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The Regional Integrated Sciences and Assessments (RISA) Program: crafting effective assessments for the long haul

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18.1 Introduction

Climate variability and change significantly influences the health, prosperity, and well-being of individuals, societies, and the environment. For the United States this has been demonstrated, most recently, by several high impact events such as the 1997–98 El Niño event, the hurricane seasons of 2004 and 2005, the ongoing drought since 1999 in the Southwest, falling Great Lake levels, and the worst drought in 100 years in the Southeast (2007). Over the past two decades there has been significant progress in understanding longer-term climate patterns that influence these events, such as the El Niño Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), the North Atlantic Oscillation (NAO), and the Arctic Oscillation (AO). Increasingly, attention is being paid to the cumulative impacts of regional climatic events driven by decadal-scale modulations of these phenomena.

Much recent research has shown that enabling effective responses to environmental variability and change requires knowledge assessments at both the global scale and at the appropriate scales of decision making i.e., the region and the locale (NRC 1999; Clark *et al.* 2001). As identified at the federal level and in academia, there is a need for credible, unbiased assessments of the status and trends of environmental patterns and processes (US Congress 1994). At the same time there are calls for more and better structured processes to identify, assess, and meet national, regional, private, and local climate-related needs, and to foster the timely adoption and effective use of commercially valuable information and technology throughout the US economy (US Congress 1998; US Congress 2007).

This paper outlines the development and evolution of a long-term US-based interdisciplinary program focusing on climate impacts assessments and regional and local decision support: the Regional Integrated Sciences and Assessments Program (hereafter RISA). The RISA program has existed for over ten years and

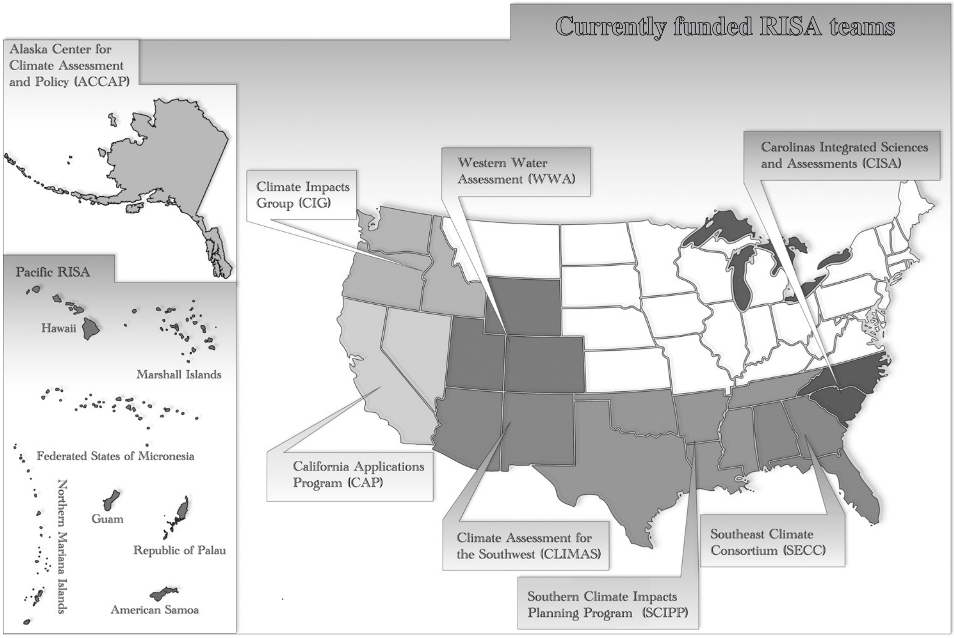

Figure 18.1. Present RISA activities: teams, critical problems, partners, and approaches. (http://www.climate.noaa.gov/cpo_pa/risa/)

tangible lessons may begin to be drawn from the experiences of the RISA teams and from program management. Many studies or even "assessments of assessments" aim at providing new frameworks, usually idealized, but offer little on how the assessment itself originated, is organized, and sustained. Put differently, knowing what to do is not the same as doing it. The RISAs have developed as decentralized scientific applications and policy experiments (Brunner 1996) providing traceable accounts of successful federal–state and local partnerships in interdisciplinary research, climate impacts assessment, and decision support.

