- ***What processes are used to include stakeholders in the research planning process, the research implementation process, and the research reporting process?***

We have conducted interviews and meetings to ascertain current and potential uses of climate information among water users and resource managers. Networking at public hearings and professional meetings has allowed us to increase our contact base, share preliminary results with stakeholders, and receive feedback from other participants. Such interactions already have led to collaborative partnerships with stakeholders. As we complete our second year, we are working to refine products by soliciting user feedback (at meetings and through written comments) and by continuing conversations with stakeholders who might benefit from similar collaborations.

- ***How are stakeholder interactions evaluated?***

We keep records of interactions and meetings with current and potential stakeholders. Our RISA team conducts regular meetings to evaluate progress and to share insights. We work collaboratively within our research group to fine-tune approaches and to identify potential projects.

In addressing potential stakeholders we consider current use of climate information and data, level of interest in developing collaborative products, and specific opportunities to collaborate. Frequent interaction and ties to other key groups with similar interests have been helpful in initiating relationships.

- ***What has your RISA learned from the process of stakeholder interaction, and how have its decision processes changed as a result?***

A wide range of climate expertise and use of climate data exists. Some water users (paper and pulp industry, major utilities) already use climate information directly and seek the development and use of more sophisticated, technical models. Other groups use information with climate data imbedded in it, but possess varying levels of interest in dealing with climate more directly.

In order to understand the diverse uses and understandings of climate information, our RISA has worked to unravel the social context in which water and climate-related decisions are made in North and South Carolina. Organizational barriers often hinder use of climate information. Political, regulatory, and financial constraints appear to limit experimental approaches. The wide variety of climate information uses requires creativity and innovation on our part to tailor RISA products to specific stakeholder needs. An understanding of established networks and interactions between user groups – some stakeholders already create their own climate data or provide climate information to others – is also required.

- ***How did you develop your process for eliciting stakeholder needs/wants?***

We used a multi-level approach in the beginning stages of our project development process. We evaluated past work with community water systems to gauge needs at the local level, while at the same time elicited information from water users and agencies on the state and regional level to give us a broader perspective on water problems and concerns in the Carolinas. This approach allowed us to introduce ourselves to potential collaborators and expand our list of contacts, to see how our RISA might fit into existing networks of users and networks of information among those users, and to begin the process of establishing more long-term relationships with interested stakeholders.

Supply Side Assessment

- ***Briefly describe the research agenda for your RISA.***

CISA's primary goal is to improve the range, quality, relevance, and accessibility of climate information for management of water resources in North and South Carolina. Current projects seek to understand the most pressing climate information needs of the water resource community, to improve knowledge of the physical system as it influences water resources in the Carolinas, and to find the most effective means of communicating climate science to decision makers.

- ***How does your RISA set its own research priorities?***

We have developed our research priorities based on the competencies of our team members, general or specific needs as identified by user groups, and what we have discovered to be vulnerabilities or long-term strategic needs of the region's water resources.

- ***How has this agenda evolved over the duration of the RISA? What new projects have been started that were not anticipated at the beginning of the RISA? What projects have been terminated, and why?***

As we finish our second year as a RISA, we continue to refine our agenda. We have evolved from general areas of interest to specific products and stakeholder partnerships. Our degree of involvement in the FERC dam relicensing process was originally unforeseen, but for our stakeholders this process is the most significant activity in which they are currently involved and has far-reaching implications for water resource management. Engagement in this process has resulted in one of our current projects – the development of a low inflow protocol for hydropower dam operations.

We have not terminated any projects. The basic work of past and current projects is generally carried over into other, related areas or projects. As we continue to engage with stakeholders in an iterative learning process, we expect our agenda will continue to evolve.

- ***In your RISA, what is the balance between research on new subjects, and assessment/compilation of existing knowledge? How is this balance determined?***

We have learned that basic climatology would make a substantial contribution to decision-makers' efforts. As we are in an academic institution, we try to extend beyond the immediate, stated needs of stakeholders and develop more sophisticated and long-term analyses. We embrace the topics they identify but anticipate related issues. Specifically we see a need for probabilistic assessments of regional effects of climate variability and change on water quantity and quality and on social institutions and decision-makers.

- ***Please describe the specific ways that knowledge is disseminated from your RISA. How would you assess the relative importance of various dissemination mechanisms, such as peer-reviewed publications, other types of publications, web-based presentations, public forums, etc.?***

We employ a variety of means of disseminating the knowledge and project information produced by our RISA. We have developed web-based products that include a GIS component. We conduct direct meetings and discussions with involved stakeholders. We present information publicly at academic and practitioner professional meetings. And, we are working on several papers to be submitted for peer-reviewed publication. All venues are viewed as important for strengthening long-term relationships with stakeholders as well as making our research known to the academic community.

Reconciliation/Managing Ecology of S&D

- ***In what ways have considerations of supply for research shaped the evolution of your research agenda?***

Team members' competencies and interests, as well as budgetary and staff constraints, have shaped the evolution of our resource agenda.

- ***What tensions have arisen between stakeholder needs, demands, and expectations, and the scientific capabilities and priorities of the RISA? How have those tensions been addressed or resolved?***

Several tensions exist between stakeholder needs and scientific capabilities to supply the desired information. For example, some stakeholders often desire clear, but currently unattainable, information about future climate. Similarly, other stakeholders may use climate dependent information, but they may resist opportunities to use climate data directly. Other users of climate information want products offered by a variety of sources to be consolidated into one accessible product.

Our RISA is currently working to address and resolve some of these tensions through continued engagement with both our local and regional stakeholders and with the larger research community.

- ***How does your RISA evaluate the appropriateness of stakeholder needs (e.g., from the standpoint of public/private sector roles and responsibilities)?***

Water resources management necessarily entails dynamics between natural and social systems and overlapping interests across federal, state, and levels. Exploring and understanding how these cross-scale interactions affect the decision-making context is crucial in evaluating the appropriateness of stakeholder needs. Introducing the potential value of climate information in the context of other conversations – reservoir management or dam operations, for example – allows stakeholders to recognize potential uses of climate data more easily. Development of specific products, and expectations for their anticipated uses, must be well-defined.

How are stakeholders identified? Which stakeholder groups are most important in influencing your RISA research agenda? Why? Which stakeholder groups are least important? Why?

We interact most closely with state-level agencies because of their day-to-day interactions with a wide range of water resource users. Thus far we have collaborated with decision-makers who already employ some form of climate information in their operations. Participation in the FERC dam relicensing process has provided us access to many other parties and broadened our perspective about which organizations might be interested in and benefit from enhanced climate information.

- ***How does your RISA evaluate its research planning process?***

We have not implemented a formal evaluation of our planning processes but expect to begin development of such a tool as our work with stakeholders progresses.

NEW ENGLAND INTEGRATED SCIENCE & ASSESSMENT

http://airmap.unh.edu/assessment/

1. Demand Side Assessment (Cameron Wake and David Brown)

1.1. Who are the major stakeholders for your RISA?

Table 1. Stakeholders currently engaged in the INHALE project.

UNH Departments and Institutes

- AIRMAP
- Institute for the Study of Earth, Oceans and Space
- Office of Sustainability Programs
- School of Health and Human Services
- Whittemore School of Business and Economics
- Masters of Public Health Program at the University of New Hampshire
- New Hampshire Institute for Health Policy
- Cooperative Extension

Key Stakeholders – Government Organizations

- New Hampshire Department of Environmental Services
- New Hampshire Health and Human Services
- Vermont Health and Human Services
- Maine Bureau of Health
- EPA Region 1

Key Stakeholders – Non - Governmental Organizations

- Lung Association (New Hampshire, Maine, New Brunswick)
- Maine Thoracic Society
- International Center for Air Quality and Health
- Asthma Regional Council (ARC) of New England
- Wentworth Douglass Hospital (Dover, NH)
- Exeter Hospital
- Portsmouth Regional Hospital
- Dartmouth Hitchcock Medical Center
- Penobscot Bay Medical Center
- John Snow Institute
- Harvard School of Public Health
- Columbia School of Public Health
- Northeast Regional Climate Center
- New England Society of Allergists (NESA)

1.2. What processes are used to include stakeholders in the research planning process, the research implementation process, and the research reporting process?

Our collaboration with stakeholders relies upon early and continued communication and interaction, primarily via working meetings, e-mail and telephone calls, although we have also invited our stakeholders to formal science presentations and have collaborated/shard results during professional meetings.

1.3. How are stakeholder interactions evaluated?

The majority of our evaluation has been informal, and has been based upon our sense of successful collaboration combined with requests from most of our stakeholders for continued interaction and collaboration. During our meetings with various stakeholders, we also often ask for direct feedback on our efforts. This is recorded and discussed within our group. We have not engaged in any formal independent evaluation of our efforts and in fact do not have the resources from the RISA program to do this.

1.4. What has your RISA learned from the process of stakeholder interaction, and how have its decision processes changed as a result?

Our stakeholder interactions have: (1) reinforced the importance and value of engaging stakeholders early and often, and having their views help shape the research questions; (2) encourage other individuals and institutions to become stakeholders in our assessment; (3) maximized benefits to our stakeholders; (4) provided deeper understanding of the key issues and how to deal with them; (5) taught us that public health professionals want to be connected with project whose focus in climate based and as a result we have been able to bring climate/air quality expertise to the table where it has not been well represented before.

1.5 How did you develop your process for eliciting stakeholder needs/wants?

We essentially learned as we went, once we had tapped into engaged networks in a variety of sectors. We listened respectfully to our stakeholders during several working meetings and informed them of our areas of expertise, and then developed key research questions together.

2. Supply Side Assessment (Tom Kelly and David Brown)

2.1 Briefly describe the research agenda for your RISA.

The NEISA project is a collaborative, interdisciplinary effort involving individuals from several departments, Institutes, and Program at UNH, the NH State Climatologist, the Northeast Regional Climate Center, and a comprehensive range of stakeholders. Our integrated assessment will continue to focus on the relationship among climate, air quality, and human health. Many studies have shown mortality and morbidity related to extreme temperatures, short term increases in criteria air pollutants, and pollen and mold events. All of these air quality measures (biological, chemical, physical) are influenced by seasonal and interannual climate variability. However, there remains much to be learned regarding the nature of the relationship among climate variability, these integrated measures of air quality, and the effect on human health. An improved understanding of these dynamic, non-linear relationships and a focus on developing decision relevant information will help reduce vulnerability to poor air quality in New England on seasonal and interannual time scales by improving adaptive capacities.

2.2 How does your RISA set its own research priorities?

Initially, based on information provided by a variety of previous research indicated that: (1) New England has a significant air quality problem (2) the fasted growing chronic disease in the US is asthma and prevalence rates are greatest in New England; (3) the situation is similar for COPD (4) health care costs are rising; (5) poor air quality has a significant impact on the economy via health care costs, worker productivity, and absenteeism; (6) air quality forecasts are available one day in advance but effectiveness of forecasts for protecting human health has not been examined; also forecasts reach limited audience. Stakeholders also provided additional details and texture to these major issues. Also, we are closely linked with the NOAA funded AIRMAP project whose focus in air quality, weather, and cliamte in New England.

2.3 How has this agenda evolved over the duration of the RISA? What new projects have been started that were not anticipated at the beginning of the RISA? What projects have been terminated, and why?

The project has evolved to include a wider definition of air quality (going from purely atmospheric chemistry (i.e. criteria pollutants) to a definition that encompasses biological, chemical and physical properties of air. It has also evolved from an initial focus on weather time scales to a focus on seasonal and interannual climate variability. Finally, our role has evolved as we have learned more of the wide variety of organizations and individuals working on the broader issue of environment and human health that while we are taking the lead (in collaboration with a few other university researchers) on the climate – air quality – human health issue, we also often a key stakeholder at the table dealing with the broader environment-health issue.

New projects started:

1. Fall rise in hospital services for asthma and respiratory problems link to fall rise in pollen (and mold?)
2. Developing example of how a systematic pollen and mold data collection network should function (physical and chemical properties of air already well tracked via EPA and NOAA)
3. Forecasting of winter snowfall and frequency of east coast winter storms based on SST, NAO. And ENSO

Projects Terminated:

1. High resolution (i.e., daily) air quality versus pulmonary function study. This study was a one time opportunity building on summer 2004 ICARTT campaign in New England

2.4 In your RISA, what is the balance between research on new subjects, and assessment/compilation of existing knowledge? How is this balance determined?

We are continuously integrating existing and new knowledge into our research efforts. The cycle of assessing – compiling – integrating – new research is ongoing and not one that is broken out into different bins. This may evolve as our project matures over time. Our direction is determined primarily via (1) discussions with engaged faculty and their students, and (2) needs/desires of our stakeholders.

2.5 Please describe the specific ways that knowledge is disseminated from your RISA. How would you assess the relative importance of various dissemination mechanisms, such as peer-reviewed publications, other types of publications, web-based presentations, public fora, etc.?

Dissemination occurs primarily via presentations and small workshops with our stakeholders, although dissemination also occurs via published papers and presentations at scientific meetings, via our web page, and via short reports written specifically for a broader, non-scientific audience. We assess the relative importance of various dissemination mechanisms via feedback from stakeholders. Published papers appear to be critical for reputation and for scientifically literate stakeholders (we provide links to our published papers and many other related published papers via a password protected area on our web site. This has apparently been very useful to a handful of our stakeholders). However, many of our stakeholders appreciate the public presentations, especially as we can provide them with the results of our most recent research and they are able to provide input to how the data is analyzed.

In the future we plan to disseminate many of our results via our recently improved web page (neisa.unh.edu). This includes access to newly developed database on air quality and a quarterly newsletter (that will also be sent out in print form).

3. Reconciliation/Managing Ecology of S&D (Tom Kelly and Cameron Wake)

3.1 In what ways have considerations of supply for research shaped the evolution of your research agenda?

- Greater emphasis on the influence of seasonal to interannual climate variability on air quality and human health
- Role of the North Atlantic Oscillation on New England climate variability
- The AIRMAP project focus on atmospheric chemistry
- Forecasts of opportunity that may be of use to health management
- Survey of worker productivity (poor air quality = lower productivity)

3.2 What tensions have arisen between stakeholder needs, demands, and expectations, and the scientific capabilities and priorities of the RISA? How have those tensions been addressed or resolved?

We have worked not to raise expectations by not presenting ourselves as the experts, but rather presenting ourselves as wanting to contribute to a larger effort on environment and health, but bringing a climate and air quality point of view.

In terms of stakeholder needs, there was a strong interest for quantification of the economic impact of poor air quality along the lines of "if your research is going to influence policy, you need to determine the economic impact". As a result, we identified and invited into the project a health economist and business management faculty (Robert Woodward and Ross Gittell) and several economics and business graduate students, worked with the Ontario Medical Association to develop a New England specific model to calculate the illness cost of air pollution, and sought out additional stakeholders that brought an economic interest to the table.

There was a minor conflict regarding the temporal range of our initial analysis (primarily from the NOAA-RISA program) as we initially focused on weather (i.e. daily) time scales in our analysis. However, this was the primary interest of many of our stakeholders. We first approached the problem from the time-scales they were interested in, and have now begun the shift to seasonal-interannual time scales and are raising this climate based variability with our stakeholders.

We also identified the lack of a systematic pollen and mold monitoring/data archiving network as a major flaw in attempting to understand the climate – air quality – health link. To address this we have identified and brought in additional scientific expertise (John King from URI and Christine Rogers and colleagues from Harvard Medical School). We will continue to look for additional expertise as we identify new needs.

3.3 How does your RISA evaluate the appropriateness of stakeholder needs (e.g., from the standpoint of public/private sector roles and responsibilities)?

We have not evaluated the appropriateness of stakeholder needs, but have rather identified areas of their particular needs that we can help address. Our efforts are limited by the small size of our project. Our response to stakeholder needs is therefore driven by our own capabilities and what the project advisory committee feels we can deliver on.

As process matures, we expect to more explicitly manage our capabilities, or expand our capabilities where resources are available. We have also identified/collected/distributed products already developed by other institutions (e.g., EPA, Ontario Medical Association). Over time, we expect to be better able to focus our efforts (this in fact is already happening) as we clearly identify specific questions/issues that we can address (based on input from within RISA and our stakeholders).

3.4 How are stakeholders identified? Which stakeholder groups are most important in influencing your RISA research agenda? Why? Which stakeholder groups are least important? Why?

Stakeholders are identified via engaged networks of individuals working in this field (e.g., word of mouth, recommendations, personal contacts). Stakeholders that are most important in influencing our research agenda are those who share interest/concern for environment/health links AND who share the integrated assessment approach/philosophy. (and vices versa for least important stakeholder groups). Those individuals and institutions who mange their boundaries by putting up walls are not important stakeholders, while those individuals and institutions who mange their boundaries with porous walls and have adopted an integrated approach to problems are our most important stakeholders.

It is therefore not necessarily different stakeholder groups that are more or less important, but rather the characteristics of individuals and institutions within different stakeholder groups that make them more of less important (health insurance companies being on exception, but we are working on this through one of our key stakeholders). We therefore are part of an emerging community of inquiry working with progressive individuals and progressive organizations with common concerns and common outlooks. One criticism of this may be that the project will remain isolated. However, we see this as an evolutionary process and, if we are successful, our approach will be adopted by others. Right now we are, in a sense, working with the early adopters of the RISA approach to move our efforts forward. We have already experienced success in our relationships with early adopters – for example being invited to give a keynote address at a large asthma conference in New Hampshire and sitting at the table with the entire senior management team for Exeter Hospital discussing ways we can improve hospital management via data analysis and enhanced messaging to employees and patients around air quality forecasting and protecting your health.

3.5 How does your RISA evaluate its research planning process?

- Ongoing stakeholder participation and engagement in NEISA
- Regular meetings and discussion by advisory committee (quarterly) and core team (monthly or more frequent)
- Informal communication with stakeholders
- Funding from stakeholders; Reports to stakeholders

3.6 What lessons in the process of the reconciliation of supply of and demand for science are relevant to the broader implementation of the CCSP?

The mission of the U.S. Climate Change Science Program is to "*facilitate the creation and application of knowledge of the Earth's global environment through research, observations, decision support, and communication*" (CCSP 2003). The NEISA project plan proposed above integrates a wide range of research and observations on air quality, climate, and health performed by a variety of federal agencies, universities, other institutions, and NEISA to develop and evaluate a suite of decision support products in collaboration with our stakeholders. This collaboration relies upon early and continued communication and interaction with our stakeholders.

In particular, CCSP Goal 5 is to "*explore the uses and identify the limits of evolving knowledge to manage risks and opportunities related to climate variability and change*". This includes building on past experiences of the scientific and technical communities to develop decision support processes and products. NEISA will integrate and apply information from the natural and social sciences to provide our stakeholders with decision support toolkits that will reduce the risk of adverse health effects resulting from poor air quality and interannual variability in the hydrological cycle. Through this process we will address our primary objective of improving public health. In addition, two of the core approaches identified CCSP to meet its goals are decision support (develop improved science based resources to aid decision making) and communication (communicate results to domestic and international scientific and stakeholder communities, stressing openness and uncertainty). Both of these approaches are central to the NEISA effort. The development and dissemination of decision support tools are described in detail above. For communication, this includes: frequent meetings (monthly and annually) with our stakeholders to share methodology, assumptions, results and to obtain feedback; dissemination of reports (based on papers published in the scientific literature) written in collaboration with and for our stakeholders; web-based dissemination of data, information, and decision support tools (via NEISA, AIRMAP and the Northeast Regional Climate Center), and via focused links to other quality sources of information (e.g., other RISAs, select EPA and NOAA sources of information).

Finally, the overall goals and activities of NEISA are most closely related to the "Decision Support Resources Development" of the CCCP. Our project embodies the decision support framework outlined in Chapter 11, consisting of: problem identification and formulation in collaboration with stakeholders; development of decision resources based on observations and data, interdisciplinary research, communication, and product development and evaluation; and eventually leading to, in our case, improvement of public health, informed policy, and identification of knowledge gaps.

RISA DOCUMENTS

PACIFIC ISLANDS

http://research.eastwestcenter.org/climate/risa/

Pacific Islands Regional Integrated Science and Assessment (Pacific RISA) Program
Input to
SPARC Reconciling Supply and Demand Workshop:
Climate Science Policy Lessons from the RISAs
Prepared by
Eileen L. Shea, Pacific RISA Director
On behalf ofTeam Pacific RISA
August 2005

Pacific Islands RISA – An Introduction

The Pacific Islands Regional Integrated Assessment (Pacific RISA) program begin in fall 2003 with a small, initial three-year grant from the NOAA Office of Global Programs. As described in the initial proposal to NOAA/OGP, the Pacific RISA program continues

"**an ongoing commitment to the emergence of a Pacific climate information system that supports the development and use of climate information to support decisionmaking**"

in the American Flag and U.S.-Affiliated Pacific Islands.[1] The Pacific RISA program emphasizes understanding and reducing Pacific Islands' vulnerability to climate-related extreme events such as droughts, floods and tropical cyclones. In other words, the Pacific RISA program has been organized to *support and enhance the climate risk management activities of Pacific Island governments, communities, resource managers and businesses*.

In the context of a climate information and risk management system, the Pacific RISA focuses these and related ongoing climate activities in the region on the following objectives:

- Sustain and expand a *focused, interactive dialogue* with decision makers in climate-sensitive sectors to enhance understanding of regional vulnerability, explore potential response options and identify critical information needs;
- Enhance regional efforts to *develop and apply climate forecasts and information products* to meet the information needs of decision makers in climate-sensitive sectors including disaster management, water resources and public health;
- Develop *enhanced data and information products* that better address the nature and consequences of current and future patterns of climate-related extreme events and the patterns of climate variability that set them in motion; and
- Adapt and apply existing *model-based decision support tools* with an initial focus on climate-related extreme events and further develop these same tools in the context of integrated climate assessment methodologies.

The Pacific RISA program is built on the foundation of a number of past climate forecasting applications, climate research and climate assessment activities in the Pacific, including: the Pacific ENSO Applications Center[2]; the Pacific Assessment of the Consequences of Climate Variability and Change conducted as part of the first U.S. National

[1] The American Flag Pacific Islands include Hawaii, Guam, American Samoa and the Commonwealth of the Northern Mariana Islands; the U.S.-Affiliated Pacific Islands include the Federated States of Micronesia (Yap, Chuuk, Kosrae and Pohnpei), the Republic of the Marshall Islands and the Republic of Palau.

[2] The Pacific ENSO Applications Center (PEAC) represents a working partnership among the University of Hawaii (Social Science Research Institute and School of Ocean and Earth Science and Technology); the University of Guam; the Pacific Basin Development

Assessment of the Consequences of Climate Variability and Change; and an East-West Center-University of Hawaii joint research project on climate and health. These earlier programs are described in more detail in Appendix 1. In addition, the Pacific RISA program builds on a long history of disaster management, risk management and climate research at the East-West Center and the University of Hawaii's Social Science Research Institute.

Dialogue with Users (Demand Side Assessment)

Who are the stakeholders for the Pacific RISA Program?

The early foundations for a Pacific RISA program were laid with the initiation of the work of the Pacific ENSO Applications Center (PEAC) in 1994. NOAA's Office of Global Programs initiated PEAC as a research pilot project following a 1992 workshop at the University of Hawaii that brought together ENSO scientists and representatives of key climate-sensitive sectors throughout the American Flag and U.S.-affiliated Pacific Islands. The idea for the 1992 workshop, and the Pacific ENSO Applications Center that would later emerge, began in the context of early presentations by NOAA/OGP[3] on emerging seasonal climate forecasting capabilities associated with the El Niño-Southern Oscillation with Pacific Island coastal zone managers during the preceding two years.