18.2 The RISA program: history and maturation

At present, there are nine regional integrated sciences and assessments activities funded by NOAA. These activities are focused on the Pacific Northwest (CIG), the Southwest (CLIMAS), California and Nevada (CAP), Inter-Mountain West (WWA), Alaska (ACCAP), Hawaii and US-affiliated islands in the Pacific Ocean (Pacific RISA), the Carolinas (CISA), and the Southern (SECC, SCIPP) regions of the United States (see Fig. 18.1 and Box 18.1 for details). The final RISA configuration is envisioned to be an ongoing assessment system distributed across relatively large regions of the United States, consisting of integrated networks

Box 18.1

1. *The California Applications Program (CAP)*, led by researchers at Scripps Institution for Oceanography, studies the impacts of climate variability and change in California and the surrounding area. CAP evaluates weather and short-term climate forecasts and climate change projections, with particular attention to climate influences from the Pacific Ocean and western North America. An associated emphasis is to develop a better capacity for observing the climate over the complex landscape of the California region. CAP is working to improve climate information for decision makers in key sectors, including water, human health, and wildfire. http://meteora.ucsd.edu/~meyer/caphome.html
2. *The Carolinas Integrated Sciences and Assessments (CISA)* project aims to improve the range, quality, relevance, and accessibility of climate information for water resource management in North and South Carolina. CISA examines water resource issues at interannual, decadal, and longer scales to determine how decision makers use climate information to manage water and how current operational practices can benefit from new climate and water resource products. CISA investigates how best to present climate sciences that are relevant to water resource policy, and to foster understanding of climate variability, issues of forecast uncertainty, and risks associated with forecast failure. http://www.cas.sc.edu/geog/cisa/
3. *The Climate Impacts Group (CIG)*, located at the University of Washington, Seattle, examines the impacts of natural climate variability and global climate change in the US Pacific Northwest. CIG's goal is to increase the resilience of the region to climate fluctuations through research and interaction with stakeholders. Research emphasizes four key sectors of the Pacific Northwest environment: water resources, aquatic ecosystems, forests, and coastal systems. Focusing on the intersection of climate sciences and public policy, CIG works with planners and policy makers to apply climate information to regional decision-making processes. http://tao.atmos.washington.edu/PNWimpacts/
4. *The Climate Assessment for the Southwest (CLIMAS)* project fosters collaboration between university researchers, agency scientists, resource managers, educators, and decision makers throughout the region to understand climate and its impacts on human and natural systems in the US Southwest and adjacent USA–Mexico border area. CLIMAS investigates vulnerability to climate variability in both rural and urban areas, how to improve climate inputs for drought planning, and climate impacts on water resources, water policy, and wildland fire. CLIMAS studies how climate information is used by decision makers and works to evaluate and improve forecasts. http://www.ispe.arizona.edu/climas/
5. *The Pacific Islands RISA* supports emerging regional efforts to pursue an integrated program of climate risk management. With an emphasis on understanding and reducing Pacific Island vulnerability to climate-related extreme events such as drought, floods, and tropical cyclones, activities within this emerging RISA build

substantially on existing regional efforts in climate sciences and El Niño forecasting. Led by researchers at the East–West Center in Hawai'i, Pacific RISA works in close collaboration with stakeholders in water and natural resources, agriculture, tourism, and public safety and health. http://research.eastwestcenter.org/climate/risa/

6. *The Southeast Climate Consortium (SECC)* is a multi-institutional, multi-disciplinary team focusing on the vulnerability of agriculture, forestry, and water resources management to climate variability. SECC scientists are developing methods to translate regional climate forecasts into local forecasts, linking them with crop and hydrology simulation models in order to enhance understanding of decision makers so they can reduce risks associated with climate variability. The consortium is developing partnerships needed to build equitable outreach programs for farmers, forest managers, water resource managers, homeowners, and policy makers to enhance user familiarity with seasonal climate forecasts. http://www.coaps.fsu.edu/lib/Florida_Consortium/ http://fawn.ifas.ufl.edu/
7. *The Western Water Assessment (WWA)* provides information about climate variability and climate change to water resource decision makers with the goal of improving management of the Intermountain West's most critical resource, water. Through partnerships with key decision makers, WWA provides vulnerability assessments, climate forecasts, and paleoclimate studies designed to enhance short-term and long-term management decisions. WWA experts focus on the Colorado and Platte River Basins, researching policy options, streamflow forecasting, snowpack monitoring, drought planning, and reservoir management. http://cires.colorado.edu/wwa
8. *The Alaska Center for Climate Assessment and Policy (ACCAP),* the newest RISA center, is being led by investigators at the University of Alaska. The primary functions of ACCAP will be (1) the synthesis of available data and information in order to quantify actual and potential impacts of changes in the seasonality of weather and climate on Alaskan people and ecosystems, and to determine corresponding needs for enhanced product delivery by agencies such as the National Weather Service; (2) research that will facilitate the product enhancement identified in (1); and (3) assessment of the vulnerability and adaptive capacity of various Alaskan sectors, together with a determination of the management and policy decisions that can reduce vulnerability and facilitate adaptation. The transportation sector will provide the initial prototype for this activity. http://www.uaf.edu/accap/
9. *The Southern Climate Impacts Planning Program (SCIPP)* was recently initiated in late-2008. It is centered at the University of Oklahoma and incorporates the states of Oklahoma, Texas, Louisiana, Mississippi, Arkansas, and Tennessee. Its emphases are on regional and cross-sectoral social and economic indicators or drought impacts and on decision support.

(discussed below) that enable local and regional capacity to address climate-related risks and opportunities.

18.2.1 Development of the RISA Program

In the late 1980s, the NOAA Office of Global Programs (OGP) was created to provide research support for the NOAA contribution to the cross federal agency US Global Change Research Program (USGCRP). The basic tenets of the 1991 "Our Changing Planet," which is the annual USGCRP report to Congress, were to:

(1) integrate science into the policy process;
(2) maintain partnerships among all participants;
(3) focus on interdisciplinary science and interactions.

While most agencies interpreted this directive to mean linking physical science models with economic and other models, the OGP leadership envisioned a more interactive process with decision makers. Additionally, the OGP support of climate variability research and seasonal forecast development resulted in an early emphasis on changes in the higher moments of the climate system in addition to changes in the mean state. For instance, both stochastic and deterministic elements of key processes were seen as fundamental to understanding ENSO variability and change (see also Peters *et al.* 2004). In this context the climatic timescale would come to be treated as a continuum rather than as completely discrete modes of variability in which change was a wholly separable component.

In the early 1990s, the NOAA Office of Global Programs began funding economics studies and then added human dimensions studies. The 1993 request for proposals written by one of this chapters' authors (CRN) described the goals of the human dimensions research as developing a greater understanding of human adaptation to past climate. A follow-up memo (1995, CRN) emphasized the need for regional assessments addressing climate change in the context of other environmental problems of significance. The Pacific Northwest Climate Impacts Group (CIG), the first RISA, was selected because of a focusing event (the 1994 closure of Columbia River salmon fisheries, resulting in the first ENSO-related disaster declaration in the USA) and the involvement of the Principal Investigator (PI) in the 1995 IPCC Assessment. The PI concluded that the IPCC process and products were not meeting regional needs at scales commensurate with decision making. This conclusion resonated with that reached earlier by disaster and development researchers. As important was the increasing recognition that definitions of community and region had been modified, beyond the physical unit of analysis, by trends toward democratic participation in planning processes and the need for mediating institutions, more recently called "boundary organizations" (Campbell

1969; Shackley and Wynne 1996; Linder 2005). Another major intervention, the US National Assessment of Climate Change Impacts on the United States (see Morgan *et al.* 2005 for an insightful review), was launched in 1998, three years after the NOAA Regional Assessment Program had been initiated. A major criticism of the National Assessment was that, while it was innovative in raising awareness of climate change-related risks, for many of the participants it was unable to sustain the follow-on interactions needed for effective learning and response. The now obvious conclusion is that complex environmental problems can seldom be dealt with by single discrete actions or policies but respond more effectively to sustained efforts.