The 1992 workshop was explicitly designed to engage representatives of key sectors affected by climate variability and change in the development of a climate forecasting and applications program. The users represented at the 1992 workshop included representatives of:

- Disaster/emergency management offices/agencies;
- Coastal zone management offices/agencies;
- Fishery management agencies and regional organizations;
- Water resource management agencies and electric utilities companies or agencies;
- The Pacific Basin Development Council comprising the Governors of the four American Flag Pacific Islands;
- The National Weather Service offices in the Pacific; and
- Academic and scientific institutions engaged in climate research in the region.

As part of the initial Assessment of the Consequences of Climate Variability and Change (2000-2003), this initial group of current and potential climate information – Pacific RISA -- users was expanded to include:

- Agriculture ministries and businesses, including small-scale farmers;
- Agencies and businesses engaged in supporting tourism including tourism authorities, risk managers and community liaison officers from the Outrigger hotel chain, faculty from the Travel and Tourism Management at the University of Hawaii;
- Land and resource management agencies in the AFPI and USAPI jurisdictions (the Department of Land and Natural Resources in Hawaii);
- Representatives of marine sanctuaries and other protected areas in Hawaii and American Samoa;
- Non-governmental organizations addressing environmental and resource conservation issues;
- Representatives of health ministries including public health officials in the region;
- The national climate change country teams emerging in the independent nations of the Pacific with U.S. affiliations (Federated States of Micronesia, Republic of Palau and Republic of the Marshall Islands); and
- Regional organizations supporting Pacific Island programs in weather, climate, disaster management, water resource management and community development, most notably the South Pacific Regional Environment Programme (SPREP) and the South Pacific Applied Geosciences Program (SOPAC).

These individuals and colleagues in their home institutions form the user base for the Pacific RISA program. More

Council (PBDC) and NOAA (the National Weather Service and the Office of Global Programs). Operational responsibility for PEAC resides with the National Weather Service, Pacific Region.

[3] NOAA/OGP was represented at these meetings by Eileen Shea who was then Deputy Director of OGP.

recently, this user group has been expanded to include groups like the Pacific Risk Management Ohana (PRiMO) representing the key Federal, state and regional agencies and scientific and technical institutions engaged in disaster management in the Pacific. PRiMO is becoming a primary source of input on the programs and plans for the Pacific RISA program as they relate to disaster/risk management. PRiMO has embraced managing climate-related risks as one of the three risk areas used to guide PRiMO's activities and the Pacific RISA program is identified as the/a primary source of guidance on the climate-related programs and activities of PRiMO and its participating agencies.

What processes are used to include stakeholders in research planning, implementation and reporting processes?

As will be described in more detail in the following section, a majority of the activities in the initial Pacific RISA program are focused on stakeholder interaction and partnerships in the emergence of a Pacific climate information and risk management system. Figure 1 provides a conceptual framework of such a system and emerged from the initial Pacific Assessment of the consequences of climate variability and change. The conceptual design of a Pacific climate information system reflected in Figure 1 emerged in response to the overarching recommendation from the initial Pacific climate assessment:

> **The shared exploration of climate vulnerability and resilience that began with the initial Pacific Assessment should be maintained as a continuing process with a goal of nurturing critical partnerships to develop, share and use climate information to support decisionmaking.**

The Pacific RISA program is a direct response to that recommendation.

Pacific RISA stakeholders are included on the Pacific RISA steering committee and are, similarly, engaged on the steering committees for the current suite of program elements including the PEAC review, the NOAA/CSC-funded Pacific Assessment follow-on education project, and the Pacific Islands Training Institute on Climate and Extreme Events. In addition, representatives of key stakeholder groups are actively recruited to serve on the organizing committees for and participate in climate-related workshops, briefings and roundtable discussions. During such meetings, we strive to ensure that breakout sessions are co-chaired by a scientist and a user and that breakout groups reflect as broad a cross-section of climate information users and providers as possible. To the maximum extent possible, reports from such RISA-related workshops, meetings and discussions are co-authored whenever possible.

The PEAC review project included several elements designed to elicit input from the users of PEAC products and services including: written surveys, in-person interviews and a June 2004 regional workshop during which PEAC users and scientists explored the first ten years of PEAC operations, identified information gaps and research needs and developed recommendations for future PEAC and RISA programs in the context of a Pacific climate information and risk management system. These findings and recommendations are being integrated into planning for PEAC and related NWS climate services in the Pacific region and will be used to help guide the development of the next Pacific RISA proposal.

During its first decade, PEAC has employed a number of activities to disseminate climate information and seek input and guidance from the users of PEAC products (stakeholders). In 1994 PEAC began issuing a quarterly newsletter describing ENSO-relevant ocean-atmosphere conditions and providing Pacific Island jurisdictions with information regarding the implications of those conditions for rainfall and other key factors. PEAC established a website early and, as a result of the PEAC review workshop in June 2004, is improving web-based opportunities for user input on PEAC products and services.

PEAC also initiated an active program of education, outreach and dialogue with users to clarify information needs and make PEAC products more useful and usable. In addition to reports, brochures and other written products, this education program included regular visits to Pacific Island jurisdictions served by PEAC to discuss current and projected ENSO conditions and facilitate discussion of adaptation measures with affected communities, agencies and businesses in those jurisdictions. One of the interesting findings of the PEAC review involves the *importance of maintaining the human resources needed to sustain the science-user dialogue*. When PEAC was created, a NOAA Corps Officer was identified to serve as an education/outreach focal point for PEAC. Unfortunately, after the first three years of PEAC operations, the Corps Officer was re-assigned and the NOAA Corps was not able to provide an officer to maintain the PEAC billet until approximately three years ago when a permanent billet was established at the Pacific Region National Weather Service for PEAC and related climate services education and outreach activities. As a result, for a period of about three years, PEAC operated without a designated education/outreach officer. Survey and interview responses during the PEAC review suggest that those user groups who first became aware of PEAC products during that three-year period were less satisfied with their opportunities for input to PEAC product design and implementation than those who were either among the first PEAC users or joined the extended PEAC family of users since the re-instatement of the education/outreach officer. *These results seem to confirm the concept that sustained communication and user engagement is critical to the co-evolution of climate science, information services and climate risk management policies.*

The NOAA/CSC-funded Pacific Assessment education workshops in Pacific RISA jurisdictions are being used to explore local vulnerability, identify information gaps and elicit recommendations for future climate observations, research, forecasting and assessment activities.

The Prescott College project involving the development of a model-based decision support tool for county planning officials in Hawaii was initially designed in consultation with country planning officials and that dialogue continues as the Digital Comprehensive Planning (DCP©) model has evolved. The initial idea for this element of the Pacific RISA program emerged during the initial Pacific Islands climate assessment when the team from Prescott College was invited by county representatives to explore the applications of their model in Hawaii. From the beginning, the development of this decision support tool included an explicit element of stakeholder engagement and, during a recent conversation with the Pacific RISA Director, the project lead (Wil Orr) noted that *the successful development and demonstration of a prototype for Maui County was "one-third (1/3) technical (technology development) and the two-thirds (2/3) a process of shared learning through interaction and dialogue with the intended users of the tool.*

How are stakeholder interactions evaluated?

We have not conducted any formal evaluation of the stakeholder interactions in the Pacific RISA program to date although we anticipate doing so in the future. Members of the Pacific RISA team do query users informally on a periodic basis and exploration of the process of science-user dialogue and interaction is routinely an explicit element of RISA-supported workshops, briefings and training programs.

The PEAC review, however, did include explorations of the effectiveness of PEAC in communicating with users as well as understanding and responding to their needs. As noted, earlier, one lesson learned from the surveys, interviews and workshop discussions conducted as part of the PEAC review is that websites, newsletters, brochures and reports are not sufficient. For PEAC – and the Pacific RISA more generally – sustained interaction with a trusted individual (or group of individuals) is essential. As you will see in the following section, building trust and credibility is essential and that takes, as one member of the extended Team Pacific says, "eyeball-to-eyeball" contact.

What has your RISA learned from the process of stakeholder interaction, and how have its decision processes changed as a result?

Answering the second part of the question first, I'd say that our thinking about the next phase of the Pacific RISA program continues to evolve as a result of our continuous interaction with the users of climate information in the Pacific. For example, discussions during the PEAC review workshop in June 2004 have lead the Pacific RISA team and the National Weather Service Pacific Region to begin development of an integrated Pacific Islands climate information and risk management system in which operational forecasting and other climate services, climate research, assessment programs like RISA and climate-related observing programs are integrated into a single, interactive and mutually-supportive system focused on the needs of Pacific Islands governments, communities and businesses. The Pacific RISA of the future will be shaped by its role in this broader system and that will undoubtedly produce a RISA that is different than one that might have evolved independently as a science program.

Much of what we have learned from the stakeholder interactions in the Pacific region were most clearly articulated in the context of the PEAC review. As described at the AMS 2005 Annual Meeting, some of these key "lessons learned" from the Pacific experience include:

- **Early and continuous partnership and collaboration with users is essential -- shared learning & shared responsibilities:**
    - Among partners in climate information system

- Across local, national, regional and international
  - Between/among providers and users
  - Among user communities
  - Dynamic nature of climate and policy
  - Continuous evaluation and revision—FEEDBACK essential
- **Education, outreach and dialogue activities play a critical role:**
  - Raising awareness and understanding
  - Identifying impacts and exploring solutions
  - Building trust and credibility
- **Building trust and credibility is a long-term endeavor:**
  - Establishing and sustaining "eyeball-to-eyeball" contact
  - Build on existing institutions and trusted information brokers
  - **Maintaining awareness between events – i.e., focus on establishing a sustained, climate information system not just an event-based early warning system**
  - Accommodating relative successes and failures (e.g., 1997-1998 vs. 2001-2002)
- **Forecasts or projections of future conditions must be set in an appropriate context:**
  - Problem to be addressed
  - Historical events, patterns and trends
  - Traditional knowledge and practice
  - Useful and usable information appropriate to the intended application and decision-making community
- **Decision makers in many sectors are interested in climate information on a continuum of timescales from extreme events through seasonal and interannual timescales to projections of changing conditions on timescales of decades and longer:**
  - Exploring linkages across timescales important
  - Extreme events can be a galvanizing focus for planning, response and capacity-building
- **Early experience points to a number of scientific, technical and institutional constraints in specific places/sectors, including:**
  - Communications – systems and language
  - Difference in forecast skill with season, place and parameter
  - Political and institutional boundaries – for both users and providers of climate information
  - Forecasts remain limited by observations, data and computational constraints
  - Understanding of consequences, vulnerabilities and options for risk management still fairly limited.

While some of these lessons are explicitly focused on ENSO-based seasonal forecasting and applications, experience during the Pacific Assessment, the Pacific Islands Training Institute on Climate and Extreme Events and related RISA activities confirm these lessons as important for climate science and services more generally.

How did you develop your process for eliciting stakeholder needs/wants?

As described earlier, the Pacific RISA has evolved from a number of previous activities, programs and institutional experience with climate and risk management in the Pacific. The processes for eliciting stakeholder needs and wants utilized in the Pacific RISA program today are based on approaches used successfully in these earlier programs (e.g., PEAC). An incident during the 1992 workshop that recommended the creation of PEAC has helped shape the Pacific

Assessment approach. Following a presentation on then current capabilities in ENSO-based seasonal forecasting, one of the scientists suggested that "these forecasts are not yet good enough for you to use." The public utilities manager for American Samoa raised his hand with the following question "Professor, do you respect me?" After a brief exchange focused on the difference between forecast skill and forecast usefulness and usability, both scientist and user arrived at the same place – mutual respect and shared understanding of the capabilities and problems on both the supply and demand side of the science-policy equation is essential for success.

Defining the Science Program (Supply Side Assessment)

Briefly describe the research agenda for the Pacific RISA and How does the Pacific RISA set its own research priorities?

The Pacific RISA Program reflects the experience acquired during the first eight years of operation of the Pacific ENSO Applications Center and specifically responds to some of the critical research and information needs identified during the initial Pacific Assessment including:

- Enhancing efforts to monitor, *document, understand and model climate processes and consequences* at local, island, national and regional levels;
- Improving *information on the nature and consequences of patterns of natural variability* including current ENSO and how those patterns might change in the future;
- Improving *understanding of climate-related extreme events* such as droughts, floods and tropical cyclone patterns;
- Enhancing efforts to *identify and evaluate adaptation measures*; and
- Improving *access to useful and usable climate information* to support decision-making related to water resource management, public health and safety, agriculture, tourism, fisheries and coastal resource management.

The research priorities for the first three years of the Pacific RISA were identified in the context of these information needs. The Pacific RISA team will review experience, consult with key partners, and discuss future priorities with the Pacific RISA steering during the coming year in preparation for the submission of a proposal for the second multi-year phase of the Pacific RISA program.

As noted previously, the Pacific RISA program has been organized to *support and enhance the climate risk management activities of Pacific Island governments, communities, resource managers and businesses*. Currently, Pacific RISA provides a programmatic framework for integrating the work of a small suite of climate research, assessment and services activities being supported by NOAA and other sponsors including:

- A review of the first ten years of operation of the Pacific ENSO Applications Center (funded by NOAA's Office of Global Programs);
- A NOAA Coastal Services Center-supported climate assessment and outreach project designed as a direct follow-on to the initial Pacific Islands Assessment of the Consequences of Climate Variability and Change[4];
- A three-year Pacific Islands Training Institute on Climate and Extreme Events being conducted jointly by the East-West Center, the University of the South Pacific and the New Zealand National Institute for Water and Atmospheric Research (NIWA) with support from NOAA and the Asia-Pacific Network for Global Change Research (APN);
- A subcontracted project with colleagues at Prescott College to explore the potential to include consideration of climate variability and change in a model-based, Digital Comprehensive Planning (DCP©) decision-support tool being developed for county officials in Hawaii; and
- An emerging partnership with the National Center for Atmospheric Research (NCAR) as part of NCAR's Extreme Weather and Climate Extremes initiative[5].

[4] The NOAA-CSC project is entitled "Addressing the Challenges and Opportunities of Climate Variability and Change for Pacific Island Coastal Communities" and provides resources to hold local workshops and briefings on the results of the initial Pacific Islands climate assessment produced as part of the first U.S. National Assessment of the Consequences of Climate Variability and Change.

How has this agenda evolved over the duration of the RISA? What projects have been started that were not anticipated at the beginning of the RISA? What projects have been terminated and why?

The Pacific RISA is only two years old so there have not yet been any major changes in the research agenda. Ongoing research and stakeholder interactions during this initial phase, however, have helped identify potential areas of new or enhanced interest including, for example:

- expansion of PEAC forecast products to include projections of sea level variability;
- development of an experiential data base that not only includes information on ENSO impacts but also on the adaptive measures undertaken in Pacific Island jurisdictions during and following the 1997-1998 ENSO event;
- greater integration with climate-related observing systems and programs;
- inclusion of capacity-building program elements including professional internships/fellowships as well as formal and informal education and training programs; and
- enhanced efforts to explore, anticipate and mitigate the consequences of climate variability and change on marine and coastal ecosystems and the sectors that depend upon them (e.g., tourism and fisheries).

No elements of the Pacific RISA program have been terminated during the first two years of the RISA existence. Most of the science programs encompassed by the Pacific RISA program are actually supported with resources from other sources and most will come to an end during the coming year. As a result, the second Pacific RISA program will provide the first opportunity to develop a scientific agenda specifically in the context of the RISA program itself and the Pacific climate information and risk management program to which the RISA program will contribute.

In the Pacific RISA, what is the balance between research on new subjects and assessment/compilation of existing knowledge? How is this balance determined?

Currently, most of the direct Pacific RISA funding and, in fact, funding for the broader suite of Pacific RISA activities is focused on the *assessment process* of shared learning and joint problem-solving with users. In a practical sense, this balance was determined on the basis of limited new funding for the Pacific RISA ($130K in year one and $170K in years two and three) and the need to leverage other, related projects. On the other hand, this balance also reflects the Pacific RISA team's recognition that facilitating a process of dialogue with users was identified as the overarching recommendation from the initial Pacific Islands climate assessment. As noted above, the development of a proposal for a second phase of Pacific RISA funding will provide an opportunity to develop a science, assessment and education agenda specifically for RISA in the context of an evolving Pacific climate information system.

Please describe the specific ways that knowledge is disseminated from the Pacific RISA. How would you assess the relative importance of various dissemination mechanisms, such as peer-reviewed publications, other types of publications, web-based presentations, public for a, etc.?

Much of the dissemination of knowledge conducted in the context of the Pacific RISA is done through public presentations at workshops, briefings and small group meetings and the dissemination of reports, brochures, newsletters, PowerPoint slides in both hard-copy and electronic forms. The rationale for this approach is partly related to funding limitations and the fact that the Pacific RISA program is, currently, comprised of suite of activities originally developed prior to the initiation of the Pacific RISA and focused on outreach, education and dialogue with governments, businesses and communities affected by climate variability and change. It's important to recognize, however, that, based on the past decade of experience in climate forecasting, applications and assessment programs, the Pacific RISA program will probably always include a focus on face-to-face ("eyeball-to-eyeball") interaction as a critical element of the Program's approach to information dissemination. The PEAC review suggests, for example, that an initial commitment to in-country education and outreach activities in the early years of PEAC was one of the keys to the successful adaptation measures taken by Pacific Islands in response to the PEAC forecast of the 1997-1998 event.

The Pacific RISA program does have a website from which formal presentations and reports can be disseminated and through which users can learn more about individual RISA projects and the people involved in them. Past experience, however, points to the significant limitations associated with web access and electronic data and information transmission in the region. As a result, for example, participants in the PEAC review have reinforced the importance of

[5] This emerging Pacific RISA-NCAR partnership is focused on the work of Drs. Jerry Meehl and Linda Mearns.

hard-copy versions of the PEAC newsletter and related Pacific RISA materials.

Peer-reviewed publications will also play a role in the Pacific RISA program but we believe they will be most important to ensuring the scientific quality and integrity of the Pacific RISA program. In the context of supporting climate risk management, the suite of dissemination avenues for the Pacific RISA information will continue to emphasize individual presentations, participation in risk management meetings, committees and task forces, education and training programs, brochures, and written materials tailored for specific sectors/user groups.

Reconciliation/Managing Ecology of Supply and Demand

In what ways have considerations of supply for research shaped the evolution of your research agenda?

The foundations of the Pacific RISA program reflect considerations of both supply – i.e., the emergence of ENSO-based seasonal climate forecasting capabilities – and demand – i.e., recognition of information needs as expressed by user communities through PEAC and the continuing Pacific Assessment process. Certainly, the availability (supply) of a new suite of scientific products precipitated the convening of the 1992 PEAC workshop and set the stage for the creation of PEAC and the emergence of the Pacific RISA program. Similarly, the desire to use new scientific insights to assess the climate-related vulnerability of Pacific Island jurisdictions helped facilitate the initial Pacific Assessment. On the other hand, the programmatic and institutional approaches now represented in Pacific RISA-related projects reflects a growing recognition of the importance of engaging scientists and users as true **PARTNERS** in the endeavor.

Initially, my Pacific RISA colleagues and I found it a bit difficult to respond to this question. The use of "supply and demand" seems to imply a one-way flow of information and actions in the sort of information pipeline often used to environmental forecasting services or the use of scientific information to support decisionmaking. The concept of *"managing the ecology"* of supply and demand and the organizers own research, however, reflect the important recognition that what we're striving for is the co-evolution of knowledge and action (science and policy) and that this kind of shared learning and joint problem-solving requires a continuous process of interaction and exploration. In a way, it's a bit like the emergence of a definition of assessment that reflects both products and process and recognizes that the process itself is as important to the usefulness and usability of assessment reports and other information products as the quality and scientific integrity of the products themselves. I commend the organizers for tackling this important challenge and look forward to the results of our deliberations in Honolulu.

What tensions have arisen between stakeholder needs, demands and expectations, and the scientific capabilities and priorities of the Pacific RISA? How have those tensions been addressed or resolved?

I'm not sure that I'd characterize any of our discussions of user needs and scientific capabilities in the Pacific RISA context as representing "tensions." In part, this may be due to the relative young age of the Pacific RISA. On the other hand, the foundation programs – like PEAC – have amassed a decade of experience. Beginning with the 1992 PEAC workshop, there have been continuous discussions of user needs for information that cannot yet be provided by the climate science community (e.g., timing of the cessation of rainfall associated with an ENSO warm event in individual jurisdictions or higher-resolution projections of the impacts of climate change on rainfall that better incorporates island topography) but the continuous, interactive nature of the dialogue between PEAC scientists and users has tended to maintain a constructive discussion of what can be provided now, how current information is being/can be used and an exploration of what might (or might not) be possible in the future given additional research or new modeling capabilities. The contributions of NCAR to the Pacific RISA program, for example, are a direct result of the desire to explore the potential for more regionally-specific, realistic projections of the effect of climate change on extreme events – a specific area of interest identified by PEAC and the Pacific Assessment process.

In a strange (and perverse) way, I think that the somewhat limited funds available for the initial Pacific RISA may have also helped preclude the emergence of "tensions" between what the Pacific climate science community might like to pursue intellectually and targeted efforts focused on stated user needs. The Pacific RISA has evolved to date as an integrating effort rather than a stand-alone science program so the Pacific RISA team primarily serves as an information broker – facilitating the dissemination of scientific information developed by the broader scientific community and supporting the user interactions that will help guide future climate research and services in the Pacific and the science-user dialogue that, we hope, will enhance resilience in the face of climate variability and change.

How does the Pacific RISA evaluate the appropriateness of stakeholder needs (e.g., from the standpoint of public/private sector roles and responsibilities)?

Since, as described above, the Pacific RISA *currently* serves as more of an information broker than direct provider, I can't say that we've ever had to formally evaluate the effectiveness of stakeholder needs directly during our first two years of existence. Discussions of public versus private roles/responsibilities have emerged as PEAC has evolved from research pilot project to operational element of the NWS Pacific region climate services but not in any dramatic way. I expect that we will face such issues in the future, however, as the Pacific RISA moves into its second stage and I look forward to the lessons being learned by our RISA colleagues in other regions. I also expect that the issue of public versus private roles and responsibilities will be explicitly addressed as we plan for the future of RISA in the context of an overall Pacific climate information and risk management system.

How are stakeholders identified? What stakeholder groups are most important in influencing your RISA research agenda? Why? Which stakeholder groups are least important? Why?

As discussed previously, Pacific RISA stakeholder groups evolved in the context of earlier programs and activities such as PEAC and the Pacific climate assessment process. In the case of both of these foundation programs, the most *active* stakeholders tended to come from the National Weather Service offices in Pacific Island jurisdictions, the scientific community engaged in climate research and assessment and the disaster management, water resource management and utilities sectors – user communities that were already utilizing weather and climate information to some extent in their work and were somewhat familiar with climate system processes or at least the general impacts of weather and climate on their sectors. In other words, these communities represented the early adapters of new climate capabilities such as ENSO-based seasonal climate forecasts. For those independent Pacific Island jurisdictions served by the Pacific RISA program, their national climate change country teams developed in the context of the UNFCCC have also become an important and continuous user community.

Subsequently, the agricultural, public health and natural resource management sectors became increasingly engaged in Pacific RISA discussions and activities. More recently, representatives of the tourism sector, land use/community planning ministries/offices and economic development ministries have become more active partners in the climate risk management dialogue supported in the context of Pacific RISA. Although I hadn't thought of it in these terms before, I suspect that the difficulties are, in part, related to the nature of the supply of climate information available. For example, ENSO-based forecasts and climate change projections tended to focus on changes in rainfall, temperature so the user communities (stakeholders) most active in the early years were those for whom changes in those parameters were most directly relevant.

I also believe that a decision to focus Pacific RISA programs on enhancing resilience to climate-related extreme events has helped engage user communities that were not easily drawn to discussions of long-term climate change (e.g., the tourism sector in the Pacific region). As discussed during a number of Pacific climate discussions, extreme events provide an opportunity to explore climate-related vulnerability in an historical context that most communities and sectors find familiar (most will have recent experience to bring to the table) and can provide an opportunity to develop recommendations for enhancing resilience that can help meet today's problems today while planning for the future.

Finally, discussions of climate vulnerability and adaptation in the Pacific region – including those facilitated by the Pacific RISA program – are highlighting the link between mainstreaming climate information and sustainable development planning. This linkage is helping to bring a broader array of ministries and sectors to the table.

Note that in these discussions, I have avoided the use of the word "important" since I do not believe that the level of engagement by a user group is, necessarily, a reflection of "importance" either in the near or short term. In the sense that active engagement implies influence on program direction, however, there is no doubt that some user communities have been more influential than others in the early evolution of the Pacific RISA program.

How does your RISA evaluate its research planning process?

Two years in, we have not formally evaluated our research planning process although we will be reviewing our scientific agenda in the coming year in the context of developing a proposal for the second phase of Pacific RISA. Pacific RISA workshops and small-group discussions with stakeholders (user communities) usually include an explicit discussion of information gaps and research needs so the Pacific RISA team is constantly receiving input on the extent to which currently available climate information is meeting user needs and providing input on priorities that can be used in planning future RISA programs. Development of a more formal process for planning and evaluating Pacific RISA programs and activities will be incorporated into the development of the proposal for the next phase of the Program. The Pacific RISA Steering Committee – which includes scientists and users – will play a key role in this process.

What lessons in the process of reconciliation of supply of and demand for science are relevant to the broader implementation of the CCSP?

The PEAC review and continuing discussions of lessons learned from Pacific climate assessment work in the context of the Pacific RISA, has helped identify a set of what I call 'guiding principles' for the emergence of a Pacific climate information and risk management system[6]. In the assumption that these concepts may also be helpful in planning for future programs under the CCSP (particularly in the decision support program element), I'm including them here, in shorthand, as a response to this question:

- Focus on the **integrated climate-society system**[7]
- **Utilize a collaborative, participatory process with involving both users and providers of climate information**
  - Science-applications partnerships
  - Continuous, interactive dialogue
  - Co-production of knowledge
  - Public education campaign an essential component
- **Use a problem-focused (vs. forecast-focused) approach**:
  - Understand place, context, history and decision making process;
  - Responsive to user needs
  - Understand vulnerability and focus on building resilience
- **Produce, communicate and apply useful and usable information**
  - Scale, timing, format, language and content appropriate to a particular application community
  - Products and dialogue processes appropriate to user needs
  - Near-term decisions and long-term planning
  - Tools and technologies (e.g., analytical products and discussion/decision support tools) that are appropriate to the user community and application
- **Recognize the importance of climate information on a continuum of timescales**
- **Address both process *and* products** in the design of climate information systems
- Recognize the need for an **integrated program of observations, monitoring, forecasting, assessment, education and applications** – *with continuous evaluation and adjustment*

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[6] An early version of these guiding principles were first developed in the context of the synthesis of a March 2003 Symposium on Climate and Extreme Events in the Asia-Pacific: Enhancing Resilience and Improving Decision-Making. Subsequently, during a September 2004 Galapagos Workshop on El Niño Early Warning for Sustainable Development in Pacific Rim Countries organized by the National Center for Atmospheric Research (www.exploratorium.edu/el_nino), this author suggested that lessons learned in the Pacific region may be pointing toward a set of guiding principles that might be considered in thinking about climate science, services and information systems more generally.

[7] Credit for the phrase 'climate-society system' belongs to Mickey Glantz who used the phrase as part of an opening keynote address at a March 2003 Symposium on Climate and Extreme Events in the Asia-Pacific: Enhancing Resilience and Improving Decision-Making.

- **Build on existing systems, institutions, programs, relationships & networks**
  - Recognize the vital role of trusted information brokers
- **Facilitate proactive decision making and iterative, reflective, flexible and adaptive approaches**
- **Climate risk management – and the information systems that support it – should be set in a sustainable development context**
  - Responding to today's variability
  - Adaptation to long-term change
  - Economic planning & community development
  - Mainstreaming climate information & adaptation

These guiding principles are still very much a work in progress and they are offered here to help support continued discussion of our shared journey toward sustained climate information systems and the mainstreaming of climate information to support adaptation in the face of climate variability and change.

In closing, however, I'd like to offer one more important lesson from the Pacific. It has to do with the meaning of the Hawaiian word ALOHA. The most important element of this word is HA – meaning breath or spirit of life. Hawaiians greeted each other by touching foreheads and breathing deeply – in other words, recognizing and sharing the life spirit, insights, experience and expertise that each brought with them. Scientists, engineers, government officials, businessmen and businesswomen, educators, the media, NGOs, community leaders and individual citizens each bring something important to our understanding of what Mickey Glantz calls the climate-society system and each will play an important role in responding to the challenges and opportunities presented by climate variability and change. If we do nothing else, we must ensure that the CCSP respects ***and supports*** efforts to establish and strengthen science-decisionmaking partnerships like those emerging in the context of the RISA programs.

Appendix 1
Pacific RISA Foundation Programs

Pacific Islands Regional Assessment of the Consequences of Climate Variability and Change

This activity, led by the PI, provided much of the conceptual, scientific and technical underpinning for this proposal. In October 2001, the East-West Center published *Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change for Pacific Islands* (Shea et al., 2001). This report synthesized the findings and recommendations of a two-year project to assess the consequences of climate variability and change for American Flag and U.S.-affiliated Pacific Islands[8]. The Pacific Assessment was conducted as a regional contribution to the first U.S. National Assessment of the Consequences of Climate Variability and Change. Based on extensive involvement of experts and stakeholders from diverse knowledge groups, the Pacific Assessment combined research and analysis of historical patterns and projected trends in climate with an organized program of outreach and dialogue that included two large workshops and small-group discussions with government officials, resource managers, businesses community leaders and scientists throughout the region.

By focusing on vulnerability (sensitivity, exposure and resilience/adaptive capacity), Pacific Assessment participants were able to develop specific recommendations for actions designed to enhance resilience in six key areas: ensuring public safety in extreme events and protecting community infrastructure; protecting public health; providing access to fresh water; sustaining agriculture; sustaining tourism; and promoting the wise use of marine and coastal resources. In the context of these recommendations, participants in the Pacific Assessment encouraged the establishment of a sustained scientific and decision support system designed to promote the development and application of climate information to support decision-making in the region (see Figure 1). The East-West Center is working with other members of the Pacific Assessment core scientific team[9] to build such a Pacific Island climate information system. The final report and additional information on the Pacific Assessment can be found at (http://www2.EastWestCenter.org/climate/assessment).

Pacific ENSO Applications Center (PEAC)

Pacific Assessment participants specifically encouraged strengthening and sustaining ongoing institutions and programs like the Pacific ENSO Applications Center (PEAC) that support decision-making by providing and applying climate information. The concept for a Pacific ENSO Applications Center emerged during a 1992 workshop on ENSO forecast applications in the Pacific organized jointly by the University of Hawaii and NOAA's Office of Global Programs. PEAC began operations as a research pilot project in 1994; beginning in fiscal year 2002, the National Weather Service Pacific Region has assumed operational responsibility for PEAC with resources made available through NOAA's Climate Observations and Services initiative. PEAC is a partnership of the University of Hawaii, the University of Guam, NOAA and the Pacific Basin Development Council, with each partner contributing their special expertise to support the development, dissemination and application of ENSO forecast information to support decision making in critical sectors including disaster management, health, water resource management, agriculture and coastal management. During the 1997-1998 El Niño, Pacific Island governments responded to PEAC forecasts and public education programs by establishing government-wide task forces to prepare for anticipated drought conditions. While those drought conditions were extensive enough to require water rationing in most jurisdictions, the availability and application of advanced forecast information significantly mitigated the negative impacts the 1997-1998 event (See Appendix A for further details). Additional information can be found on the PEAC website (http://lumahai.soest.hawaii.edu/Enso/).

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[8] The American Flag Pacific Islands include Hawaii, Guam, American Samoa and the Commonwealth of the Northern Mariana Islands; the U.S.-affiliated Pacific Islands include the Federated States of Micronesia (Yap, Chuuk, Pohnpei, and Kosrae), the Republic of the Marshall Islands and the Republic of Palau.

[9] The Pacific Assessment core scientific team included: Dr. Michael P. Hamnett (University of Hawaii and co-PI for PEAC), Cheryl Anderson (UH Social Sciences Research Institute) and Dr. Nancy Lewis (East-West Center Director of Studies), all of whom will be actively involved in the work proposed here.

Climate and Health in Pacific Islands

During the past six years, the East-West Center and the University of Hawaii have been involved in a series of related efforts aimed at improving the use of seasonal to inter-annual climate forecasting to reduce the negative impacts of climate variability on people in the Pacific region. The first was a research project that investigated the relationship between El Niño-Southern Oscillation (ENSO) events and water-borne and water-related disease in the Pacific Islands funded by the NOAA Office of Global Programs (NA67J0154). Multiple methods were used in analyzing the relationship between monthly, national-level, epidemiological data (1973-1994) for dengue, diarrheal disease, cholera and ciguatera fish poisoning and ENSO indices. These included Southern Oscillation Index (SOI), Sea Surface Temperature (SST) in the Niño 3-4 region, and rainfall and temperature for 66 locations in the Pacific Islands. A second component of the initial project was added with the onset of the 1997-1998 El Niño. This focused on dengue fever in the Pacific Islands region prior to and during the 1997-1998 ENSO warm event. This was based largely on review and analysis of epidemiological and climate data, and information gathered from PACNET and media reports.

Finally, a two-country study of the impact of climate variability on health in Cook Islands and Fiji has recently begun and is being funded by NOAA's Office of Global Programs and the Asia-Pacific Network for Global Change Research (APN). This new study, which is a collaborative effort involving the East-West Center, the University of Hawaii, the Fiji School of Medicine, the Cook Islands Meteorological Service and Ministry of Health, and the Fiji Meteorological Service and Ministry of Health, will compile and analyze sub-national climate and health data to further assess the feasibility of using climate forecasts to anticipate and respond to increases in the risk of dengue fever, diarrheal disease, cholera, leptospirosis, acute respiratory infections, influenza and ciguatera. An initial project meeting was held in Fiji in July 2001 with support from APN. A workshop to disseminate the results is tentatively scheduled for June 2003 with support from APN.

RISA DOCUMENTS

PACIFIC NORTHWEST: CLIMATE IMPACTS GROUP

http://www.cses.washington.edu/cig/

2005 Workshop on RISA Science Policy
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Climate Impacts Group, Amy Snover
Center for Science in the Earth System
Joint Institute for the Study of the Atmosphere and Oceans
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Demand Side Assessment

- **Who are the major stakeholders for your RISA?**

  The Climate Impacts Group (CIG) has cultivated close connections with public (federal, state, and local), private, and North American tribal groups and agencies responsible for managing the region's water, forest, fishery, and coastal resources. Below we list many of these entities.

Local Level

- Central Puget Sound Water Suppliers' Forum
- City of Tualatin, Oregon
- King County, Washington (County Council, Office of the Executive, Department of Natural Resources)
- Local watershed planning units (Washington State)
- Portland Water Bureau
- Puget Sound Clean Air Agency
- Puget Sound Energy
- Seattle City Council
- Seattle City Light
- Seattle Public Utilities
- Tacoma Power and Light
- Thurston County, Washington

State Level

- Alaska Department of Fish and Game
- California Department of Water Resources
- Idaho Department of Water Resources
- Oregon Department of Agriculture
- Oregon Department of Land Conservation and Development
- Oregon Department of Water Resources
- Puget Sound Action Team
- State Governor's Offices (Washington, Oregon, Idaho)
- State Legislatures (Washington, Oregon, Idaho)
- Washington Department of Agriculture
- Washington Department of Ecology

- Washington Department of Fish and Wildlife
- Washington Department of Health
- Washington Department of Natural Resources
- Washington Division of Emergency Management
- Washington State Office of Financial Management

Federal Level

- Bonneville Power Administration
- International Pacific Halibut Commission
- National Marine Fisheries Service [Northwest Fisheries Science Center and the Alaska Fisheries Science Center]
- National Oceanic and Atmospheric Administration, River Forecast Center
- National Park Service
- U.S. Army Corps of Engineers
- U.S. Bureau of Land Management
- U.S. Bureau of Reclamation
- U.S. Congress, PNW delegation
- U.S. Department of Agriculture, Natural Resource Conservation Service
- U.S. Department of Energy, Pacific Northwest National Laboratory
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- U.S. Geologic Survey

Tribal

- Columbia River Inter-Tribal Fish Commission
- Northwest Indian Fisheries Commission

Other

- BC Hydro (British Columbia, Canada)
- Idaho Power Company
- Northwest Power and Conservation Council
- Northwest Independent Power Producers Coalition
- National Wildlife Federation
- North Pacific Fisheries Management Council
- Oregon State University, Coastal Impacts
- Sustainable Development Research Institute, University of British Columbia
- University of Idaho
- PNW news media (print and broadcast)
- Wild Salmon Center
- Climate Solutions

- **What processes are used to include stakeholders in the research planning process, the research implementation process, and the research reporting process?**

  Interviews and surveys of mid-level managers and senior scientists in natural resources agencies (planning, via assessment of stakeholder needs and knowledge).

Research consultancies (planning, via stakeholder/RISA negotiation of research problem definition; implementation, via consulting relationship; reporting).

Annual water resources planning workshops, occasional targeted workshops for forest/fish/coastal resources, and periodic climate change workshops aimed at upper level policy-makers (planning and reporting).

Informal contacts/discussion at conferences, meetings, in response to email/phone queries (planning and reporting).

- **How are stakeholder interactions evaluated?**

Overall attendance and repeat participation in workshops. Surveys after workshops. Periodic interviews (every 5 years to assess knowledge gain). Number/quality of incoming queries.

- **What has your RISA learned from the process of stakeholder interaction, and how have its decision processes changed as a result? (not sure how this question is different from #1 under 'reconciliation' below)**

Research priorities.

- Ensuring that research results in information useful to stakeholders requires some up-front understanding of the decision context, but stakeholders cannot be relied on to define research agenda (asking them what they want will only get you so far). For example, in 1995 the water resources management community knew little about the predictability of climate variations or associated water resources impacts and, as was later determined, even less about the potential impacts of anthropogenic climate change. It was clear that simply developing pilot water resource forecasting methods in an academic setting would not produce the desired outcome, i.e., their use by water managers. In addition to the development of improved forecasting methods, a well-coordinated outreach effort was required to (1) introduce the water management community to the potential role of interannual climate forecasts in water resources management, and (2) to facilitate the transfer of information from the research context to one of practical water management applications.
- Because CIG's institutional analysis indicated that the regional water resources management system has a much lower capacity to respond to the threat of droughts than to the threat of floods, CIG focused much of its research on projecting and responding to drought-like conditions and outreach on preparing for droughts and emphasized the drought-related impacts of anthropogenic climate change. Because management inflexibility was shown to increase the region's vulnerability to droughts, CIG has focused its research and outreach on ways to use climate information to increase flexibility. Finally, because regional vulnerability to drought is increased by a fragmented management structure, CIG has worked to engage and inform stakeholders from all user groups about using climate information.
- Some activities undertaken in response to requests from stakeholders include: an investigation of climate influences on Puget Sound coho salmon for the Washington State Department of Fish and Wildlife, an analysis for the Washington State Department of Ecology of the ways in which coastal planners use climate information in their long-range planning, expert briefings on climate impacts for state and federal resource management agencies and legislative bodies.

  Spatial scale. CIG learned that the spatial scale of interest is neither the Pacific Northwest nor the Columbia River basin, but the individual watershed. Moreover regional differences in climate sensitivities and resource constraints mean that research and outreach need to be targeted to different sub-regions of the PNW. As a result, we hold several parallel water resources planning workshops at different locations around the region each fall, with the content tailored to each location, and have expanded CIG's research scope to include hydrologic modeling of the smaller-scale urban water systems west of the Cascade Mountains.

- **How did you develop your process for eliciting stakeholder needs/wants?**

We began by interviewing representatives from organizations that were judged likely to use, or able to benefit from the use of, climate information in operational decisions. Much of the information obtained from these interviews about the extent of understanding and (lack of) utilization of climate information shaped CIG's subsequent research and outreach strategies.

Interviewees and other identified members of the user community were invited to CIG's annual meetings wherein the team presented research results and proposed future work and asked to provide feedback on the team's approach and findings. In order to facilitate personal, less formally structured communications between the research team and the regional community, the meetings were also used to introduce the "targeted" users to the specific CIG team members working in their area of interest.

In July 1997, CIG hosted a workshop on "The Impacts of Global Climate Change on the PNW", in order to initiate a dialogue with regional stakeholders concerning potential impacts of future human-caused climate change on the PNW, important regional vulnerabilities, and strategies for adaptation. In addition to the public agencies already engaged by the regional assessment project, the expanded group of stakeholders targeted for this workshop included city and state elected officials, the business community, and the public (represented by non-governmental organizations). CIG teamed up with the Northwest Council on Climate Change, a local organization focused on public education concerning climate change, in order to utilize that group's established contacts with elected officials, the business community, and the public. Targeted members of the user community were asked to assume leadership roles at the workshop (as discussion facilitators or rapporteurs) to simulate their engagement with the topic. Many of these targeted stakeholders have since become active members of CIG's user community.

Throughout the years, CIG team members have expended significant effort behind the scenes to foster and maintain informal relationships with the user community. As a result of contacts made through the above-mentioned interviews, annual meetings, and workshops, as well as on-going networking efforts, team members have many opportunities for eliciting stakeholder needs and/or wants. In addition, stakeholders now initiate conversations with CIG on potential research projects which sometimes result in formal research consultancies.

Supply Side Assessment

- **Briefly describe the research agenda for your RISA.**

  The **Climate Impacts Group (CIG)** is an interdisciplinary research group studying the impacts of natural climate variability and global climate change ("global warming") on the U.S. Pacific Northwest (PNW). The CIG's research focuses on four key sectors of the PNW environment: water resources, aquatic ecosystems, forests, and coasts.

  The Climate Impacts Group (CIG) is working to further our understanding of the patterns and predictability of regional climate variability, the influence of climate variation on the Pacific Northwest (PNW) environment and its institutions, and strategies for increasing societal resilience to climate. CIG's research is fundamentally organized around an analysis of PNW climate, augmented by an examination of regional socioeconomic systems. Our advancing understanding of regional climate – the patterns of its variability in both space and time, the predictability of those variations, and the projections of future changes in climate – helps us to focus our research on those components of life in the PNW that are likely to be most affected by climate fluctuations and on information that could be incorporated into decision making. The examination of regional eco- and human systems subsequently narrows the field to points where ecological sensitivity and human sensitivity coincide.

  We examine how climate variations and human choices have interacted in the past to produce societal impacts. We then use this information to develop projections of future climate impacts. By specifying the processes through which natural variations in regional climate were manifested as impacts on natural and human systems, and by understanding the role that human choices played in determining these impacts, we establish a basis for suggesting how the same systems may respond to future climate change. By evaluating how human systems can adapt to better cope with or respond to climate variability, we can suggest how these same systems might adapt to future climate change.

- **How does your RISA set its own research priorities?**

  The crucible for making those decisions is the Principals' Group of sub-group leaders which functions as the executive committee of the team. The group meets regularly, at least quarterly and whenever circumstances demand. The team also goes through a formal strategic planning exercise every five years.

We consider: the state of knowledge relative to the regional climate system, linkages to sectoral impacts via environmental sensitivities, the level of understanding achieved within and across sectors, and input from the large group of stakeholders about their needs and desires based on their participation in workshops and partnerships and on their responses to our quinquennial surveys of the community. We look for missing pieces and disconnections in the flow of information from climate forecasts to regional resource managers and we focus our efforts in these problem areas. We also use the feedback from our outreach program to understand where these kinds of problems are from the resource manager's perspective and attempt to balance academic research needs with those of the water resources management community.

We have also made considerable efforts to maintain an equitable balance between climatically distinct parts of the region (east and west of the Cascades, for example) and between different kinds of water resources systems (e.g. hydropower vs. urban water supply vs. irrigated agriculture). Because of limited resources, this balance has been challenging to maintain in that we are constantly confronted with the tradeoffs between our desire to create more depth in one area of research and our desire to provide broader coverage of issues that are important to different constituents in the region.

The planning is as comprehensive in scope as we can make it with decisions about priorities based on available funding.

- **How has this agenda evolved over the duration of the RISA? What new projects have been started that were not anticipated at the beginning of the RISA? What projects have been terminated, and why?**

  Evolution.

  - Changing (ever finer) spatial scale of analysis.
  - Planned progression of emphasis from climate, to impacts on natural systems, impacts on human systems, and response strategies.
  - Planned progression of focus on exclusively natural climate variability to both climate variability and anthropogenic climate change.

  New projects. Many, including

  - Large scale patterns of salmon production and their relationship to the PDO,
  - Connections between tree growth and regeneration and the PDO,
  - Research to support development of decision support tools tailored for specific management needs at relatively small spatial scales,
  - Snow-hydrology,
  - Water markets & institutions for coping with water shortages.

  Temporarily terminated. Pilot studies of climate impacts on the coastal zone and on human health (due to lack of funding).

- **In your RISA, what is the balance between research on new subjects, and assessment/compilation of existing knowledge? How is this balance determined?**

  At the start of the RISA project as well as any new research effort, we perform a literature review and overall assessment of existing knowledge on the topic. The RISA quickly reaches the limits of knowledge concerning climate impacts on PNW resources, requiring research in each individual sector (climate, water resources, forest ecosystems, marine ecosystems) for advancement. Simultaneously, two members of CIG focus on integrated assessment. The balance is reflected in the proportion of sub-group leaders responsible for research (6) and for integrated assessment (2).

- **Please describe the specific ways that knowledge is disseminated from your RISA. How would you assess the relative importance of various dissemination mechanisms, such as peer-reviewed publications, other types of publications, web-based presentations, public fora, etc.?**

  Peer-reviewed publications. CIG-generated reports and white papers (gen. distributed at meetings and via CIG website). Commissioned reports and white papers (delivered to (sometimes distributed by) client and via CIG website). Web site (overview of role of climate in PNW natural resources, climate impacts, research results, forecasts, climate outlook; papers, presentations). List-serve. Quarterly newsletter (email). CIG-hosted meetings and workshops. Presentations, guest lectures, briefings for public meetings, government agencies, conferences, classes, and special events. Participation in/organization of scientific meetings/workshops. Consultancies and technical assistance. Work with the media. Academic courses at UW. Weekly seminar series. Email queries. Technical review of climate impacts reports/studies.

  Relative importance. Peer-reviewed publications are indispensable foundation for credibility of our work. Less technical interpretations of the same material (reports and white papers) are essential for communicating with many of our stakeholders. CIG-sponsored workshops and invited briefings are an enormously important component of our knowledge dissemination. Newly revamped web-site is a very important resource for communicating within group and with stakeholders.