Integrated knowledge about climate and climate impacts was being built on components of two major activities already being supported within NOAA Cooperative Institutes, with federal, state, and academic partners across the country and internationally. These activities were: (1) climate and environmental monitoring and research; and (2) economic and human dimensions research (now the Sectoral Applications Research Program) on vulnerability and on the usability of climate forecasts. Targeted sub-activities would form a third focus area on integrated risk assessment applications and decision support (i.e., the development and communication of relevant research results to meet specific needs). This third area would provide the basis for the RISA program. Integrated risk assessments were viewed as occurring over the many dimensions of a resource (e.g., surface, groundwater, humidity), as a component interacting with other systems (e.g., climate and ecosystems) and, with reference to broader interrelationships (e.g., negative and positive impacts of climate on social and economic development).

Advances in our appreciation of complex systems allowed for a reframing of the climate–society interface as a set of multi-dimensional problems in which studies of larger-scale climatic forcings and regionally-focused assessments of impacts and decision making contexts all needed to proceed simultaneously (Figure 18.2). In 2000, the name of the program was changed by the then Program Manager (RSP), in agreement with the project leads, from Regional Assessments to RISA to emphasize the fully interdisciplinary and contextual nature of conducting ongoing regionally-specific knowledge assessments in conjunction with decision support. Context here was taken to include situation, capacity, and also the ways in which a problem is constructed, perceived, and represented by different stakeholders.

As noted above, global- to sub-continental-scale climate initiatives are necessary to provide a foundation for knowledge use by society, but these initiatives are not, by themselves, sufficient to provide the potential users of climate information with the requisite capacity for use. The RISA program was initiated to make and secure the connection with the stakeholders, and to generate the regional science and capacity for learning from those connections.

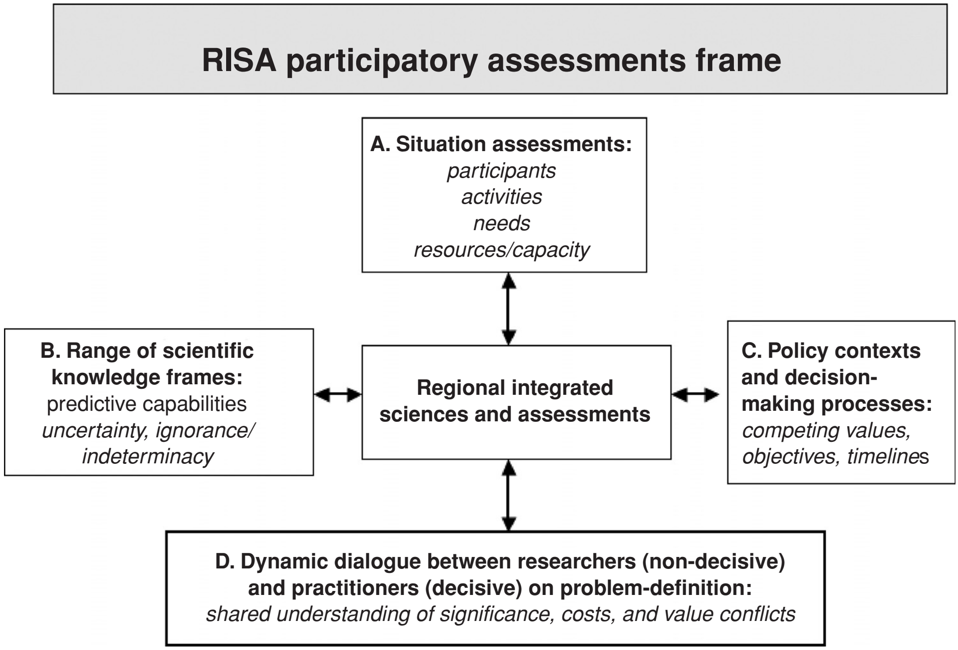

Figure 18.2. RISA participatory assessments framework.