Reconciliation/Managing Ecology of S&D

- **In what ways have considerations of supply for research shaped the evolution of your research agenda?**

  For a project to be undertaken by CIG scientists it must be work that will move science forward (rather than simply applying old methods to a slightly different case study), i.e., be scientifically interesting.

  We certainly consider/are constrained by the supply of research from NCEP (climate prediction capabilities) and global climate modelers (e.g., GCM projections of anthropogenic climate change (shifts in means and variability).

- **What tensions have arisen between stakeholder needs, demands, and expectations, and the scientific capabilities and priorities of the RISA? How have those tensions been addressed or resolved?**

  Tensions (how addressed).

  - Push to ever smaller spatial scale vs. resolution of climate information and degree of financial support for research. (Use case studies to develop methods and demonstrate feasibility of working at smaller scale, focus on case studies with broad applicability, look for local support for work.)
  - Demand for fine scale, precise, deterministic forecasts to enable maximization of resource utilization vs. limits of predictability and understanding. (Change focus of research and outreach from prediction to resilience.)
  - Demand for research on coastal systems, irrigated agriculture, and human health vs. funding support. (Still looking for funding.)

- **How does your RISA evaluate the appropriateness of stakeholder needs (e.g., from the standpoint of public/private sector roles and responsibilities)?**

  We refuse to engage in proprietary work and require openness of information/data produced in research. Favor research with potential for wider application rather than one-off case studies.

- **How are stakeholders identified? Which stakeholder groups are most important in influencing your RISA research agenda? Why? Which stakeholder groups are least important? Why?**

  CIG began by identifying the entire suite of resource management agencies in the PNW, i.e., municipal, state, regional, tribal, and federal resource management agencies dealing with water resources, forest resources, fisheries, and/or coastal management. For tractability, the team planned to focus first on public and tribal agencies, then on private organizations. We chose not to target environmental organizations due to their different focus and the fear that their involvement would prevent candid dialogue with resource managers, private industry, and elected officials. Since this initial assessment, CIG has added to its stakeholder list by continued networking, still seeking resource management and planning entities whose operations are likely to be affected by climate variability or climate change. We focus on stakeholders with a wide reach, i.e., those that represent or provide a conduit to a larger group and those likely to be early adopters of new climate information (in order to develop case study information for use by other stakeholders).

- **How does your RISA evaluate its research planning process?**

  Periodic external reviews. Internal assessments by principals group and periodic strategic planning.

- **What lessons in the process of the reconciliation of supply of and demand for science are relevant to the broader implementation of the CCSP?**

  Research about climate variability and future climate change is purely an academic exercise, unless the results are useful for, and used in, decision making and long-range planning. Research must be grounded in the issues and time frames salient to specific decisions and/or decision makers.

  Demand for scientific information is strongly a function of the biogeophysical and socioeconomic characteristics of a specific location. Scientific research therefore needs to be specifically tailored to the specific conditions and concerns of that context.

  A mutually satisfactory research and outreach agenda requires finding the overlap between stakeholder needs (decision calendars, context, management purview) and scientifically interesting/tractable problems.

  Stakeholders are never interested in global warming only--the time scales of interest must range from seasonal-to-interannual to decadal time scales.

  A research program focused on providing useful information to stakeholders needs strategies for providing (in an operational sense) the ultimate products developed by the research, so as to prevent overtaxing research teams (or converting them from research to operations).

  In order for a research group to have credibility with stakeholders, it needs to have demonstrated itself to be a stable and dependable entity over a significant time period in the past (5+ years) *and* projected into the future.

  The only way to deliver useful information to stakeholders is by sustained engagement with these stakeholders. Operations that do not take this sustained engagement as a guiding principle will surely fail.

RISA DOCUMENTS

SOUTHEASTERN CLIMATE CONSORTIUM

http://secc.coaps.fsu.edu/

Climate Information and Agricultural Decision Support in the Southeastern U.S.: A Partnership Linking User-Driven Research and Operational Services

By the Southeastern Climate Consortium:

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Abstract prepared for the Science Policy Research and Assessment on Climate (SPARC) RISA Workshop, Honolulu, August 15-17, 2005.

Who We Are

The Southeastern Climate Consortium (SECC) provides information and decision aids to help producers in three southeastern states reduce economic losses associated with climate and weather variability. Vulnerability of southeastern agriculture to climate fluctuations and weather extremes prompted formation in 1996 of a consortium of universities (Florida State, Florida, Miami, and Georgia, Auburn and Alabama-Huntsville) to capitalize on the predictability of climate impacts associated with ENSO. Our work is performed as a partnership between NOAA's Office of Global Programs, USDA, the Cooperative Extension Services and state climatology offices in each state, and the investigators. We intend our research and outreach to have a wide ranging, operational impact on productivity and profitability of selected crops and forestry. Fundamental to our approach is a symbiotic relationship between the research and operational communities.

User-Driven Research and Operational Services

If a climate information system is to be sustainable, the initial, research-intensive stages must transition toward an appropriate balance of operational and research activities. We have found agricultural applications of climate information require multi-disciplinary, multi-institutional collaboration and active involvement of decision makers from the start. Sustained interactions with growers, through operational entities such as the Cooperative Extension Service, help guide our research and amplify its impact.

Our research is of necessity demand-driven. Translating imperfect ENSO□related climate forecasts into information useful for improved decision making is a complex issue that goes well beyond simply producing better climate forecasts. Through our studies, we learned that simply documenting the effects of climate variability and providing better climate forecasts to potential users are not sufficient. Producers need feasible alternatives for adaptive actions in response to climate forecasts, and they must understand risks associated with these options to realize benefits. In many meetings with farmers and extension personnel, we found strong interest in learning more about climate variability impacts and in the use of localized climate information to improve agricultural decisions. Further, these interactions identified several decisions that could be changed in response to a climate forecast. In several instances, we identified farmers who have been using ENSO information. But, in general, farmers want more information and decision aids. We have conducted research to estimate the economic value and risks of using ENSO-based climate forecasts in several commodities and concluded that a high potential exists. However, due to the biophysical, societal and institutional complexities of agricultural systems, decision aids and technical assistance are needed to bridge the gap that now exists between climate forecasts and their routine applications.

Climate information systems must balance research and service, which in turn requires that academicians partner with operational entities. Academia offers few rewards for operational efforts, and fortunately groups and agencies with operational mandates exist to do the job better than we could. Our efforts would be naïve and likely counter-productive if we did not recognize and take advantage of the existing agricultural and climatological technological infrastructure. The agricultural and climatological extension systems (the Cooperative Extension Services and state climatology offices in each state) have emerged as our major partners, providing a conduit for information flow from our research effort to end users, and helping prioritize our research efforts.

Our cooperation with agro-climatological extension has allowed us to evolve from a research-oriented project to a proto-operational one, and has three motivations. First, the experience of agro-climatological extension in facilitating other technological transfers helps us understand how to disseminate climate information effectively. Second, agro-climatological extension offers a readily available infrastructure for delivery of information and evaluation of its effectiveness. Third, the relationship of trust that state climatologists and agricultural extension already enjoy with farmers facilitates the iterative bridging process between forecast producers and users.

Approach

The SECC develops new information associated with climate-induced risks to agriculture and forestry and new decision aids for helping producers reduce economic risks and increase profits. Our approach has two main themes. First, we focus on climate analyses to produce forecast information for use at local scales and to produce data products necessary for analysis of uncertainty and risks to agriculture and forestry in the 3-state region. Second, we analyze climate variability effects on important yet vulnerable crops and develop decision aid products for them and for forest management. Our studies originate directly from interactions with farmers and extension agents, and build upon our assessment of how ENSO affects SE agriculture.

We use generic approaches so our results can be applied to other crops and SE states. For example, our analyses use crop simulation and economic models to translate climate and weather variability into economic and environmental risks. Our peanut, potato, livestock forage and tomato case studies use crop simulation models in the DSSAT suite of models. Since DSSAT also has models for many other crops--all of which use the same farm-specific soil, management, and weather inputs--our analyses can be extended to other crops and regions.

Climate-related risks are not the same for all crops due to differences in the crops themselves, management systems, soils, and the climate that occurs during the growing season. We selected four crops because of their economic importance to the 3-state region and because they offer an opportunity to develop and evaluate risk reduction products for very different types of risks. For livestock winter forage and peanuts, the most important risk is limited rainfall during their different growing seasons. In the case of winter-grown tomato, excess rainfall reduces yields, and prices vary with monthly harvests. The potato crop requires high levels of nitrogen fertilizer, which may leach during high rainfall.

The SECC partnership of user-driven research and operational services builds on previous research for selected crops, to develop and evaluate risk reducing management options and decision aids that make use of climate and weather forecasts.

RISA DOCUMENTS

SOUTHWEST: CLIMATE ASSESSMENT OF THE SOUTHWEST

http://www.ispe.arizona.edu/climas/

Demand Side Assessment

- Who are the major stakeholders for your RISA?
  - The major stakeholders for CLIMAS are air quality managers, water resource managers, fire managers, land-use managers, public health officials, small-scale agriculturalists (including ranchers), tourism and recreation concerns, county and municipal managers. (See list attached at end of document.)
- What processes are used to include stakeholders in the research planning process, the research implementation process, and the research reporting process?
  - The two major processes that CLIMAS uses to include stakeholders in research planning are dialogue development, and taking advantage of events and opportunities. In the former, we develop topical dialogues on subjects important to stakeholders. During the process we exchange information, learn each other's vocabulary, and through iterative interactions refine concerns and problems into researchable questions. An example of the former is our work with air-quality managers in the Southwest. We developed our air quality research agenda through initial contacts with federal or regional agency offices (EPA, Western Governors' Association) and state or county-level departments of environmental quality. We then conducted a stakeholder workshop together with one of our partners (Pima Association of Governments), in which we garnered advice on decision contexts, and useful research outputs. The workshop allowed us to identify early adopters and research collaborators, who advised us on site selection and data to use in model development. In the latter example of our processes, stakeholder contacts, developed during the course of the project, have invited CLIMAS PIs to serve as co-authors on white papers and other reports. These reports were driven by events, e.g. severe drought, requiring expert input.
  - During the early years of CLIMAS we tried instituting an advisory board, with a multisector focus, to assist in developing a research agenda. The advisory board process was not sufficiently productive at the time and was discontinued in favor of other sector and project-specific forms of interaction and feedback.
  - Today, we include stakeholders in the research implementation process through information sharing, and review and evaluation of products. For example, CLIMAS researchers participate in an ongoing multidisciplinary research forum on Valley fever, an important public health risk in the semi-arid United States. Medical researchers in the forum advise CLIMAS researchers on continued basic science research and refinements to a decision-support tool developed by CLIMAS; in addition these researchers exchange data and information with CLIMAS. We have included stakeholders in reporting CLIMAS research through workshop presentations and internal reviews of manuscripts.
- How are stakeholder interactions evaluated?
  - Evaluations of stakeholder interactions vary depending on the purpose of the evaluation. Evaluations may be done, for example, to determine allocation of project resources and potential need for leveraging from other sources, to prioritize research initiatives, to assess success in knowledge transfer and exchange, and to assess the utility, usability, and timeliness, of specific products or suites of products.
  - One criterion for evaluating success is receipt of repeat requests for interaction or information. In some cases, achieving sustained interaction is a metric for evaluation. In our work with the Governor's Drought Task Force, for example, interactions have led to enhanced credibility, continued engagement, and involvement in larger initiatives. In other cases, such as our experience in generating interest in paleoclimate information, stakeholders did not respond until years later, when an event (in this case, severe drought) generated interest.

- What has your RISA learned from the process of stakeholder interaction, and how have its decision processes changed as a result?
  - The most valuable lesson we learned was that stakeholder interaction requires iterativity, which Lemos and Morehouse (2004) defined for integrated assessments as achieving three objectives: a good fit between knowledge production and application, disciplinary and personal flexibility, and availability of resources. Achieving iterativity requires ongoing collaboration, time, persistence, and identification of areas of mutual concern and interest.
  - Developing multidirectional formal and informal communication channels, and developing ***trust*** between scientists and stakeholders are also fundamental to building sustainable stakeholder relationships. These goals are most effectively achieved by working at regional and sub-regional levels.
  - Stakeholder interactions have affirmed the very high value of working in an area that has regional-scale ecological, climatic and social coherence; such coherence facilitates development of knowledge and products that cut across geographical locales and social structures. At the same time, demand exists for climate information that has salience at subregional levels, especially at the watershed scale. Stakeholders participating in our drought-related research expressed the need for watershed-scale drought analysis, forecast, and planning information. The watershed is a unifying theme for climate vulnerability assessment, because commonalities in livelihoods, water supplies, natural resources, and management concerns are linked at this scale. Based on this insight, we have tailored our rapid rural climate vulnerability assessments to the watershed scale. Moreover, in 2003-2004 we decided to invest resources and effort to an integrated multidisciplinary investigation of vulnerability to long-term climate variations and climate change in a single watershed.
  - We have also found that tailoring information to fit stakeholder needs, for example to fit decision calendars, is very important (Bales, Liverman and Morehouse 2004). For example, working with fire managers we learned that key resource allocation decisions are made by March of each year. We also learned that fire seasons very geographically across the country. Therefore, we adapted our annual fire-climate workshop to meet stakeholder needs, by holding a separate winter workshop for the eastern and southern United States, and a spring workshop for the rest of the country. Working in conjunction with the Western Water Assessment RISA, we decided to put greater effort into climate education for fire managers and to emphasize particular climate products valued by those managers (e.g., 14-day and seasonal forecasts, and snowpack monitoring tools).
  - Our END InSight project (Carter et al. submitted) demonstrated the importance of conducting longitudinal studies of use of climate information and of packaging specific products and thematic information pages, with interpretive guidance, on a regular basis.
  - We learned how to better estimate the amount of time and effort involved in stakeholder-oriented projects and processes. Effective projects require evaluating trade-offs between project breadth and time. We decided to invest more heavily in a smaller number of projects that are sustained, lead to improved multidisciplinary integration and increased stakeholder contact. We now attempt to explicitly address stakeholders' short-term (often value-added repackaging of existing information) and long-term (novel research) needs. By balancing our work on multiple time horizons, we can gradually develop the resources necessary to meet stakeholder needs and maintain relationships, with less team burn out and more realistic stakeholder expectations.
  - We learned how to better define research questions, in order to simultaneously meet stakeholder needs for usable information and academic needs to perform challenging and publishable research.
  - Our decision processes now include a greater role for partnerships. We realize that information is often best served through intermediaries, such as cooperative extension. These intermediaries typically serve as boundary organizations between our activities in collaborative production of applications-based science – which can include stakeholders – and diffusion of that scientific knowledge to users. In this process, we realize that it is of

paramount importance to identify early adopters and key informants, as these people are likely to multiply the effectiveness of our efforts. Moreover, we realize that we cannot do everything for all stakeholders with our limited resources. Partnering expands our capabilities, enhances our credibility and promotes greater acceptance of research results, as well as decision support processes and products.

- How did you develop your process for eliciting stakeholder needs/wants?
  - Stakeholder needs/wants are elicited through a combination of supply and demand or push and pull. In some cases we "push" information and research that we suspect stakeholders need. In other cases, things develop "organically," out of explicit or implicit stakeholder articulation of needs. An example of this latter case may be found in development of downscaled climate information in response to repeated comments from stakeholders that existing information was too coarse to be useful in their decision making processes. Specific efforts to identify stakeholder needs/wants include an initial stakeholder survey conducted at the inception of the CLIMAS project, participation in meetings such as those held by local cattle growers' association groups and by the Natural Resource Conservation Districts, organization of workshops for specific sectors such as water resource management, and organization of workshops involving a mix of stakeholder interests. One of the significant outcomes of these types of collaborations was a demand-driven pull for a formal forecast evaluation product that went beyond evaluation of individual forecasts.
  - We also elicit stakeholder needs and wants through rapid rural multi-sector assessments of vulnerability to climate variability and change. Our rapid rural assessments are based around watershed boundaries and common livelihood issues. Key to the effectiveness of rapid rural assessments are snowball sampling techniques, repeated intensive visits that include extensive ethnographic interviews, and integration between CLIMAS social and physical scientists.

Supply Side Assessment

- Briefly describe the research agenda for your RISA.
  - The CLIMAS phase 2 (2002-2007) research agenda is guided by the following overarching science questions:

    Climate and hydrological variability and forecasts

    - What is the nature, and what are the causes of climatic and hydrologic variability in the Southwest on interannual, decadal, and century time scales?
    - How do climatic and hydrologic variability vary geographically within the region?
    - How predictable is seasonal to inter-annual climate and hydrology, and how might better mechanistic understanding of climate affect predictability?

    Vulnerability and impacts

    - What are the impacts of climate variability on local populations and what sectors are particularly vulnerable?
    - How does climate variability affect Native Americans and their lands, and what sectors/populations are particularly at risk?
    - What are the impacts of climate variability on ecological processes and interactions, and on conservation/preservation efforts?
    - How do local populations adapt - short term and long term - to climate variability, and how do larger changes in the economy and in resource tenure influence their ability to cope?

    Use and value of climate information

    - What use is being made of climate information in the Southwest, what is the demand for and value of improved climate information, and how can climate information and uncertainty be best communicated to stakeholders?
    - How might a better understanding of climate benefit vulnerable stakeholders in the Southwest?

    - How can economic information and incentives analysis contribute to improving dissemination and use of climate and related information?
    - What are the best methods for integrating information on climate, hydrology and vulnerability into assessments and decision support systems that respond to regional needs?

  - Tasks include the following:
    - assessment of vulnerability and adaptation to climate in representative southwestern rural communities and in northern Mexico;
    - analyses focusing on the co-production of science in the water and fire sectors;
    - economic analysis climate impacts on water and agriculture;
    - investigation of climate and health interactions;
    - research on climate-fire interactions, and annual fire-climate workshops;
    - climate and hydrologic forecast evaluations;
    - improvement of snowpack assessment for hydrologic forecasting (discontinued in summer 2005),
    - refinement and expansion of fine-scale, gridded paleo and modern climate data;
    - diagnostic studies focused on the nature and causes of climatic and hydrologic variability in the region;
    - research on drought planning and drought management;
    - development of CLIMAS information products, in conjunction with agency partners;
    - structured assessment of stakeholders' interpretation and use of climate information, including stakeholders' needs for climate information.

- How does your RISA set its own research priorities?
  - CLIMAS has relied on the overall objectives outlined in the NOAA-OGP RISA Program description to formulate our research agenda. We are committed to gaining a better understanding of climate and its impacts in the Southwest, and to providing insights and information regarding what sorts of climate services/products are needed by whom, when, and for what purposes.
  - The initial research priorities were in part guided by a USGCRP climate change workshop held in Tucson in 1997. The need for better climate information to manage water resources, for example was a major theme stressed by participating stakeholders. Two other important decisions were also made as a result of this initial meeting; the first was to emphasize climate variability as a way of engaging a range of stakeholders who might have rejected efforts related to climate change, and the second was to draw on lessons from the Human Dimensions of Global Change community by explicitly emphasizing the integral nature of the social sciences in climate assessment.
  - Research priorities are set, in part, in anticipation of or in response to events. For example, the decision to place a high priority on fire and drought research was a result of (a) anticipated needs for climate information on these topics -- based on the results of prior research, forecasts, and careful climate monitoring, and (b) needs expressed by agency partners and stakeholders.
  - Research priorities are also determined based on available expertise and resources.
  - The mechanics of setting the research agenda, include
    - exchange of information and discussion of research and "climate events"during bi-weekly team meetings
    - discussion and setting of preliminary research priorities by CLIMAS executive committee
    - changes to research priorities are made by consensus of all CLIMAS PIs
    - changes to overarching goals and guidelines are made during proposal processes

- How has this agenda evolved over the duration of the RISA? What new projects have been started that were not anticipated at the beginning of the RISA? What projects have been terminated, and why?
  - Our fundamental research agenda of linking science and stakeholders, as outlined above, has remained relatively unchanged over the duration of CLIMAS. Naturally, there have been changes in the selection and mix of specific projects over time that reflect "adaptive management" in response to recognized opportunities. These fall into two categories:
    - Probably the largest evolution of our research agenda was the decision to be nimble in responding to opportunities. While these new projects fit clearly within our vision and mission, we did not anticipate their scope or topic in our formal proposal. This flexibility has been exceptionally valuable, resulting in several of our most successful projects. These projects grew rapidly out of initial contacts and exchanges, and required internal reallocation of priorities and funds within the confines of an annual budget cycle (see the next section on "New projects, not anticipated" for examples).
    - A second evolution was recognizing the variation in individual project life cycles. Some are finite in time, centered around a product or service, others have a high-activity phase (e.g., in association with a graduate student thesis, or a climate event) sometimes preceded and usually followed by a period of lower activity with sustained contact, and yet others are more-or-less permanent over time. This view is a strong departure from conventional research grant practice, and it also underscores the flexibility needed to optimize CLIMAS activity with stakeholder needs.
    - Both of these valuable developments in the character and execution of our research agenda have been enabled by an extended funding commitment from NOAA. This commitment has also enabled us to sustain critically important long-term iterative relationships with stakeholders.
  - New projects, not anticipated:
    - Fire sector research. In particular, we did not anticipate collaborative work on fire outlooks and fire management decision-making processes.
    - Monthly climate outlooks. We did not anticipate the combination of El Niño and drought and other potentially confusing climate situations that might require a rapid response to stakeholder needs for information. Moreover, we never anticipated the ongoing need for quasi-operational climate information products, and the value that producing these products would provide to the project.
    - In 1997, when the project was conceived, we did not anticipate the relatively rapid development of extreme drought in the Southwest. Therefore, we did not anticipate our extensive foray into drought planning, drought policy, and supporting operational drought monitoring.
    - We did not anticipate that forecast evaluation would require long-term, sustained effort.
    - We added resource economists to the project, in response to stakeholder and agency needs for information on the economic impacts of climate variability.
    - The CLIMAS fine-scale climate mapping project, based on multi-sector stakeholder requests for improved data, evolved into the multi-institution WestMap initiative (now funded under NOAA-OGP's National Climate Transition Program).
    - We did not anticipate inter-RISA research projects and other efforts.
    - We did not anticipate the need for "Climate 101 for Society," and the requests for workshops and materials to build capacity for decision-making. These workshops have become somewhat of a cottage industry.
    - In 1997, we did not anticipate the emergence of West Nile virus as a major climate-related public health threat.
  - Terminated projects.
    - We terminated spatial snow estimation project, due to the need for extensive additional resources. In addition, this project suffered from a, lack of stakeholder engagement during the long turnaround time

necessary for the development of a decision-support product.

    - The paleoclimatology basic research effort was completed. An investigtor left the project, in order to pursue more basic science research. The project continues through the analysis of the data produced during the first several years of the project.
    - The Native American research project was terminated at the request of the Native American community. They preferred to be included as part of sectoral research, rather than be considered as a unique sector.
    - CLIMAS ranching initiatives were terminated after investigators left the project. The first investigator left the project after completion of initial reports to providing background on ranching stakeholders. The second investigator, who researched rangeland economics, left the project after failing to attain tenure at the University of Arizona. CLIMAS continues to work with ranching stakeholders, albeit in a less structured manner.

- In your RISA, what is the balance between research on new subjects, and assessment/compilation of existing knowledge? How is this balance determined?
    - The balance between new research and assessment/compilation of existing knowledge is not readily quantifiable, but we estimate that fundamental research (i.e., research that seeks to produce new knowledge) accounts for about 40 percent of our effort, and assessment/compilation for about 60 percent.
    - Broadly speaking, the balance between new research and assessment/compilation of existing knowledge is negotiated through interactions within our Executive Committee and with the full complement of CLIMAS PIs. The Core Office provides a substantial balancing point through its responsibilities for building bridges between science and society, which involves disseminating existing information as well as participating in the development of products based on new research.
    - In some cases, work on new projects has been driven by the thesis interests of individual graduate students (e.g., the Valley Fever research effort).
    - In other cases, events (eg, the recent drought) have generated opportunities to mobilize, refine, and package existing knowledge to meet stakeholders' specific needs.
    - Also influential in balancing our research activities is viewing our activities as a progression over time, beginning with a "Climate 101" effort to educate stakeholders about what information exists, where/how it can be accessed, and what it says about climate, through vulnerability assessment to identification of needs that can be met through value-added compilation, evaluation, and repackaging of existing information and, where appropriate, new research to fill identified needs.
    - An additional, and very important, factor is keeping up with or staying ahead of current topical issues and events and sustaining sufficient flexibility to mobilize when conditions provide unanticipated opportunities for identifying and filling needs for climate information and climate research.
    - An example of balancing new research with compilation is the CLIMAS paleoclimate effort. We did not develop any new tree-ring *chronologies* (which requires field work); however, we developed new tree-ring *reconstructions* (which requires analysis and re-combination of existing data) using improved methodology. The stakeholder interest was long, climate division-level paleoclimate information; the scientific interest was comparison and evaluation of methods used to create the reconstructions.
- Please describe the specific ways that knowledge is disseminated from your RISA. How would you assess the relative importance of various dissemination mechanisms, such as peer-reviewed publications, other types of publications, web-based presentations, public fora, etc.?
    - CLIMAS disseminates knowledge through the following mechanisms: peer-reviewed publications, white papers and conference proceedings, trade journal articles, quarterly newsletters, factsheets and brochures, occasional web-based PDF reports, monthly web-based publications, web pages, interactive web tools, e-mail listservs, newspaper opinion pieces, public talks, stakeholder workshops, academic conferences/stakeholder

conferences, climate-related training sessions, and press briefings.

- Text-based dissemination.
    - Peer-reviewed publications are most effective for conveying results to our scientific peers. Very few, more sophisticated, stakeholders are interested in peer-reviewed literature.
    - White papers are enthusiastically received by agency stakeholders, committees, and mid-level resource managers, as they provide substantial detail and can be made available in hard copy and on the web.
    - Newsletters, factsheets, brochures, are effective at reaching many managers, and for disseminating interim results at workshops and conferences. Some managers have commented that they are more likely to read items 1-4 pages in length than they are to read longer items. We make many of these items available on the web, as well.
    - Our monthly climate summary is disseminated by e-mail notice accompanied by an executive summary and a link to PDF and HTML versions. Stakeholders have remarked that 2-4 page articles that accompany the monthly summaries are exceedingly valuable, because they provide a combination of climate fundamentals, new insights, and evaluation of recent events, all of which are written in a journalistic style. Stakeholders remarked that they were not aware of similar easily-accessible materials on regional climate topics. Our investigations indicate that stakeholders value regular, monthly climate-related content presented in a consistent format.
    - We have only recently delved into trade journal publications, so it is too early to evaluate their effectiveness. However, water resources managers indicated that they would be more likely to read research reviews in professional society journals and newsletters than in even the most widely distributed science journals (e.g., BAMS, EOS).
    - We have not evaluated that efficacy of distributing information through HTML web pages. Our informal observations show that this is an effective medium for some stakeholders, and that it is effective for archiving data and reports of interest to stakeholders.
    - Interactive web tools are important for disseminating some information, such as forecast evaluations. Web tools are most effective when accompanied by training.
- Oral dissemination.
    - Stakeholder workshops are exceedingly effective for conveying research results, synthesizing the state of knowledge and raising awareness about an issue, and in generating further interest in climate-related issues and possible collaborations. The effectiveness of workshops is enhanced when accompanied by written materials (in print and on the web). Workshop face-to-face interactions cement relationships, enhance credibility, and instill trust. These workshops have, by and large, been worth their weight in gold.
    - Stakeholder professional society conferences are important venues for raising awareness about issues and developing future collaborations. Recently, we have focused more effort on providing professional development workshops and trainings at professional society conferences. The credibility of information presented at these conferences and trainings benefit from the imprimatur of the professional society and by connection to the overall mission of the professional society. In our view, working with professional societies is one of the more effective ways of conveying information.
    - We have found that it is exceedingly effective to disseminate information through intermediaries, such as cooperative extension agents and specialists.
    - Academic society conferences are valuable for alerting peers to research projects and results, and for developing collaborations. Occasionally, our work gains a multiplier effect from media reports about these conferences.
    - Press briefings are valuable, especially when the information presented is connected with topics of broad interest and timely subjects (e.g., “Is the drought over?” “Will this be a devastating fire season?”). We have

used press briefings effectively to counteract previously sensationalistic coverage (e.g., associated with topics such as El Niño). Regular briefings are less effective, as journalists require a salient "hook." We have also held press briefings associated with stakeholder workshops. These are most effective when connected to pre-meeting press releases. Perhaps the most valuable aspect of our interactions with the media has been to foster working relationships and to gain credibility and reliability as a source of information.

- Summary. The most effective means of disseminating information from CLIMAS include stakeholder workshops and trainings, hard copy newsletters and factsheets, and regular monthly publications distributed through the web. White papers and executive research summaries are effective for working with agency stakeholders. We believe that presenting information at stakeholder professional society meetings, as well as through their journals and newsletters, is potentially an exceedingly effective means of information dissemination. Similarly, boundary organizations, such as cooperative extension, are effective at multiplying our efforts to disseminate information. Press briefings can be valuable, but are less reliable.

Reconciliation/Managing Ecology of S&D

- In what ways have considerations of supply for research shaped the evolution of your research agenda?
  - Research supply has shaped the evolution of the CLIMAS research agenda chiefly through the expertise of individual investigators and their students. For example, CLIMAS has devoted substantial resources to hydrological investigations and ethnographic analyses, due to the renowned expertise of individual investigators. Conversely, a lack of expertise (supply) in visualization and state-of-the-art web-based knowledge transfer, combined with limited financial resources, has thwarted a planned effort to emphasize research activities and products concerning the communication of climate information, especially with respect to graphics, visualization and cartography. Instead, given financial constraints, we chose to emphasize better science writing in our outreach products, and to leverage decision-support projects with other closely-related projects on campus (e.g., the EPA-funded WALTER project for wildfire decision support [http://walter.arizona.edu]).
- What tensions have arisen between stakeholder needs, demands, and expectations, and the scientific capabilities and priorities of the RISA? How have those tensions been addressed or resolved?
  - Tensions have largely involved three general topical areas: the spatial scale at which climate information is provided, assessments of the accuracy and skill of climate forecasts, and lack of good monsoon forecasts (onset, intensity, intraseason dry spells, end).
  - With regard to monsoon research, for example, CLIMAS stakeholders have been almost unanimous in calling for improved forecasting and better information on spatial variability of monsoon precipitation. Delivering the needed information is beyond the scope and capability of CLIMAS resources. We address this tension by providing annual monsoon summaries, and by reporting on NAME science activities in our monthly climate summary. In addition, we devote some effort to applied monsoon research, primarily for the fire management community.
  - Similar issues exist with regard to providing information at fine spatial scale. For example ranchers wanted information specific to individual ranches, which CLIMAS is not in a position to provide. This tension was resolved via education on the nature of climate data and its availability, provision of interim gridded data, and most recently by obtaining separate funding for a specific project to provide such data (WestMap).
  - We identified some tension between needs and capabilities involving stakeholder need for frost forecasts. CLIMAS did not have the capability to produce frost forecasts and, due to NWS policy, it is not seen as an agency responsibility. The primary issue is that responsibility for producing frost forecasts was transferred to the private sector, but the forecasts that have been produced since the transfer have not been useful to stakeholder groups with whom we have established communications.
  - There is a definite tension with regard to our ability to turn around research within the time frame most desired by stakeholders. Often stakeholders require a research results in less than one year, and frequently they require

results "yesterday." We have addressed this tension in several ways, including (a) identifying value-added information that we can provide in a short time span, while keeping the stakeholder group engaged in the long-term effort, (b) by shifting effort to stakeholder implementation efforts. An example of the latter is our work with the Governor's Drought Task Force. We were only able to provide part of the research and information necessary during the development of the state drought plan. Following the successful development of a state drought plan, we shifted our efforts to providing support for emerging issues and drought plan implementation. Our plan implementation work includes evaluating impediments to drought plan implementation in rural communities, developing a drought impacts database, and holding workshops to develop drought planning and monitoring capacity in rural areas.

  - Another tension is the mismatch between stakeholder's interpretation of available information and (a) the extensive information actually available, as well as (b) content that can be gleaned from correctly interpreted available information. We have addressed this tension through workshops and trainings.

- How does your RISA evaluate the appropriateness of stakeholder needs (e.g., from the standpoint of public/private sector roles and responsibilities)?
  - The major climate-related issues in the Southwest are drought, water resources, and fire. In each of these three areas, there is no closely relevant private sector attention focused on providing climate services of the type carried out by CLIMAS. Private sector roles and responsibilities are evaluated in preliminary discussions on new research projects. Continued stakeholder engagement also enables us to monitor changing circumstances in this regard, should such a sensitive situation emerge.
  - CLIMAS (via our core office, project personnel, or via P.I. meeting) assesses the appropriateness of stakeholder needs on a case-by-case basis as information or service requests are received. It is seldom an issue because we have defined ourselves as less product-oriented and more engagement-oriented. Therefore, we sometimes refer product-oriented stakeholders to other entities. We are also concerned about equity, again discussing this issue on a case-by-case basis. For example, with the forecast evaluation tool project (Hartmann et al., 2002) it was important to the investigator to maintain open source code rather than develop proprietary software. The CLIMAS Team has a strong commitment to equity, thus we do not do consulting work.
  - Frost forecasting has been a private sector activity for a decade. We recognized this in early interactions with stakeholders and the NWS, and have therefore not become involved.

- How are stakeholders identified? Which stakeholder groups are most important in influencing your RISA research agenda? Why? Which stakeholder groups are least important? Why?
  - Stakeholders are identified through strategies such as conducting surveys, holding workshops, attending public and professional meetings, and monitoring news coverage of climate-related stories.
  - Determining which stakeholder groups are most important to our research agenda involves strategies such as assessment of a group's openness to learning about/using climate information, availability of intellectual resources and interest among researchers to pursue particular avenues, and availability of resources to actually conduct the needed research.
  - For example, CLIMAS made an explicit decision *not* to target large agricultural stakeholders in our region, in part due to lack of interest among CLIMAS PIs in pursuing the subject and in larger part because much of the "big agriculture" in Arizona traditionally expressed little to no interest in climate. In fact, some agriculturalists have flatly stated they would prefer if it never rained, because precipitation merely interrupts their irrigation schedule. These stakeholders are well insulated from the vicissitudes of climate by availability of Colorado River water, to which they have the highest priority rights. Further, there was not much value added work that we could do. There was no obvious "low-hanging fruit" and only marginal benefit would accrue either to the farmers or to the researchers from the amount of effort required to do the extensive research that would be needed.

    - Instead, our agriculture-related research has emphasized study of rural livelihood vulnerabilities, using well-developed rapid rural assessment methods.. We have placed a high priority on equity in these vulnerability assessments and subsequent efforts to deliver needed climate information.
    - Importance *per se* is not necessarily the only criterion for selecting projects within CLIMAS. For example, we recognize that one of the very important areas of concern in the Southwest is the impact of climate on ecosystems. However, until recently the project lacked substantive connections with stakeholders in the wildlife/land management/ecosystem management sectors. Further, even having recently established a stakeholder base, lack of resources prevents us from initiating extensive research activities in this area. Addressing the myriad ecological issues would require bringing in additional university-based investigators, agency scientists, and entities representing NGOs and the public work through other University of Arizona or multi-university large science efforts.
    - Another criterion for identifying stakeholder groups is the status of our resources for extensive travel to areas distant from our home base at University of Arizona. Due in no small part to limited resources, much of our work has been conducted in Arizona. In the process of working within a relatively easily accessible radius of campus, we have been able to establish a team-building process that has in turn provided a firm foundation for developing and refining our collaborative process. This process has allowed us to focus on developing a successful integrated assessment and climate services model.
- How does your RISA evaluate its research planning process?
    - Renewal proposals. In the process of writing our 2002-2007 renewal proposal, the PIs looked back over the first three-year funded period, seeking to discover the extent to which we had been able to deliver on the objectives articulated in the original proposal, the history of how we came to work on particular initiatives, the types of information and products that we were providing (or in the process of developing) to stakeholders, our internal success in achieving integration as an interdisciplinary team, and our progress in integrating stakeholders into our research process. We identified areas for improvement, such as the need to focus on integrating stakeholders more fully, and developed a set of research questions that would provide clearer guidance for activities to be pursued over the next five-year grant period. In recognition that introducing climate information into decision processes often requires some sort of change in conditions that renders "business as usual" untenable, we agreed to increase the team's flexibility to respond to unforeseen issues and event-driven opportunities (e.g., climatic conditions that generate big fire seasons, extended severe drought, etc.).
    - We established a four-member executive committee, made up of the lead PI and three co-investigators, to review research planning. The decisions and recommendations of the executive committee are presented to the full team of co-investigators for review, modification, and approval.
    - We initially established an advisory board to assist with planning and decision making; however, we decided to eliminate the board due to inability to effectively integrate board members into the project's activities, and due to the fact that the interests of board members were too diffuse to achieve a common vision. We now believe that we have sufficient experience and understanding in integrated, iterative research to convene an effective advisory board; this will likely occur as we move into our next funding phase.
    - More generally with regard to evaluation of planning efforts, we have consistently invested considerable time and effort in team building. We meet as a team every two weeks. The 10 principal investigators meet at least twice a semester, and the Executive committee meets at least that often. We conduct half-day team retreats each semester; at least half of the retreat time is devoted to evaluation of research and research integration. Moreover we occasionally hold weekend-long principal investigator and postdoc retreats. One of these retreats produced four papers summarizing CLIMAS experience with establishing climate services, developing stakeholder-driven science projects, and improving integrated assessment. All of the retreats and principal investigator meetings emphasize self critique.

- What lessons in the process of the reconciliation of supply of and demand for science are relevant to the broader implementation of the CCSP?
    - CLIMAS lessons in the process of reconciliation of supply and demand for science that are relevant to the broader implementation of the CCSP fall into the following categories: multi-party communication, sustained and iterative stakeholder engagements, adaptive/evolutionary approaches, regional foci, interdisciplinarity, collaborative efforts, resources and commitment.
    - The CCSP, like the RISAs, will need to communicate with a variety of publics. Establishing and maintaining two-way communication among agency partners, between project members/administrators, and with stakeholders is essential to the success of CCSP. The foundation of successful climate services is relationship, and relationship requires commitment to solid, frequent two-way communication (i.e., avoiding the "loading dock").
    - The CLIMAS experience demonstrates the need for commitment to long-term engagement and sustained iteration with stakeholders. Honing the stakeholder-scientist research process requires iterating many times with stakeholders. Stakeholders prefer face-to-face interactions. We've learned that stakeholders are more apt to use decision-support products, information, websites, if the products are accompanied by training and outreach. As one stakeholder noted, "don't put the burden on the user." CLIMAS has also learned that one-time engagements are far less successful than sustained and iterative engagements. One-time engagements often merely scratch the surface with regard to issues of mutual interest; moreover, needs and comprehension change over time – necessitating repeat engagement. Thus, demand comes with needs that must be met in order to increase the chances of success.
    - Implementation of the CCSP stands a greater chance of success with the explicit acknowledgement that climate services is a process involving experimentation, evolution, and change. Examples of change that require a flexible process include:
        - Changes in science, technological improvements, and improvement in scientific understanding, changing paradigms, etc.;
        - The mutual understanding between stakeholders and scientists changes and develops in response to improved knowledge about (i) climate and products by stakeholders and (ii) specific stakeholder information needs by scientists. As stakeholder-scientist relationships evolve, they sometimes develop into partner-scientist relationships – whereby it becomes difficult to distinguish, e.g., agency stakeholders from partners in the research and knowledge-transfer enterprise.
        - External factors, such as climate and weather events, influence stakeholder needs and garner the attention of scientists;
        - Economic and social changes can result in changes in demand, as well as the ability to supply science.
        - In this regard, in some ways an end-to-end approach is misleading, as it implies the static completion to what we have observed as an ongoing process of anticipating, responding to, and meeting changing decision-making needs and scientific challenges. While the underlying philosophy is similar, instead of the "linear" imagery of the "end-to-end" approach, we prefer the "circular" imagery of what we term the iterative approach.
    - CLIMAS believes that CCSP implementation will be enhanced by focusing on regional, subregional and local needs. The maxim states that "all decisions are local." Consequently, regional context and knowledge of key decision-making issues is important, including intimacy with regional atmospheric and societal processes.
    - Commitment to and support for interdisciplinary work will enhance the chances for success. CLIMAS has found that interdisciplinarity among the natural and social sciences encourages novel approaches, synergies, and enhances the project's ability to bridge with stakeholders.
    - We believe that collaboration between agencies and initiatives will improve CCSP implementation.

Collaborations encourage the development of more effective synergies, and help to break down those barriers to innovation that are due to institutional culture. Similarly, the efforts of constituent components of CCSP will be enhanced by creative leveraging of resources, which can be accomplished through inter-agency, inter-regional, and inter-disciplinary partnerships and collaboration.

- Successful use-inspired and user-oriented climate services, as part of the climate change science program, is a labor-intensive effort. The chances of successful implementation of the CCSP will increase in proportion to commitment of resources to human resources, in addition to obvious commitments to instrumentation, observations, modeling, and product development. In addition, having sufficient resources (funds, researchers, equipment, access to data) is essential.

Selected NOAA Partners

- National Weather Service Forecast Offices: Albuquerque, Phoenix, Tucson – drought, forecast evaluation, climate forecasts, press briefings
- NOAA-NWS Colorado Basin River Forecast Center – forecast evaluation
- NOAA Climate Services Division – forecast evaluation, knowledge transfer, climate forecasts
- NOAA Climate Prediction Center – forecast evaluation, fire outlooks, knowledge transfer
- NOAA Climate Diagnostics Center – drought, forecast evaluation, fire outlooks, climate data
- NOAA Regional Climate Centers: Northeast, Southern, Western – forecast evaluation, fire outlooks
- NOAA Office of Climate, Water, and Weather Services – forecast evaluation
- RISAs: Western Water Assessment, California Applications Program – drought, forecast evaluation, fire outlooks, fire decision making, climate data

- **Selected Agency Partners**
  - Arizona Cooperative Extension – forecast evaluation, drought, climate change, vulnerability assessment
  - Arizona Department of Health Services – health
  - Arizona Department of Water Resources – drought, vulnerability assessment
  - Colegio de Sonora – drought, vulnerability assessment, U.S.-Mexico studies
  - NASA-RESAC – snow estimation
  - National Drought Mitigation Center – drought, knowledge transfer
  - National Interagency Coordination Center (a division of the National Interagency Fire Center) – fire outlooks, forecast evaluation, fire decision making
  - Oregon State University – climate data
  - Pima Association of Governments – air quality, drought
  - Program for Climate, Ecosystem, and Fire Applications (a division of the Desert Research Institute) –fire outlooks, fire decision making
  - Scripps Institution of Oceanography – fire outlooks, climate data
  - USDA-Natural Resources Conservation Service – drought, snow estimation, forecast evaluation
  - United States Bureau of Reclamation – drought, water economics, forecast evaluation
  - United States Environmental Protection Agency – air quality
  - University of New Mexico – knowledge transfer, forecast evaluation
  - Upper San Pedro Partnership – vulnerability assessment, U.S.-Mexico studies
  - Western Governors' Association – air quality

- **Selected Stakeholders**
  - American Meteorological Society – forecast evaluation
  - Arizona Daily Star – knowledge transfer
  - Arizona State Parks – tourism economics, knowledge transfer
  - City of Chandler, Arizona – forecast evaluation
  - City of Santa Fe, New Mexico – water economics
  - City of Sierra Vista, Arizona – U.S.-Mexico studies
  - Comision Nacional del Agua, Mexico – U.S.-Mexico studies
  - Havasupai Tribe – agricultural economics
  - National Predictive Services Group Geographic Area Fire Meteorologists and Intelligence – fire outlooks, forecast evaluation
  - Navajo Nation – agricultural economics
  - New Mexico Air Quality Bureau – air quality
  - New Mexico Cooperative Extension – knowledge transfer
  - New Mexico Department of Agriculture – knowledge transfer
  - New Mexico Rural Water Association – knowledge transfer
  - Pojoaque Pueblo – water resource economics
  - Salt River Project – forecast evaluation, drought, use of ENSO information
  - San Carlos Apache Tribe – forecast evaluation, vulnerability assessment, agricultural economics
  - The Albuquerque Journal – knowledge transfer
  - USDA-Forest Service – forecast evaluation, fire outlooks, fire decision making
  - U.S. National Park Service – air quality, knowledge transfer, tourism economics
  - Valley Fever Center for Excellence – health

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RISA Documents

Western Water Assessment

http://wwa.colorado.edu/

Demand Side Assessment

- Who are the major stakeholders for your RISA?

  The WWA has a very wide diversity of stakeholders, loosely grouped into four categories: (1) climate-information providers (National Weather Service including NWS River Forecast Centers, National Interagency Fire Center, Colorado Drought Task Force, USDA NRCS); (2) operational water managers (e.g., federal, regional and municipal reservoir managers); (3) planning and policy interests (e.g., municipal water providers, regional water planners, legislators, county commissioners); and 4) finally, we are often called upon to appear at or make presentation to meetings that include the general public or major interest groups, and to provide information to the media. With very few exceptions, these interests all share a focus on water resources in the interior West. As noted elsewhere, this diversity of stakeholders necessitates an equally diverse set of processes and products.

- What processes are used to include stakeholders in the research planning process, the research implementation process, and the research reporting process?

  The WWA uses a variety of meetings, workshops, conferences, and other face-to-face meetings with stakeholders. Examples include a major "summit meeting" with officials from Denver Water; meetings of water management groups, the periodic meetings of the Drought Task Force; annual conferences of the Natural Resources Law Center; and so on. In most cases, we find that interactive, two-way communications have more utility than one-way "briefings," although each mode of communication has its place. For example, briefings and presentations at conferences can be useful in inviting follow-up conversations with stakeholders. Similarly, presentations of basic climate information/processes can help establish a baseline of common knowledge necessary to set up more focused discussions. Other tools used mostly for information dissemination include web pages and the Intermountain Climate Summary (a recently established publication of the WWA). Some limited surveys have also been used to elicit stakeholder needs and wants. Finally, in the case of the one project, periodic face-to-face meetings and progress reports with water management personnel have been a successful means to plan and carry a collaborative research program.

- How are stakeholder interactions evaluated?