The RISAs have come to function under several key empirically grounded observations, many of which had been articulated in disparate sources such as agricultural extension, disasters, and adaptive management (see White 1966; Holling 1978). These may be summarized as follows:

- adaptation involves a broad range of responses and practice of which climate sensitivity and information are parts;
- new knowledge, new problems, and opportunities continuously arise as events unfold;
- there is no uni-causal model of explanation of system behavior in a particular region; no set of dynamics holds identically true across all regions;
- predicted effects are highly uncertain, implying the need for better characterization of uncertainties, use of existing data on past and contemporary events, and stakeholder experience with those events;
- assessment of effects involves tradeoffs between the multiple interests of current and future generations;
- increased methodological complexity (see Toth and Hiznyik 1998) does not necessarily result in better assessments nor does better information always result in better decisions;
- there is a need to re-define relationships among federally-funded efforts with academic, non-governmental, and local partners (see below).

The key initial assumption was that public and political perceptions of the value of integrated science would be higher if research and products are regionally specific. Regional research would provide important case studies, reliable climate information from global models and local data, and innovative methods for transfer upscale and across regions. As such the RISAs emphasized, from their earliest stages, the:

- value of interaction with stakeholders when they and scientists are regionally co-located;
- climate research and information specific and scaled to regions (observations, forecasts, impacts, projections); and
- responses to agendas established by the USGCRP/CCSP, NRC, and IPCC.

In 2002, the US House of Representatives noted the following:

Other than a relatively small program [RISA] at NOAA, there is currently no structure or process within USGCRP to identify potential users, understand their needs, and connect them to the research agenda . . . RISA has been called a step in the right direction by some while others view it as a model that could guide larger efforts within USGCRP. Committee on Science US House of Representatives, New Directions for Climate Research and Technology Initiatives, April 17, 2002.

Similar observations have recently been made in National Academy reports on the US Climate Change Science Program (NRC 2007), an incarnation of the USGCRP (US Global Change Research Program).

Key to the RISA approach, and as observed by Brewer (1999), is the framing that problems should designate theory, not the reverse. The risk communication dialogue developed allowed articulation of contested values among resource users and researchers, and preferred outcomes in a particular setting. A fundamental and ongoing issue is to uncover the practical degree of flexibility within regions and communities to adjust decision making in climate-sensitive sectors based on the informed application of science-based information and past experience. This problem orientation allowed RISA the added impetus of having to outline alternative decision pathways and to legitimize discussions of the consequences of those decisions in public fora.

In the RISA context, “regions” exist at the nexus of the local to global continuum. Integrated scientific assessments constitute the sum of efforts to (1) characterize the state of knowledge of climate variations and changes at appropriate scales of interest, (2) identify knowledge gaps and linkages in selected climate–environment–society interactions, and (3) provide an informed basis for (a) responding to climate-related risks and for (b) establishing priorities in basic research investments to meet these needs. To achieve the goals of meeting evolving needs, assessments must be forward looking and anticipatory, and broad enough to evaluate the potential for scientific surprises.

Because of their initiation with a focus on climate variability and extremes, and now across variability and change, the RISAs are not tied to a specific scenario or set of scenarios but link assessments and impacts to emergent problems in the context of short and longer-term vulnerabilities. Their major innovation has been iterating climate impact and response assessments across timescales (ENSO, PDO, long-term trends and projections) and sectors (e.g. fisheries and hydropower) and as such presaged much of the recent climate change literature emphasizing information mainstreaming into existing practice and cross-scale response.