  While this is a subject that has been discussed several times within the WWA, the formal evaluation of stakeholder interactions is generally absent from our program as we have not identified a practical way to collect measures that promise useful information. Some exceptions exist, such as a recent survey of users of Klaus Wolter's forecasts and a planned survey of recent stakeholder interactions by our CSU program element. Many WWA products generate responses from stakeholders; e.g., Denver Water has gone out of their way to praise the value of the Intermountain Climate Summary. But in general, the quality of stakeholder evaluations is measured by the extent to which stakeholders choose to continue or expand their interactions with WWA, by the number and "importance" of invitations to present information or collaborate on problem-solving, and so on. Repeat (and new) business is a sign of success. Success is also shown in stakeholders willingness to write letters of support for WWA-related proposals to NCTP (for 2005 and 2006 RFPs) and SARP; funding for WWA-related activities, both in the form of grants/contracts (USBR/WCAO and CWCB) and in-kind support (e.g. Denver water and CRWCD hosting meetings). We are aware of some poorly executed stakeholder evaluations conducted by outsiders at other RISAs and hence are leery of utilizing this pathway without adequate supervision.

- What has your RISA learned from the process of stakeholder interaction, and how have its decision processes changed as a result?

  Several lessons have emerged. First, the most productive interactions involve developing partnerships with key stakeholders and stakeholder groups that involve two-way communications. One-way communications are generally valuable only to the extent that they are likely to encourage and set-up the two-way communications useful in better understanding the relationship between information supply and demand. (For example, a presentation on climate basics or the distribution of a "primer" may be a necessary first-step before a potential stakeholder is comfortable having a more focused conversation.) Healthy stakeholder partnerships are characterized by: (1) recurring and iterative interactions over time; and (2) mutual development of fora for communication, learning, and bringing perspectives together. Such partnerships lead to innovation in both science and management from interaction. It takes significant time to develop these relationships. (The antithesis of the WWA approach is "drive by consulting"—i.e., one-way, one-time communication.) Within these parameters, the mode of communication (e.g., phone, email, meetings) is best left to the discretion and preferences of the stakeholder. Our strong beliefs about the high value of stakeholder interactions are reflected in our criteria used internally to design and evaluate projects for funding. Another key lesson has been: **take advantage of windows of opportunities!** The drought created a wonderful opportunity as it focused the needs of water management in an area that had largely been ignored (drought planning). In the case of the paleo work, the drought resulted in the lowest annual streamflows on record for many gages, motivating interest in assessing this drought in a longer-term context than provided by the gage records. It also had the effect of calling into the question the appropriateness of basing drought planning on the length-limited gage record.

- How did you develop your process for eliciting stakeholder needs/wants?

  Our processes are varied, evolving, and sometimes ad hoc. Different stakeholders are reached in different ways. We have used methodologies including questionnaires and surveys, formal and informal interviewing, and acting as participant-observers in several water management fora. We have also used environmental scanning, document analysis, and process tracing techniques to identify critical water management decisions and the stakeholders in those decisions. Again, to the extent that personal relationships exist or can be developed with key members of key stakeholder groups, the opportunities for eliciting stakeholder needs/wants increases dramatically. To the extent that we rely upon personal networks to identify and flesh out research needs and opportunities, it is important to employ team members with excellent social skills. Researchers with self-defined agendas that prefer to remain locked in their labs are not the ambassadors we rely upon. Eliciting stakeholder needs/wants is viewed as an ongoing activity to which all team members are engaged; it is not viewed as an activity best suited to periodic surveys.

Supply Side Assessment

- Briefly describe the research agenda for your RISA.

  The WWA has carefully developed the following mission statement to explain our agenda: ***The mission of the WWA is to identify and characterize regional vulnerabilities to climate variability and change, and to develop information, products and processes to assist water-resource decision-makers throughout the Intermountain West.*** Ultimately, our activities are designed to help a variety of stakeholders in the intermountain West identify and address the vulnerability of water systems to climate variability and change. This mission is very broad in terms of substantive and geographic scope, so our selection of projects within this broad mission is guided by practical considerations, such as the expertise of personnel, budget constraints, and other factors.

- How does your RISA set its own research priorities?

  Through internal discussions and our discussions with stakeholders, the WWA attempts to identify projects and research priorities within our defined agenda that are important, "manageable" (i.e., likely to yield tangible benefits to society), and that provide service to our full spectrum of stakeholder groups. It should be noted that WWA's policies and procedures in this area have evolved over time. The following criteria are used to compare (internally) competing projects:

1. *NOAA Vision and Mandates. Projects must be compatible with the NOAA mission, NOAA strategic goals, NOAA cross-cutting priorities as well as Congressional NOAA mandates such as the U.S. Global Change Research Act of 1990 and Administration initiatives such as the Climate Change Science Program which involve NOAA . Acceptable projects will help NOAA line offices meet their current responsibilities, and will seek to identify, and ideally fulfill, information needs that are currently poorly provided by NOAA. Other creative projects meeting any of the NOAA goals, mandates and initiatives as envisioned by NOAA, Congress, and the Administration are encouraged.*

2. *RISA Criteria. Projects must meet one or more RISA activities criteria (see the RISA vision document for more details). These include (a) integrated research; (b) regional assessment; (c) links to decision-makers; (d) links to operations; (e) education; and (f) cross-RISA activities.*

3. *WWA Mission. Projects must be consistent with the WWA Mission Statement and Research Objectives. In particular, projects should:*

    (a) involve research, education, and/or outreach that directly addresses the WWA mission.

    (b) be of significance, interest and use to decision-makers in the water-related decision-making community.

    (c) address issues related to climate variability and change.

    (d) provide products and information in a reasonable timeframe.

    (e) be based on a strong understanding of user needs, or alternatively, include a user needs assessment.

    (f) provide for two-way communication and feedback between the research community and the community of water-related decision-makers.

    (g) be conducted in partnership with climate-sensitive users (e.g., Denver water) and/or information providers (e.g., the State climatologist).

    (h) explicitly consider the mechanisms, opportunities, and constraints (i.e., the "decision environment") associated with the application of research results and/or products.

    (i) dedicate resources to evaluate what worked, what did not work, and what results can be more broadly applied to meet user needs for decision support so that NOAA and WWA can perform at a higher level.

    (j) explicitly consider how products and information can be transferred from a research context to an operational context.

    (k) not be redundant of other work both within WWA and in other science-programs—the intent should be to synthesize, integrate, and/or transform existing work into knowledge and products that are new and innovative.

4. *Project Length. Multi-year projects are encouraged. Proposed projects should not, however, require a level of funding that is beyond the scale of what WWA can support or can commit to in a given budget year. Projects that are envisioned as multi-year undertakings will only be supported if the project can be distilled into annual phases with associated products—multi-year undertakings will require a proposal every year. This said, extra credit will be given for building on WWA successes.*

5. *Deliverables. Journal articles are usually not sufficient, and generally must be accompanied by other deliverables. Examples of suitable deliverables are (a) articles written for a general audience; (b) sustained interactions with users and/or information providers; (c) web sites; and (d) models and datasets.*

- How has this agenda evolved over the duration of the RISA? What new projects have been started that were not anticipated at the beginning of the RISA? What projects have been terminated, and why?

  The selection of projects is perhaps the area where the WWA has enjoyed the greatest innovation and maturation. Initially, participating researchers all submitted one-page summaries of individual research proposals that, generally, were all pursued within budget confines. This approach suffered from four major problems: (1) the agenda was set almost entirely by researchers, not stakeholders; (2) linkages between projects were poor; (3) there were no explicit criteria used to select among projects when necessary; and (4) the high diversity of projects made it difficult to build real strengths in a smaller set of issues. The first 3 of these issues was resolved by an internal competition of proposals that included explicit design and selection criteria (specified above). The final problem has been addressed recently by a decision to take less of a scattershot approach to research and instead focus on a smaller set of themes.

  New projects generally reflect stakeholder requests (e.g., Klaus Wolter's forecasts) or special opportunities, many of which were provided by the regional drought that began soon after WWA's formation. "Terminated" projects are generally those that did not generate of sustain a critical level of stakeholder involvement and support, or that provided technical or budgetary problems that were not easily overcome. The most prominent example of a terminated program area is our focus on water quality (and the resulting ecological impacts), terminated due to a lack of stakeholder demand and a difficulty in maintaining sufficient expertise within the WWA. For practical reasons, we try to "play to our strengths" in terms of personnel, expertise, resources, and stakeholder contacts.

- In your RISA, what is the balance between research on new subjects, and assessment/compilation of existing knowledge? How is this balance determined?

  We balance our work by selecting projects that provide the desired budgetary balance for the different categories of our mission. Projects related to new, cutting-edge research include forecasting work by Wolter and Clark, among others. Generally, this is work that is to be handed-off to existing information providers (e.g., river forecast centers) or water operations personnel (e.g., reservoir operators) already familiar with climate research and products. At the other end of the spectrum, many planning and policy stakeholders are not familiar with climate research, concepts, or products. In these cases, primers, briefings, and conferences (such as the Natural Resources Law Center activities) are often more appropriate. In other cases, it is a combination of both. For example, we spent several meetings with water managers from Denver Water explaining how tree-ring data are used to reconstruct streamflow, but in subsequent meeting, the focus shifted to how traditional tree-ring methods might be refined or advanced to meet the planning needs of Denver Water. The decision to focus on "new" or "existing" knowledge is not driven by ideological considerations, but rather by a desire to make the most significant impact possible in helping our diverse community of stakeholders respond to the many, multi-faceted challenges associated with climate variability and change.

- Please describe the specific ways that knowledge is disseminated from your RISA. How would you assess the relative importance of various dissemination mechanisms, such as peer-reviewed publications, other types of publications, web-based presentations, public fora, etc.?

  A tremendous variety exists. What is most appropriate or "important" is largely determined by the desired audience. Technical innovations are often best disseminated in professional journals (e.g. BAMS), however, some audiences—including many in the operational and policy and planning communities—have expressed a preference for less formal publications (summary reports, newsletter, letters) or oral presentations. Publishing in journals read by professional water managers, such as the American Water Works Association publications, remains a goal. Documents are often distributed directly to target audiences, and of course, on the web. The web pages of the WWA include forecasts, primers, reference materials, contact information, and a variety of other information. Workshops, conferences, briefings, and other face-to-face interactions are also a staple of WWA activities. Being responsive to media requests is also a major activity of several WWA personnel, as is appearing at various conferences and other public settings. WWA personnel have also written press releases and regular newspaper columns. E-mail 'alerts' are used to inform our stakeholders of new information, frequently with an associated web address for additional information. In general, most "products" are disseminated in multiple ways. In general, traditional academic knowledge distribution pathways are ill-suited for most of our stakeholders.

Reconciliation/Managing Ecology of S&D

- <u>In what ways have considerations of supply for research shaped the evolution of your research agenda?</u>

  WWA views the supply side of research as larger than that produced in the WWA itself. It has been a challenge has been to follow through on identified user needs (many key needs were identified early in the project), by developing applied research products to generate useful products as prototypes, then to cultivate the interest of operational entities to issue them as products. Even when the research is from within the WWA community (although not necessarily funded under that umbrella) it is a challenge to adequately fund applied work, which may take several years to produce prototypes, and maintain user interest, then re-iterate on prototypes. Examples include the paleoclimate research, hydroclimatology research, and intraseasonal forecast research that originated outside WWA, but within CIRES or CDC. Another challenge is when the research relevant to user needs is external to WWA. In these situations we continue to seek relevant research and to cultivate partners for applied projects wherever the results are suited to user needs. Currently, WWA is seeking to identify the needs of more users, but we have a backlog of needs we are working on applied projects to meet.

- <u>What tensions have arisen between stakeholder needs, demands, and expectations, and the scientific capabilities and priorities of the RISA? How have those tensions been addressed or resolved?</u>

  Some stakeholders ask questions that are beyond our expertise (e.g., when will the drought end?) or request information in an impractical format (e.g., a desire for absolute rather than probabilistic forecasts). In general, these requests are easily converted to more practical conversations exploring the existence of opportunities for matching information supply and demand, or initiate discussion that reframe questions. (For example, in the absence of absolute information, we can help stakeholders think about how to best understand and deal with scientific uncertainty.) More problematic is finding the right balance between being an operational entity that directly helps stakeholders solve problems, and being an intermediary entity that helps to build the strengths of other information providers (both public and private) already established to serve stakeholders. This tension was evident when the WWA was asked by NOAA to rename our Outlook newsletter to the Intermountain Climate Summary, as the first name implied a more operational mission than was considered appropriate. There is a problem of developing long-term relationships with stakeholders, yet maintaining scientific integrity (we are not consultants) AND not becoming service providers. "Experimental" products unfortunately have a way of becoming quasi-operational, while not being transferred (yet) to operational entities who may or may not be enthusiastic about this. The need for evaluation of experimental products takes time since climate forecasts are not issued daily. Both of these problems limit our ability to quickly move funds from one endeavor to another. Finally, WWA members operate in an academic setting yet some of our work products do not lend themselves to scientific papers which are necessary for advancement. NOAA's definition of the RISA role is evolving and, at times, somewhat contradictory, ensuring that the RISA's are all "shooting at a moving target" when it comes to defining our role.

- <u>How does your RISA evaluate the appropriateness of stakeholder needs (e.g., from the standpoint of public/private sector roles and responsibilities)?</u>

  The WWA has had (surprisingly) few issues where a concern over public/private roles emerged. (There are relatively few private climate information providers in the region, which is perhaps one explanation for this lack of conflict.) Many potential conflicts are avoided by WWA ground-rules. First, we make it clear that we are not consultants, and a primary WWA goal is to help NOAA learn how to provide and implement Climate Services. In addition, we avoid collaborations where we are likely to lose control of how scientific findings are interpreted and disseminated in public settings. We enter into relationships (e.g. paleo streamflow reconstruction work) with a clear understanding with our stakeholders and collaborators that we expect such efforts to produce *public* products, or techniques, that will made available to other similar stakeholders. We are also well aware of NOAA constraints and sensitivities with respect to certain products and activities.

- How are stakeholders identified? Which stakeholder groups are most important in influencing your RISA research agenda? Why? Which stakeholder groups are least important? Why?

  Early on in WWA, we used environmental scanning and critical water problems approaches to determine some of the major water problems and user groups in the WWA domain. In general, we seek out collaborations with the largest and most powerful water interests in the region (e.g., Denver Water, Colorado River Water Conservation District). We have been fortunate in that these large groups feature "early adopters" regarding the use of climate information/products, and in some cases (paleo) these entities have contacted us first. (We attribute these contacts to widespread publicity and subsequent interest in this work.) We utilize a "bang for the buck" mentality in seeking collaborations, hoping to exploit the most promising and practical opportunities for matching information supply and demand. Additionally, some groups come to us, asking usually for presentations or articles for specialized journals (e.g., the nursery industry).   The ideal stakeholder is one that can aid and inform our work and that, conversely, can implement and benefit from the resulting information/products. Relationships of this nature that have two-way benefits are likely to be lasting and are ideally suited to publicly funded enterprises such as RISAs.

- How does your RISA evaluate its research planning process?

  There are apparently two aspects to this question. The first is evaluation of the criteria that we use to judge projects. The second aspect is the judgment of research results. The former is evaluated by discussing our criteria in meetings to make sure that we are not either overlooking important criteria that should be added, or removing unnecessary criteria that serve no purpose. With regard to the latter question, we match our criteria to project results. For example, given the high value of stakeholder interactions, projects that generate ongoing stakeholder interactions and support are an obvious sign of success. Annual Reports from funded personnel, and quality and timeliness of deliverables are other important factors used to decide if research should continue to be funded.

- What lessons in the process of the reconciliation of supply of and demand for science are relevant to the broader implementation of the CCSP?

  Despite thousands of popular press articles on climate change over the last twenty years, many of our stakeholders are unaware of even very basic scientific findings and the structure of climate change research. For example, during WWA public presentations knowledge of the basic physics of greenhouse gases is absent and a question about what is the Intergovernmental Panel on Climate Change is likely to result in blank stares. Without this fundamental foundation, stakeholders can not provide the necessary 'demand' for science. (WWA has, and will continue, to spend a significant amount of resources providing this educational function.) And without a well enumerated demand function, the supply side operates without any guidance on what to produce. While it may seem simple to educate the stakeholder 'consumers', the dynamic nature of climate science means that this is not a simple one-stop job. Confounding the educational process is that many water manager stakeholders are older, risk averse, and very busy. In our fast growing region of the country, population growth may serve as an analog to future climate change impacts.

APPENDIX A

Participant List and Biographies

Cheryl Anderson, canderso@hawaii.edu
Social Science Research Institute, University of Hawai'i

Cheryl L. Anderson is a certified planner (AICP), doctoral candidate, and the Director of the Hazards, Climate, and Environment Program, University of Hawai'i Social Science Research Institute. For the last thirteen years, she has conducted research and planning projects in the areas of climate variability and change, hazard mitigation, hazard risk and vulnerability assessments, coral reef protection, ocean resource management, and watershed management in the Pacific Islands region and in Southeast Asia with collaborative partners in regional, federal, state, and local agencies and organizations. These projects include: the State of Hawaii Multi-Hazard Mitigation Plan, the County of Kauai Multi-Hazard Mitigation Strategy, and a Drought Impact Assessment of the 1997-1998 ENSO in the US-affiliated Pacific Islands. In August 2004, she co-convened and coordinated the international Gender Equality and Disaster Risk Reduction Workshop in Honolulu, Hawai'i with support from USAID, USDA, NOAA, NSF, UN International Strategy for Disaster Reduction, University of Hawai'i, the East-West Center, Pacific Disaster Center, the Center of Excellence in Disaster Management and Humanitarian Assistance, and other organizations. Workshop outcomes and materials were incorporated into the World Conference on Disaster Reduction (WCDR) in Kobe, Japan in January 2005, where Ms. Anderson was invited as a presenter.

Susan Avery, susan.avery@colorado.edu
Vice Chancellor for Research/Dean of the Graduate School, University of Colorado

Susan K. Avery is the Vice Chancellor for Research and Dean of the Graduate School and is currently serving as Interim Provost and Executive Vice Chancellor for Academic Affairs at the University of Colorado at Boulder. She has recently served as Director of the Cooperative Institute for Research in Environmental Sciences (CIRES) and is a Professor of Electrical and Computer Engineering.

As director of CIRES, Avery oversaw a diverse and rich research agenda in Earth System Science. During her ten years as director, CIRES facilitated new interdisciplinary research efforts spanning the natural sciences and bridging with the social sciences. A strong K-12 outreach program was developed and a number of new seed programs were established. She helped form a regional integrated science and assessment program that examines the impacts of climate variability on water in the interior west and spent a year working with NOAA and the Climate Change Science Program in Washington, DC.

Avery has served on a number of national committees and boards. Currently she serves as the Union of Radio Science Representative to the international Scientific Committee on Solar Terrestrial Physics and as a member of various panels of the National Research Council and the National Science Foundation. She is a Fellow in the Institute of Electrical and Electronics Engineers and the American Meteorological Society and is the Past-President of the AMS.

Avery has earned numerous awards including the University of Colorado Robert L. Stearns Award, recognition for exceptional achievement and/or service; the Elizabeth Gee Memorial Lectureship Award for scholarly contributions, distinguished teaching and advancing women in the academic community; and the Margaret Willard Award, University Women's Club, for her outstanding contributions to the University of Colorado at Boulder.

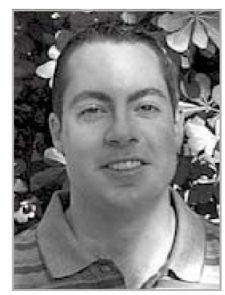
Avery received her Ph.D. from the University of Illinois in 1978. Her research interests include the use of Doppler radar techniques for observing physical processes in the atmosphere; climate variability and water in the interior west; and the role of science in decision making processes. She is currently studying the characterization of the structure and evolution of the upper atmosphere using meteor radar techniques and satellite data. Through the regional integrated science and assessment project she has been working with an interdisciplinary team to apply climate information for decision support in water management in the interior west. She is the author of over 75 publications in the refereed literature. Avery's teaching includes courses in radar science and techniques, geophysical data analysis, and policy responses to climate variability.

Kenny Broad, kbroad@rsmas.miami.edu
Center for Ecosystem Science and Policy, University of Miami

Dr. Broad is an environmental anthropologist who received his Ph.D. from Columbia University in 1999 and is currently an Assistant Professor in the Division of Marine Affairs and Policy, RSMAS. He holds a joint appointment at Columbia University's Lamont-Doherty Earth Observatory. Prior to anthropology, Broad participated and led several scientific and documentary film expeditions around the globe, including the exploration of the world's deepest cave in the Huautla Plateau in Mexico.

His current work focuses on human-environment interaction related to natural resource management. Working in the United States, Latin America, the Caribbean and Indonesia, Broad studies climate impacts and human perception, the use and misuse of scientific information, decision making under uncertainty, marine protected areas, as well as issues related to societal equity. This work involves close collaboration with hydrologists, oceanographers, economists, ecologists, climatologists and other strange creatures.

David Brown, david.brown@unh.edu
New Hampshire State Climatologist, University of New Hampshire



Dr. David Brown has been the New Hampshire State Climatologist since August 2004. He also holds an appointment as Assistant Professor of Geography at the University of New Hampshire, where he teaches courses on weather and climate, physical geography, and environmental geography.

Dr. Brown received his Ph.D. and M.A. degrees in Geography from the University of Arizona, and his B.S. degree in Meteorology from Penn State University. His research interests include synoptic and applied climatology, geospatial climatology and the use of GIS in climate analysis, climate services, and human-environment interactions. He is currently investigating the role of interannual climate variability on New England air quality, the linkage of climate teleconnections such as El Nino and La Nina to multi-decadal temperature and precipitation patterns across the western United States, and the influence of urbanization and irrigation on local precipitation enhancement in semi-arid regions. He has been funded by the National Oceanic and Atmospheric Administration (NOAA) for his work on the New England Integrated Sciences and Assessment (NEISA) and Climate Assessment for the Southwest (CLIMAS) projects, and his research has been published in several peer-reviewed journals *including Geophysical Research Letters, International Journal of Climatology, Climate Research*, and *The Professional Geographer*. He is a member of the American Geophysical Union, the American Meteorological Society, and the Association of American Geographers.

James Buizer, james.buizer@asu.edu
Office of Sustainability Initiatives, Arizona State University

In addition to his role as advisor to the President at Arizona State, Dr. Buizer serves as the Director for Science Applications with the office of the Vice President for Research and Economic Affairs. He is responsible for the design and implementation of University-wide sustainability institutional development, including research, education, and applications initiatives. The scope includes all aspects of the establishment of the International Institute for Sustainability and the forthcoming School for Sustainable Environments and Societies, and the Sustainability

Partnership Enterprise, which is designed to bridge the gap between production of science and practical use. He assisted with securing $15M in private donor funding for the establishment of the International Institute for Sustainability at ASU, November 2004.

Prior to joining Arizona State University, Dr. Buizer served as Director of the Climate and Societal Interactions Program at the National Oceanic and Atmospheric Administration (NOAA) in Washington, D.C., where he was responsible for providing programmatic vision, design and leadership of NOAA's integrated, multidisciplinary research and applications program positioned at the climate and societal interface.

Greg Carbone, carbone@gwm.sc.edu
Department of Geography, University of South Carolina

Dr. Greg Carbone (PhD, University of Wisconsin 1990, Geography) is an Associate Professor of Geography at the University of South Carolina. His research interests center on climate variability and change and impacts on agriculture and water resources. He is the principal investigator for the Carolinas Integrated Science and Assessment group, part of NOAA's Regional Integrated Science and Assessment (RISA) program. His current research examines the link between interannual climate variability and water supply, drought forecasting, and measuring uncertainty. He has published on impacts of climate change on agriculture, methodological issues in climate impacts research, statistical downscaling, uncertainty, and drought forecasting. Some of his recent papers have appeared in *Agronomy Journal, Climatic Change, Integrated Assessment*, and *Journal of the American Water Resources Association*. His research has been sponsored by NOAA's Office of Global Programs, NASA, EPA, UCAR, and the Southeast Regional Climate Center.

Maria Carmen-Lemos, lemos@umich.edu
School of Natural Resources and Environment, University of Michigan

Maria Carmen Lemos is Assistant Professor of Natural Resources and Environment at the University of Michigan. She is also a Senior Policy Analyst with the Udall Center for Studies of Public Policy at the University of Arizona where she develops research initiatives in the U.S-Mexico border. Her research focuses on the human dimensions of global climate change, especially the co-production of science and policy, the role of technocrats as decisionmakers, the use of seasonal climate forecasting in drought planning and water management, the role of stakeholder-driven science in producing usable knowledge, and the broader social and political impacts of the use of technoscientific knowledge in policy making. She was part of an OGP/NOAA funded interdisciplinary project on the socioeconomic and political implications of the use of seasonal climate forecasting on drought-relief and agricultural policymaking in Northeast Brazil. She is currently the PI of two other grant proposals-funded by NSF and NOAA-to understand institutional opportunities and constraints for the use of techno-scientific information, especially seasonal climate forecasting, in water management in Brazil and Chile. Prof. Lemos holds a PhD and a MSc. in Political Science from the Massachusetts Institute of Technology-MIT.

Netra Chhetri, netra.chhetri@asu.edu
Consortium for Science, Policy & Outcomes, Arizona State University

Netra Chhetri's research interests center around science and policy issues on human and physical dimensions of climate change. He is specifically interested in understanding the impacts of and adaptation to climate variability and change in managed ecosystems. Other areas of research include land-use land cover change; political ecology of land and forest degradation; community based resource management; risks and vulnerability assessment; and agro-ecology and sustainable agriculture. For the past seven years, Netra has been conducting research on the sensitivity of agricultural systems to climate change and variability using Erosion Productivity Impact Calculator (EPIC) crop model with geographic focus to south-eastern United States. He has contributed to the Third Assessment Report of the Working Group II of the IPCC by reviewing scientific literature on the impacts of climate change in agriculture. Netra is also one of the contributing authors in the upcoming Fourth Assessment Report of the Working Group II of the IPCC where he is compiling the outcomes of climate impact studies using a range of climate scenarios as well as reviews of adaptation to climatic risks and uncertainty in small-holder agricultural societies. At Penn State, Netra has taught a course in Physical Geography and has also assisted in teaching, human-environment, and spatial analysis.

During the fifteen years between the completion of his undergraduate degree (1982) and his entering graduate school (1997) Netra had a successful career in community development and natural resource management in Nepal. At that time he worked with interdisciplinary team of social scientists, engineers, agronomists, and foresters. During his professional career Netra successfully introduced the concept and practice of conservation farming in the agro-ecosystems of the Himalayas. Conservation farming involves adaptive management of resources based on the carrying capacity of a given ecosystem.

Andrew Comrie, comrie@arizona.edu
Department of Geography and Regional Development, University of Arizona

Dr. Andrew Comrie is a Professor in the Department of Geography and Regional Development at the University of Arizona, with joint appointments in Atmospheric Sciences, Global Change, Arid Lands Resource Sciences, and Remote Sensing & Spatial Analysis. He is a climatologist specializing in the geographic aspects of atmospheric environmental issues, and he has published widely in specialized and interdisciplinary international journals. His expertise includes climate impact assessment, applied climatology, synoptic climatology, urban and regional air pollution, climate variability and change, climate and health, multivariate statistical climate analysis, and computerized map-pattern recognition and classification techniques. Dr. Comrie is currently investigating summer and winter climate variability in the Southwest United States, climatological and human factors influencing air pollution at local and regional scales, links between climate and disease, climate and wildfire, and new techniques for mapping climate and air quality information. His work has been funded by NSF, EPA, NOAA, NASA, and state and local agencies. He serves, or has served, on numerous national and international professional committees and editorial boards, and he is currently American Editor of the International Journal of Climatology. He is the CLIMAS lead P.I. for 2005-2006.

Lisa Dilling, ldilling@cires.colorado.edu
Center for Science and Technology Policy Research, University of Colorado

Lisa Dilling studies how to develop science policies to support the use of climate-related research in decision-making. Lisa Dilling, a CIRES Visiting Fellow with the Center for Science and Technology Policy Research, received her Ph.D. in biology from the University of California-Santa Barbara. She spent six years in Washington, DC where she managed and expanded a program in integrated carbon cycle research for the Climate and Global Change Program of the National Oceanic and Atmospheric Administration, and co-developed a national interagency program to study the integrated carbon cycle that links together relevant research in six Federal agencies for the U.S. Global Change Research Program (now the U.S. Climate Change Science Program). She then spent two years as an interdisciplinary scientist with the Environmental and Societal Impacts group of the National Center for Atmospheric Research, working on the connection of carbon cycle science to policy, communication for climate change, and scales of decision making. Her current research at the Center focuses on the use of information in decision making and science policies related to climate and, in particular, the carbon cycle.

Kirstin Dow, KDow@sc.edu
Learning Center for Sustainable Futures, University of South Carolina

Dr. Kirstin Dow (PhD, Clark University 1996, Geography) is an Associate Professor of Geography and Director of the Learning Center for Sustainable Futures, a green-design residence and learning facility, at the University of South Carolina. She has diverse policy and research experience related to vulnerability, hazards, and human dimensions of global environmental change. She is former Coordinator of the Risk and Vulnerability Programme across the internationally distributed centres of the Stockholm Environment Institute. Based in SEI's Main office in Stockholm, she was also the Manager of the Poverty and Vulnerability Programme.

Her long-term research addresses environmental hazards and the dynamics of vulnerability as broad social and environmental changes affect local decisions, capabilities, and options for reducing hazard vulnerability. Her current research efforts focus on assessing the potential uses of climate information for vulnerability reduction and improved environmental management. Currently, she is a co-PI of the Carolina Integrated Science and Assessment Center, part of NOAA's Regional Integrated Science and Assessment (RISA) network, which works to bring climate information to decision makers. She has published on vulnerability to global environmental change, climate change adaptation, vulnerability of water systems to climate variability, response to hurricane hazards in the Southeastern US, urban ecology, and environmental equity and justice. She is a contributing lead author to the *Millennium Ecosystem Assessment* chapter, "Vulnerable People and Places". Her work also appears in such journals as the *Natural Hazards Review, Environmental Hazards, Coastal Management, and Global Environmental Change, and Journal of the American Water Resources Association*, as well as numerous book chapters. In 2001, the University of South Carolina recognized her contributions to the campus community with its Environmental Stewardship Award. She is also a National Councilor of the Association of American Geographers.

Gregg Garfin, gmgarfin@u.arizona.edu
Climate Assessment for the Southwest, University of Arizona

Gregg Garfin is project manager for the NOAA-funded Climate Assessment for the Southwest (CLIMAS), a multidisciplinary integrated assessment project designed to identify and evaluate climate impacts on human and natural systems in the Southwest, and to identify climate services useful in assisting decision makers to cope with climate-related risks. As manager of the project, Garfin works to bridge the science-society interface and to facilitate knowledge exchange across that interface. He is trained as a climatologist, and has a Ph.D. from the University of Arizona. His research interests include climate variability, paleoclimatology, and the impacts of climate on society. His research and outreach activities focus on drought, effective communication of climate history and forecasts to decision makers, relationships between climate and fire. Garfin is a co-author of the 2004 Arizona Drought Preparedness Plan. He serves as co-chair of Arizona's state drought monitoring committee. He has served as a member of the Western Governors' Association integrated team for the development of a National Integrated Drought Information System.

David Guston, David.Guston@asu.edu
Consortium for Science, Policy, and Outcomes, Arizona State University

David H. Guston is Professor of Political Science and the Associate Director of the Consortium for Science, Policy, and Outcomes at Arizona State University. Prior to joining the ASU faculty in January 2005, Professor Guston directed the Public Policy Program at Rutgers, The State University of New Jersey, where he had been on the faculty since 1994.

Professor Guston's current research includes a project sponsored by the National Science Foundation on the public value of social policy research (with Jocelyn Crowley of Rutgers, co-PI). He continues work on boundary organizations in politics and science, including (domestically) issues of peer review and (internationally) issues of agricultural policy. He is also investigating issues of the governance and societal implications of nanotechnologies.

Professor Guston's book, *Between Politics and Science: Assuring the Integrity and Productivity of Research* (Cambridge U. Press, 2000), was awarded the 2002 Don K. Price Prize by the American Political Science Association for best book in science and technology policy. He has also co-authored *Informed Legislatures: Coping with Science in a Democracy* (with Megan Jones and Lewis M. Branscomb, University Press of America, 1996) and co-edited *The Fragile Contract: University Science and the Federal Government* (with Ken Keniston, MIT Press, 1994). He has published more than thirty articles and book chapters and made more than seventy-five research presentations on research and development policy, scientific integrity and responsibility, public participation in technical decision-making, peer review, and the politics of science policy.

Professor Guston is the North American editor of the peer-reviewed journal *Science and Public Policy*, and he serves on the editorial boards of *VEST: Nordic Journal of Science and Technology Studies*. He has served on the National Science Foundation's review panel on Societal Dimensions of Engineering, Science, and Technology (2000-2002) and on the National Academy of Engineering's Steering Committee on Engineering Ethics and Society (2002). He will be co-vice-chair of the Gordon Research Conference on Science and Technology Policy for its 2006 meeting.

In 2002, he was elected a fellow of the American Association for the Advancement of Science (AAAS), and he is the current chair of the AAAS Section on Societal Impacts of Science and Engineering.

Professor Guston holds a B.A. from Yale and a PhD from MIT, and he performed post-doctoral training at the Belfer Center for Science and International Affairs at Harvard University's Kennedy School of Government.

Randy Hanson, rthanson@usgs.gov
US Geological Survey

Randy Hanson is a research hydrologist in the San Diego projects office of the U.S. Geological Survey's (USGS) California Water Science Center and has been studying regional ground-water/surface-water flow systems with the USGS for 25 years. Current research incorporates regional flow modeling with hydroclimatology, geohydrologic framework analysis, wellbore hydraulics and geochemistry, and borehole geophysics. Current regional flow studies in California include the Salinas and Pajaro Valleys of Monterey Bay, the Santa Clara Valley, the Ventura area and the Los Angeles Basin of Southern California, and the Central Valley. Current hydroclimatology research includes linking Global Climate Models (GCMs) to regional ground-water flow models (RGWMs) in Ventura and linking GCMs with RGWMs through the new Farm Process for MODFLOW-2000 in the Central Valley. Other climate analysis includes analysis of climate variability throughout the hydrologic cycle of the southwestern U.S. and Wisconsin, and co-variation of climate and water-quality for the High Plains Aquifer system. Geohydrologic framework analysis of the Santa Clara Valley includes the analysis of glacial/interglacial sedimentation cycles as part of the estimation of sequence stratigraphy and depositional fabrics of regional flow systems.

Lori Hidinger, lori.hidinger@asu.edu
Consortium for Science, Policy & Outcomes, Arizona State University

Lori Hidinger is the Program Manager for the Consortium for Science, Policy and Outcomes at Arizona State University. She is involved in developing and implementing the Ecosystem Function Sensitivity Analyses activities under the Science Policy Assessment and Research on Climate (SPARC) project. Previous to joining CSPO, Lori was a program manager with the Ecological Society of America's Sustainable Biosphere Initiative Science Program's Office where she was responsible for managing a number of projects that seek to develop or define the science of ecology to inform management and policy decisions. Currently Lori serves on the program committee for ESA's upcoming meeting on "Ecology in an Era of Globalization." In addition, she participates in the Sustainable Rangeland roundtable, for which she serves on the Steering Committee and chaired the Outreach Working Group. Lori received her Bachelor's of Science in Zoology from the University of Maryland and her Master of Environmental Management in Resource Ecology from Duke University's Nicholas School of the Environment.

Helen Ingram, hingram@uci.edu
School of Social Ecology, University of California, Irvine

Dr. Ingram received her Ph.D. in Public Law and Government from Columbia University in 1967. From 1969- 72, she served as Staff Political Scientist/Consultant at the National Water Commission, Washington, D.C. She served as Director of the Institute of Government Research, University of Arizona from 1974-1977. For the next two years, she was a Senior Fellow at Resources for the Future in Washington, DC. After returning to the University of Arizona as a Full Professor in the Political Science Department with joint appointments in the School of Public Administration and Policy, Hydrology and Water Resources and College of Law, she served as Director of the Udall Center for Studies in Public Policy from 1988-1996.

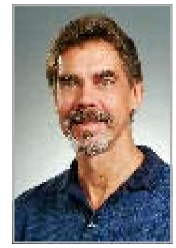
She currently holds joint appointments at the University of California, Irvine with the Departments of Urban and Regional Planning and Criminology, Law and Society in the School of Social Ecology, and the Department of Political Science in the School of Social Science. She is also Professor Emeritus at the University of Arizona and a Distinguished Research Associate at the University of Arizona's Southwest Center. She is the author of 13 books, over 45 articles and over 50 book chapters.

Dr. Ingram teaches undergraduate and graduate courses in public administration, public policy, environmental policy and environmental ethics. Her research interests include: (1) Transboundary national resources, particularly on the US/Mexican border, (2) Water resources and equity, (3) Public policy design and implementation, (4) The impact of policy upon democracy, public participation and social movement formation, and (5) Science and Society. She is best known in the field of water research for her contribution to the understanding of water policy-making and its effects both internationally and domestically with particular attention to the US-Mexico border region.

Her work on transboundary water resources has gained her significant international recognition over the years. These awards include the W. R. Boggess Award, American Water Resources Association, for the most outstanding article published in the *Water Resources Bulletin*, 1972, the Iko Iben Award in recognition of promotion, understanding and communication between disciplines involving water resources, American Water Resources Association, 1987, and the Abel Wolman Distinguished Lecture, sponsored by the Water Science and Technology Board of the National Research Council "Transnational Water Resources Management: Learning from the U.S.-Mexico Example," Washington, D.C., November 8, 1993. In 1995 she was the U.S. recipient of "Frontera" International Excellence Award, Fundación Margarita Miranda de Mascareñas, Ciudad Juárez, Mexico and in 1998, she received the "Friends of UCOWR" Certificate of Appreciation for vision and leadership in the advancement of water resources education and research, presented by the Board of Directors of Universities Council on Water Resources.

Dr. Ingram's recent work ranges from the role of scientific knowledge in the policy-making process to more organizational and institutional analyses of the water resource management programs taking place in the United States and abroad. She was recently invited to address the Plenary Session of the Annual Meeting of the Pacific Division of the American Association for the Advancement of Science. Irvine, California, June 19, 2001 with a talk entitled, "Science and Environmental Policy". Her recent research awards highlight her interest in institutional design. She was recently awarded a Seed Grant from the Center for the Study of Democracy to pursue work on a project entitled, "Path Dependency and Democratic Responsiveness: A Case Study of US Water Policy".

Keith T. Ingram, ktingram@ifas.ufl.edu
Southeast Climate Consortium, University of Florida

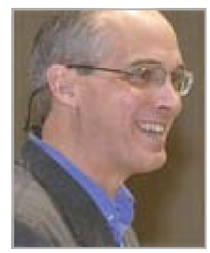


Dr. Ingram is a coordinator for the Southeast Climate Consortium and also a research scientist for University of Florida's Department of Agricultural and Biological Engineering. He received his Ph.D. in Agronomy and a minor in Botany at University of Florida. Dr. Ingram's research experience includes:

- Environmental agronomy and physiology of rainfed farming systems, including identification of plant traits that confer drought resistance, managing crops under water-limited conditions, and application of climate forecasts to improved resource management.
- Global environmental change impacts on agricultural production, including interactive effects of carbon dioxide and heat stress on crop growth, development, and productivity.
- Modeling Aspergillus spp. infection and aflatoxin contamination of peanut in response to genotype and drought.
- Design and management of controlled environment research facilities.

Other Professional Activities: Coordinate collaboration and communications among the six member institutions of the Southeast Climate Consortium (SECC) and serve as liaison among SECC, funding agencies, and other research groups.

Thomas H. Kelly, tom.kelly@unh.edu
Office of Sustainable Programs, University of New Hampshire



Thomas H. Kelly, Ph. D became the first director of the Office of Sustainability Programs at the University of New Hampshire in July 1997. As director, Dr. Kelly collaborates with faculty, staff, students and others in the development of teaching, research, policy and outreach activities related to the OSP's four educational initiatives in biodiversity, climate, culture and sustainability and food and society.

In the area of public health, Dr. Kelly is a member of the planning committee that developed and oversees the UNH Master of Public Health Program. In addition to teaching a course on Climate and Health within the MPH track in Public Health Ecology, he collaborates with faculty on the design of related courses in environmental health and disease ecology. Dr. Kelly is a co-principal investigator on the INHALE project, a NOAA funded research effort by the UNH Climate Change Research Center and School in collaboration with the School of Health and Human Services to investigate the effect of climate variability, air quality and weather on human health in New England.

Dr. Kelly was a visiting scholar at the Center for U.S.-Mexican Studies at the University of California/San Diego, and a visiting professor of transboundary environmental issues in the U.S.-Mexican borderlands at El Colegio de Mexico, Mexico DF. He holds a master's degree and a Ph.D. in International Relations from the Tufts University Fletcher School of Law and Diplomacy.

Doug Kenney, Douglas.Kenney@colorado.edu
Natural Resources Law Center, University of Colorado

Doug Kenney is a Senior Research Associate at the Natural Resources Law Center, located within the University of Colorado School of Law. In that capacity, he designs and implements a comprehensive research agenda examining a variety of public policy issues associated with natural resources, with a particular emphasis on water. He has written extensively on several water-related issues, including river basin and watershed-level planning, the design of institutional arrangements, alternative strategies for solving complex resource issues, and the nexus of western water management and climate variability/change. He is also a member of the core faculty of

CU's Environmental Studies program, a research affiliate with the Center for Science and Technology Policy Research (CU-CIRES), and a team member with the Western Water Assessment (a cooperative program between CU-CIRES and NOAA). His most recent publication (as editor) is *In Search of Sustainable Water Management: International Lessons for the American West and Beyond* (Edward Elgar Press, 2005). Doug has a B.A. in biology from the University of Colorado, a M.S. in Natural Resources Policy and Administration from the University of Michigan, and a Ph.D. in Renewable Natural Resource Studies from the University of Arizona.

David Letson, dletson@rsmas.miami.edu
Marine Affairs and Economics, University of Miami

David Letson is associate professor of Marine Affairs and Economics at the University of Miami. Letson focuses on natural resource economics and the economics of weather and climate. He has a Ph.D. in economics from the University of Texas at Austin. Letson participates in a multi-disciplinary evaluation of climate forecasting for agricultural and water resources management in the southeastern US and Argentina, as part of the Southeastern Climate Consortium (http://secc.coaps.fsu.edu/), a representing six universities (Alabama-Huntsville, Auburn, Georgia, Miami, Florida and Florida State). The SECC receives support from NOAA, the National Science Foundation and USDA. He is also a member of NOAA's Hurricane Working Group (http://swiki.ucar.edu/sip-hwg/1), convened by the National Weather Service and the Office of Atmospheric Research to develop a hurricane socio-economic research agenda.

Nancy Lewis, LewisN@EastWestCenter.org
East-West Center

Nancy Davis Lewis is Director, Research Program, East-West Center and formerly Associate Dean of the College of Social Sciences at the University of Hawaii Manoa and Professor of Geography. She holds affiliate appointments in the Center for Pacific Island Studies, the Department of Urban and Regional Planning and the Women's Studies Program. Having joined the faculty at U.H. in 1981, the majority of Nancy's research and much of her teaching has focused on human ecology, the geography of health and disease, health and development in the Pacific Islands, expanded definitions of women's health or safe womanhood and recently on climate and health and emerging infectious disease. Nancy is the Secretary General of the Pacific Science Association and she also leads that organization's efforts to promote women in science and technology in the US, Asia and the Pacific. She also served as the U.S. representative on the International Geographical Union's Commission on Health, Environment and Development and she is a past President of the Hawaii chapter of Sigma Xi, the Scientific Research Society. She serves on the editorial boards of four professional journals and on the U.S. National Research Council Committee for the Pacific Science Association. She was a Kellogg National Leadership Fellow Nancy is interested in policy issues related to vulnerability and the human dimensions of global change and she contributed to two chapters of the recently released Millennium Ecosystem Assessment.

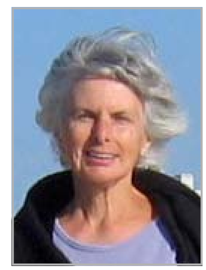
Genevieve Maricle, genevieve.maricle@colorado.edu
Center for Science and Technology Policy Research, University of Colorado

Genevieve Maricle is a graduate student in Environmental Studies at the University of Colorado at Boulder studying Atmospheric Science and Environmental Policy. Genevieve is also a fellow in the NSF Integrated Graduate Education and Research Traineeship Program. Her research focuses on climate services and the transfer of technology from climate research to useful weather and climate products for both decision-makers and climate-sensitive end users. She graduated from Northwestern University with a BA degree in both Mathematics and Environmental Science. Her undergraduate studies were primarily in the sciences but she maintained a keen awareness and interest in the political implications of her work. She became extremely interested in studying problems that transcend traditional disciplinary boundaries as she began to see a disconnect between the scientific and political worlds. This is what drew her to the University of Colorado.

Elizabeth McNie, McNie@colorado.edu
Center for Science and Technology Policy Research, University of Colorado

Elizabeth McNie is a Ph.D. student in the Environmental Studies Program at the University of Colorado, Boulder and holds a Master of Arts degree in Psychology-Organization Development from Sonoma State University in California. She is also a Fellow in the NSF – Integrated Graduate Education and Research Traineeship Program examining carbon cycle science, climate change and society. Elizabeth's research interests include institutional design, group dynamics and decision making processes in 'boundary organizations' and other organizations that enhance the linkages between scientists and decision makers. Other interests include ocean-related policy and interdisciplinary education. Elizabeth is also a licensed U.S. Merchant Marine Officer.

Barbara Morehouse, morehoub@u.arizona.edu
Climate Assessment for the Southwest, University of Arizona

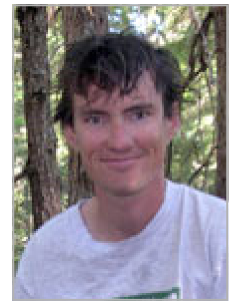


Barbara Morehouse is Deputy Director and, currently, Acting Director of the Institute for the Study of Planet Earth at the University of Arizona. She is also affiliated, as Adjunct Associate Professor, with the UA's Department of Geography and Regional Development. Her research interests include examination of institutional interactions with environmental variability and change, and analysis of processes involved in the development of integrated and collaborative science initiatives. She was the principal investigator on an interdisciplinary project funded by the EPA STAR program to build a web-based interactive fire-climate planning model. With Dr. Henry Diaz, she was co-editor of *Climate and Water: Transboundary Challenges in the Americas*. Barbara is one of the co-investigators on the Climate Assessment for the Southwest (CLIMAS) project, and serves as a member of the CLIMAS Executive Committee. She is principal investigator on an NSF-funded project to initiate a planning process for establishing a binational center for sustainability of the greater Sonoran Ecosystem and co-investigator on a project to assess climate information needs for water management in the Upper San Pedro River Basin, located in northeastern Sonora and southeastern Arizona. Barbara spent three months in spring 2004 in Greece on a Fulbright fellowship to examine wildland fire management on three islands in the northern Aegean. She has taught undergraduate courses in political geography and environmental conservation, and graduate seminars on environmental topics. She is a member of the Association of American Geographers, the Ecological Society of America, and the American Water Resources Association.

Ami Nacu-Schmidt, ami@cires.colorado.edu
Center for Science and Technology Policy Research

Ami has been with the Center for Science and Technology Policy Research for four years in providing administrative support. She is also the Outreach Coordinator for the Center's SPARC project in which she coordinates workshops and special events, such as the Center's Presidential Science Advisor Series in 2005. Ami also serves as the Associate Editor for the Center's newsletter, Ogmius, published four times a year. She is also the Program Coordinator for the Center's Graduate Certificate Program in Science and Technology. In addition to Ami's administrative responsibilities, she also enjoys being able to illustrate her creative side and has done the graphic and website design for the SPARC website (http://sciencepolicy.colorado.edu/sparc) and the Presidential Science Advisor Series website (http://sciencepolicy.colorado.edu/scienceadvisors).

Mark Neff, mark.neff@asu.edu
Consortium for Science, Policy and Outcomes, Arizona State University



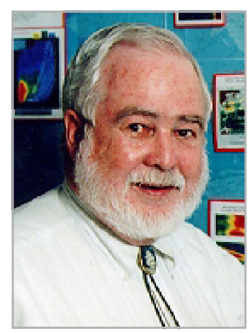
Mark Neff will be pursuing a doctoral degree from Arizona State University beginning in September, 2005. He will be working with Dr. Sarewitz at the Consortium for Science, Policy and Outcomes. He will initially focus on the Ecosystem Function Sensitivity Analysis component of the SPARC program. Mark recently received his Master's degree in Environmental Studies from the University of Oregon. His Master's research was on the politics of wildlife disease management at the National Elk Refuge in Jackson, Wyoming and the possibility of using scenario planning to advise management in that contested social-ecological system.

Gunilla Öberg, gunilla.oberg@ituf.liu.se
The Swedish Institute for Climate Science and Policy Research, Linköping University

Gunilla Öberg's work focuses on research development at Campus Norrköping, teaching in the Environmental Science Programme, and research. Since 2004, she is director of the Swedish Institute for Climate Science and Policy Research which is an interdisciplinary research unit dealing with the science-policy interface.

Gunilla's research focuses on the biogeochemistry of chlorine as well as on the use of scientific knowledge in the environmental field. During 1997-98, she was responsible for developing the new undergraduate programme in Environmental Science. As a result her interest in pedagogic issues increased. Therefore, her research now also encompasses environmental didactics.

James O'Brien, jim.obrien@coaps.fsu.edu
Center for Ocean-Atmospheric Prediction Studies, Florida State University



Dr. James O'Brien is currently the Secretary of Navy Professor in Meteorology and Oceanography at Florida State University. Dr. O'Brien received his Ph.D. in Meteorology from Texas A&M University. He is an Honorary and Professional Society Member for AAAS, AGU, AMS, RMS, OSJ, SIAM, and SX. Some of his past honors include: Medal of Honor, Liege University, Belgium, 1978; Fellow, American Meteorological Society, 1981; Fellow, Royal Meteorological Society, 1983; Secretary of Navy Professor in Oceanography, 1985; Sverdrup Gold Medal in Air-Sea Interaction, 1987; ONR Distinguished Ocean Educator, 1989; Fellow, American Geophysical Union, 1987; Fellow, AAAS, 1998; Distinguished Research Professor, FSU, 1991; Foreign Fellow, Russian Academy of Natural Science, 1994; Medal of Honor, Ocean University of Quindao, China, 1999; State of Florida Climatologist, 1999-; Robert O. Lawton Distinguished Professor, FSU, 1999; Member, The Norwegian Academy of Science and Letters, 2000; and Member, Rutgers Distinguished Alumni Hall of Fame, 2002. With over one hundred scientific publications, some of Dr. O'Brien's relevant publications include: "Information content in the ERS-1 three day repeat orbit scatterometer winds over the North Pacific: from January through March 1992" in *Monthly Weather Review*, "5-day average winds over NorthWest Atlantic from ERSI using a variational analysis" in *The Global Atmosphere and Ocean System*, "Non-Inertial Flow in NSCAT Observations of Tehuantepec Winds" in *Journal of Geophysical Research*, "Cyclone Surface Pressure Fields and Frontogenesis from NASA Scatterometer Winds" in *Journal of Geophysical Research*, "Objectively derived daily pseudostress fields from NSCAT data created through direct minimization, cross validation, and multigridding" in *Monthly Weather Review*, and "Early detection of tropical cyclones using SeaWinds-derived vorticity" in *Bulletin of American Meteorological Society*.

Richard Palmer, palmer@u.washington.edu
Water Resources Management and Drought Planning Group, University of Washington

Dr. Palmer currently teaches courses and performs research on the topics of drought planning, water resource management, impacts of climate change, and decision support systems. Dr. Palmer is the author of over 85 refereed papers, conference proceeding papers and technical reports. He is a member of the American Society of Civil Engineers and is a registered professional engineering in the State of Washington. Dr. Richard N. Palmer received his Ph.D. from the Johns Hopkins University in 1979.

Dr. Palmer received the "Service to the Professional" Award from the Water Resources Planning and Management Division of American Society of Civil Engineers (ASCE) in 1998. He was awarded the "Certificate of Recognition" for his editorial services to the Journal of Water Resources Planning and Management of ASCE in 1997, for which he was editor from 1993-1997. Dr. Palmer was awarded the Huber Award for Research Excellence by the American Society of Civil Engineers (ASCE) in 1992. His paper entitled "Operational Guidance during Droughts: An Expert System Approach" was awarded the Prize for Best Practice-Oriented Paper of the Year in the Journal of Water Resources Planning and Management by the ASCE in 1989. Dr. Palmer was a member of a team of researchers from the Johns Hopkins University and the Interstate Commission on the Potomac River Basin recognized as a finalist by ASCE for Engineering Achievement of the Year in 1983. In 1987 he was awarded a fellowship for study in Spain at the Centro de Estudios Avanzados de Blanes, Spain, and in 1988 was a Fellow at Heriot-Watt University in Edinburgh, Scotland.

Dr. Palmer's primary areas of interest are in the application of structured planning approaches to water resources. This includes impacts of climate change on water resources, drought planning and management, watershed management, the application of decision support and expert systems to civil engineering management problems, and real-time water resource management, particularly applied to drought. Since the early 1990s, he has been a leader in the field of climate change impacts on water resources, and is an active member of the University of Washington Climate Change Impacts Group, lead by Dr. Edward Miles. His most recent research projects include developing a state-wide drought plan for the State of Georgia, creating decision support tools to aid negotiations between the US and Mexico on the Rio Bravo River and evaluating climate change impacts for the Central Valley of California and urban water supplies in the Pacific Northwest.

Roger Pielke, Jr., pielke@colorado.edu
Center for Science and Technology Policy Research

Roger Pielke, Jr. has been on the faculty of the University of Colorado since 2001 and is a Professor in the Environmental Studies Program and a Fellow of the Cooperative Institute for Research in the Environmental Sciences (CIRES). At CIRES, Roger serves as the Director of the Center for Science and Technology Policy Research. Roger's current areas of interest include understanding the politicization of science, decision making under uncertainty, and policy education for scientists. He serves on the Advisory Panel of the NSF Program on Societal Dimensions of Engineering among other advisory committees. In 2000, Roger received the Sigma Xi Distinguished Lectureship Award and in 2001, he received the Outstanding Graduate Advisor Award by students in the University of Colorado's Department of Political Science. Before joining the University of Colorado, from 1993-2001 Roger was a Scientist at the National Center for Atmospheric Research. Roger sits on the editorial boards of Policy Sciences, Bulletin of the American Meteorological Society, Environmental Science and Policy and Natural Hazards Review. He is author of numerous articles and essays and is also co-author or co-editor of three books.

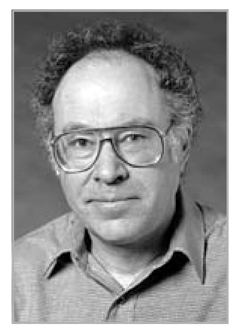
Kelly Redmond, kelly.redmond@dri.edu
Western Regional Climate Center, Desert Research Institute

Dr. Redmond is currently Deputy Director and Regional Climatologist at Western Regional Climate Center, Desert Research Institute. Dr. Redmond maintains an interest in all facets of climate and climate behavior. Over the past 17 years he has conducted studies on topics including forest climatologies, insect growth and development, mixing depth probabilities, tree ring core sampling intervals, low ceiling/visibility probabilities at airports, Crater Lake climate and hydrology, data quality, heavy precipitation episodes and landslides, development of information for energy consumption calculations, drought frequency and characteristics, climate indices, wind speed trends, spatial patterns of western U.S. climate variability, ENSO links to western climate, water supply diagnostics, biases in historical temperature records, design criteria for engineering applications, salmon and hydropower issues in the Pacific Northwest, conditional forecast probabilities, and others, for federal, state and private organizations. Dr. Redmond has played an active role nationally in the development of the climate services sector, and has served on three National Academy of Science review panels. Dr. Redmond received his Ph.D. in Meteorology from University of Wisconsin, Madison.

Anja Reissberg, reissbea@eastwestcenter.org
Department of Geography, University of Hawaii at Manoa

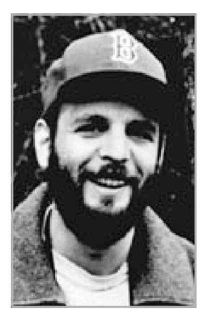
Anja Reissberg is a PhD student in Geography at the University of Hawaii at Manoa. Her focus is on climate-related disaster management in developing countries. She works for the Environment Program at the East-West Center under Eileen Shea, Pacific RISA program. She calls her home Munich, Germany and has lived in the islands for 4 years.

Edward S. Sarachik, sarachik@atmos.washington.edu
Atmospheric Sciences, University of Washington



Ed Sarachik is Professor of Atmospheric Sciences and Adjunct Professor of Oceanography and of Applied Mathematics at the University of Washington. He co-leads the Center for Science in the Earth System, a combination of an Applied Research Center and a RISA. His areas of interest are: the physics of climate variability and change especially El Niño/Southern Oscillation; tropical oceanography; tropical meteorology; the thermohaline circulation and the applications of climate information. He has served on many NRC committees (including the Climate Research Committee and the Committee of the Human Dimensions of Seasonal-to-Interannual Variability), on Advisory Committees on Forecast Applications for the IRI, and on NOAA and NSF advisory committees. He is a fellow of the American Meteorological Society, the American Geophysical Union, and the American Association for the Advancement of Science.

Daniel Sarewitz, Daniel.Sarewitz@asu.edu
Consortium for Science, Policy & Outcomes, Arizona State University



Daniel Sarewitz's work focuses on understanding the connections between scientific research and social benefit, and on developing methods and policies to strengthen such connections. His most recent book is Living with the Genie: Essays on Technology and the Quest for Human Mastery (co-edited with Alan Lightman and Christina Desser; Island Press, 2003).

He is also the co-editor of Prediction: Science, Decision-Making, and the Future of Nature (Island Press, 2000) and the author of Frontiers of Illusion: Science, Technology, and the Politics of Progress, (Temple University Press, 1996).

He has also written many other articles, speeches, and reports about the relationship between science and social progress. Prior to taking up his current position as director of the Consortium for Science, Policy and Outcomes, he was the director of the Geological Society of America's Institute for Environmental Education.

From 1989-1993 he worked on Capitol Hill, first as a Congressional Science Fellow, and then as science consultant to the House of Representatives Committee on Science, Space, and Technology, where he was also principal speech writer for Committee Chairman George E. Brown, Jr. Before moving into the policy arena he was a research associate in the Department of Geological Sciences at Cornell University, with field areas in the Philippines, Argentina, and Tajikistan. He received his Ph.D. in Geological Sciences from Cornell University in 1986.

Eileen Shea, SheaE@EastWestCenter.org
East-West Center

Ms Shea currently serves as the Climate Projects Coordinator at the East-West Center in Honolulu, HI, USA. In this context, she continues work in climate forecast applications, climate vulnerability assessment and climate risk management with a primary focus on Pacific Islands. Ms Shea also currently serves as the Interim Director of the NOAA Integrated Environmental Applications and Information Center (NIEAIC) in Honolulu, HI. Recent and ongoing projects include: an initial assessment of the consequences of climate variability and change for Pacific Islands; a Pacific Islands Training Institute on Climate and Extreme Events organized in collaboration with the University of the South Pacific (USP) and the New Zealand National Institute of Water and Atmospheric Research (NIWA); an ongoing review of the first decade of operation of the Pacific ENSO Applications Center (PEAC); and the Pacific Regional Integrated Science and Assessment (Pacific RISA) program focused on enhancing the resilience of Pacific Island communities, businesses and ecosystems in the face of climate-related extreme events such as droughts, floods and tropical cyclones. Ms Shea is involved in a number of Asia-Pacific regional endeavors focused on improving coordination among scientific institutions and government agencies engaged in climate and environmental observations, forecasting, assessment and risk management programs including: service on the Regional Committee of the Pacific Islands Global Climate Observing System (PI-GCOS) program and leading regional efforts to develop of a Pacific Islands Integrated Ocean Observing System (Pacific IOOS).

Prior to joining the East-West Center in 1998, Ms Shea served as the founder and Executive Director of the Center for the Application of Research on the Environment (part of the Maryland-based Institute for Global Environment and Society) and before that spent over eighteen years in government service in the U.S. National Oceanic and Atmospheric Administration (NOAA), culminating in her position as the Deputy Director of the NOAA Office of Global Programs. During her time in NOAA, Ms Shea helped organize the NOAA Climate and Global Change Program and the inter-agency U.S. Global Change Research Program. Ms Shea also served for two years as Environment and Natural Resources Staff Director for the Board on Sustainable Development of the U.S. National Research Council and has experience in congressional relations and budget and finance in NOAA. Her educational experience focused on marine science and environmental law and resource management at the University of Delaware and the Virginia Institute of Marine Science, College of William and Mary.

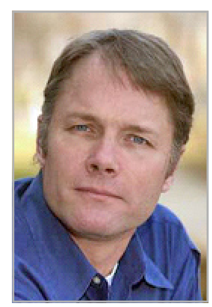
Amy Snover, snover@atmos.washington.edu
Joint Institute for the Study of the Atmosphere and Ocean, University of Washington

Amy K. Snover is a research scientist with the Climate Impacts Group at the Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington. Dr. Snover performs integrated assessment of the impacts of both natural climate variability and future human-caused climate change on the natural and human systems of the Pacific Northwest. Other foci include communication of complex scientific topics and facilitating a mutually beneficial relationship between science and decision making. Dr. Snover received a BA in Chemistry from Carleton College in 1990 and a PhD in Analytical/Environmental Chemistry from the UW in 1998. She was a joint recipient of the American Water Resources Association W.R. Boggess Award for the best paper published in the *Journal of the American Water Resources Association* in 2000 (Miles et al. "Pacific Northwest Regional Assessment: The impacts of climate variability and climate change on the water resources of the Columbia River Basin") and is currently editing a book, *Rhythms of Change: Climate Impacts on the Pacific Northwest*, about the role of climate and human choice in shaping future regional impacts of global warming.

Brad Udall, bradley.udall@colorado.edu
Western Water Assessment, NOAA-CIRES Climate Diagnostics Center

Brad Udall is the Western Water Assessment's Director. He is trained as an engineer (Stanford) and has an MBA (Colorado State). He was formerly a consulting engineer and the managing partner at Hydrosphere Resource Consultants. Hydrosphere specializes in modeling large western river basins with complicated water rights allocation and operational issues. While at Hydrosphere, Brad worked on South Platte River questions including studies of the proposed Two Forks Dam and the City of Boulder Raw Water Master Plan, an original jurisdiction Supreme Court case on the North Platte River in Wyoming and Nebraska, interstate compact issues on the Rio Grande including its major tributary the Conejos, Colorado River hydrology and modeling, and flushing flows for native fishes on the Snake River in Idaho. In addition, he had overall management responsibility for the firm. As Director of the Western Water Assessment, Brad shares responsibility over the entire program including budget authority, outreach, and strategic direction with its PIs, Randy Dole and Susan Avery. In addition, Brad serves as 'Science Integrator' of the project, and hence has a broad working knowledge of all science and water questions key to the success of the project. He is especially interested in Colorado River policy and hydrology issues, and in the enhanced use of climate information by water managers.

Cameron Wake, cameron.wake@unh.edu
Climate Change Research Center, University of New Hampshire



In addition to directing an active ice core paleoclimate research in central Asia and the Arctic, Professor Wake is involved in the NOAA funded AIRMAP (Atmospheric Investigation, Regional Modeling, Analysis and Prediction) project (http://airmap.unh.edu). AIRMAP seeks to improve our understanding of New England's changing climate and air quality through the investigation of the physical and chemical aspects of the New England atmosphere, with a particular focus on the relationship between weather and air quality. Outreach and engagement efforts are focused on improving the public's awareness and knowledge of climate change and air quality issues in New England and highlighting the availability of decision relevant real time air quality information. Dr. Wake is also leading the New England Integrated Sciences and Assesments - INHALE (Integrated Human Health and Air Quality Assessment) project (http://inhale.unh.edu) aimed at improving our understanding of how air pollution and weather effect human health. The results will be used to create informed public policy and guide the development of air quality forecasting tools. In addition to climate research at UNH, Dr. Wake serves on the board of the Kittery Land Trust and Seacoast Area Bicycle Routes, and is an avid photographer.

Misty Wing, misty.wing@asu.edu
Consortium for Science, Policy & Outcomes, Arizona State University

Misty Wing has been supporting CSPO as the Administrative Associate for the past year. She assists with the administrative and business operations of CSPO as well as maintains the CSPO website. Prior to joining CSPO Misty worked for the Center for Solid State Science while she obtained her B.S. in Computer Science at Arizona State University.

Klaus Wolter, klaus.wolter@noaa.gov
NOAA-CIRES Climate Diagnostics Center

Klaus Wolter is a climatologist at the NOAA-CIRES Climate Diagnostics Center. His main research interests lie in empirical climate research, in particular the application of statistical methods to societally relevant climate problems, such as the impact of ENSO (El Niño/Southern Oscllation) on world-wide climate. Klaus has developed and refined a "Multivariate ENSO Index" (MEI) based on tropical Pacific observations of sea level pressure, near-surface wind fields, sea – and air surface temperatures, as well as total cloudiness. The MEI is more robust than conventional indices in monitoring the ENSO phenomenon and appears to associate better with global impacts as well. Monthly updates and discussions of the MEI can be found under http://www.cdc.noaa.gov/people/klaus.wolter/MEI/.

In the last decade, Klaus has been able to devote more attention to the analysis and understanding of western U.S. climate, being involved in the Western Water Assessment (WWA) project at the University of Colorado. In the context of widespread drought conditions over Colorado and surrounding states, and prompted by repeated requests for better regional climate forecasts, Klaus has developed statistical tools that allow him to make seasonal precipitation predictions. Originally, these forecasts leaned heavily on statistical associations with ENSO, but became based on a much wider variety of influences on our climate since late 2001. Monthly updated discussions and forecasts are posted under http://www.cdc.noaa.gov/people/klaus.wolter/SWcasts/. Klaus received his Ph.D. in Meteorology at the University of Wisconsin, Madison.

APPENDIX B

SPARC-RISA Workshop Agenda
Day 1

Monday August 15, 2005	Breakfast ON OWN - *Please use $10 hotel dining credit for breakfast*
7:45am - 8:00am	Shuttle to East-West Center - *Meet in hotel lobby for AM shuttle pick up*
8:30am	*Asia Room* Introductions, Goals for the Workshop Roger Pielke
9:00am	Reconciling Supply and Demand – Dan Sarewitz and Discussion
10:00am	Break

Session #1 Demand Characterization
Moderated by Maria Carmen-Lemos

10:30am Panel RISA

- New England Integrated Sciences and Assessments (NEISA)
- Carolinas Integrated Sciences and Assessments (CISA)
- Southeastern Climate Consortium (SECC)
- Western Water Assessment (WWA)

20 minute presentations from each RISA, followed by Q&A.

12:00pm Lunch – Dave Guston on Boundary Organizations

1:00pm Panel RISA

- Climate Assessment of the Southwest (CLIMAS)
- Pacific Northwest - Climate Impacts Group (CIG)
- California Applications Project (CAP)
- Pacific Islands (Pacific)

20 minute presentations from each RISA, followed by Q&A.

3:00pm	Break
3:30pm	Discussion on Demand Characterization Moderated by Maria Carmen-Lemos
5:30pm	Adjourn
5:30pm	Shuttle to Hotel
***	Dinner on your own

SPARC-RISA Workshop Agenda - Day 2

Tuesday August 16, 2005 Breakfast ON OWN - *Please use $10 hotel dining credit for breakfast*

7:45am - 8:00am Shuttle to East-West Center - *Meet in hotel lobby for AM shuttle pick up*

Session #2 Supply Characterization
Moderated by Lisa Dilling

8:30am Panel RISA

- New England Integrated Sciences and Assessments (NEISA)
- Climate Assessment of the Southwest (CLIMAS)
- Pacific Northwest - Climate Impacts Group (CIG)
- Pacific Islands (Pacific)

20 minute presentations from each RISA, followed by Q&A.

10:00am Break

10:30am Panel RISA

- Carolinas Integrated Sciences and Assessments (CISA)
- Southeastern Climate Consortium (SECC)
- Western Water Assessment (WWA)
- California Applications Project (CAP)

20 minute presentations from each RISA, followed by Q&A.

12:00pm Lunch

1:00pm Discussion on Supply Characterization

Session #3 Managing the Ecology of Supply and Demand
Moderated by Dan Sarewitz

2:00pm Panel RISA

- New England Integrated Sciences and Assessments (NEISA)
- Western Water Assessment (WWA)
- California Applications Project (CAP)
- Pacific Islands (Pacific)

20 minute presentations from each RISA, followed by Q&A.

3:30pm Break

4:00pm Panel RISA

- Carolinas Integrated Sciences and Assessments (CISA)
- Southeastern Climate Consortium (SECC)
- Climate Assessment of the Southwest (CLIMAS)
- Pacific Northwest - Climate Impacts Group (CIG)

20 minute presentations from each RISA, followed by Q&A.

5:30pm Adjourn

5:30pm Shuttle to Aquarium

6:30pm – 8:30pm Aquarium Reception

8:45pm Shuttle back to Hotel

SPARC-RISA Workshop Agenda - Day 3

Wednesday August 17, 2005	Breakfast ON OWN - *Please use $10 hotel dining credit for breakfast*
7:45am - 8:00am	Shuttle to East-West Center - *Meet in hotel lobby for AM shuttle pick up*

Session #3 Continued - Managing the Ecology of Supply and Demand
Moderated by Dan Sarewitz

8:30am	Discussion: Reconciliation of Supply and Demand Moderated by Dan Sarewitz
10:00am	Break

Small Group Discussions

10:30am	Charge to Breakout Groups Run by Roger Pielke
10:35am	Breakout Groups Overarching question: What lessons have we learned from the RISAs for Climate Science Policy in the Climate Change Science Program?
12:00pm	Working Lunch in Breakout Groups
2:00pm	Breakout Group reports
3:00pm	Break
3:30pm	Discussion on Breakout Group Reports Moderated by Roger Pielke
5:30pm	Adjourn
5:30pm	Optional Shuttle to Hotel or Honolulu Airport