18.3 The structure of RISAs

Not all RISAs started the same way. The RISAs were deliberately allowed to develop different pathways to allow for experimentation and critical issue definition. Following Guston and Sarewitz (2002), we can articulate the RISA programs in terms of different scales, types of impacts and decisions, participation mechanisms, and organization. The user-driven dialogue in each case was designed and implemented by the individual teams and was given high and visible priority in the context of program goals by program management. As expected, those activities funded first have been making inroads to meeting the longer-term goals of the program, in large part because they have refined participation mechanisms over time. Those in pilot or preliminary stages focus on clarification of initially defined critical regional issues, integration of the team, developing cooperative stakeholder linkages, knowledge development intended to lead to user-inspired tools, and data assimilation. Many individual researchers had previously worked on integrated projects in their regions (sometimes supported by NOAA) before the formation of their particular RISA (see Shea *et al.* 2001). These researchers often came on board with science-stakeholder experience and moved more quickly through the early implementation phases.

Implementation of RISA projects has taken the form of several co-evolving tasks, including:

- team development: selection of physical and social science researchers; initial characterization of current state of knowledge of relevant climate, ecological, and hydrologic variability, and various units of analysis (watershed, urban etc.) depending on recent and other historical events;
- developing stakeholder linkages (build on earlier work) to deepen the identification of climate-related critical issues/problems within the region; further refine assessment goals and expectations; determine database and methods integration needs;
- assessing social, economic, and ecological impacts and vulnerability to climate on multiple timescales in selected cases vertically (linking assessment and management); to begin with, identify levels of critical decision-making needs within 1–3 important sectors and/or groups (e.g. water resources, energy, urban areas, agriculture, fisheries etc.) in the region;

- developing pilot projects and implementing prototypes for characterizing environmental information and enhance collaboration among researchers, decision makers, and the public;
- improving horizontal (i.e., across sectors) decision-support dialogues, openness, and developing awareness with respect to integrated climate impacts on regional and local system outputs;
- developing frameworks for structuring a process to articulate present knowledge and knowledge gaps; testing these in different fora, such as in responding to shorter-term events and extremes in the region and providing feedback into assessment design;
- refining mechanisms of interaction and learning among the research and resource management and planning communities;
- capacity building within user communities as needed to realize the benefits afforded by developments in climate research, products, and services.

Pilot efforts have undergone external reviews and evaluation before consideration of continuation and/or expansion to the next phase of assessments. Funds are also targeted in the program towards research on assessment design, including deliberate lesson drawing exercises, such as cross-RISA comparative studies of stakeholder engagement and transferability of approaches, etc. Vehicles for learning include the development of prototypes and more recently, exploratory implementation in other areas and regions. Prototyping allows for sensitivity to context and explicitly draws on lessons from the diffusion of information and incorporation of those innovations into the evolution of assessment design and management.

Each set of investigators within a region was asked to design a research agenda in partnership with stakeholders in their particular region. For example, in the Southeast, the “problem” was defined in terms of the vulnerability of important crops to climate variability and access to climate information for risk reduction and opportunistic planning; in the Pacific Northwest, the problem was variations and changes in ocean and hydrologic variability and land use in relation to thresholds in fisheries (Salmonids) and hydropower. The scope of a “region” would be refined through interaction with decision makers networked across a relatively broadly defined area facing climate-sensitive challenges. Whereas the signal problem that the USGCRP Program addressed was establishing and characterizing predictability of the climate system, the RISA program established a mechanism to legitimize the pursuit of climate-sensitive problems, and identifying stakeholders’ needs in combination with scientific capacity to bridge the information gap between needs and problems. This emphasis grew out from several studies (funded by the NOAA economic and human dimensions and other programs) showing that many resource management decisions are made under time, financial, institutional, and other constraints that limit the utility of comprehensive modeling exercises. In addition, the modeling approaches focus primarily on efficiency from an economic perspective and may not be able to accommodate other management objectives such as equity (see Pulwarty and Melis 2001; Rayner *et al.* 2005).

After ten years of experience, the (general) temporal phases involved in program implementation may be characterized as:

Years 1–2: team integration and building to ensure interdisciplinary approaches; more defined regional characterization; development of core capacity (e.g., core offices with 1–2 full-time personnel for some of the larger teams); start-up pilot projects;

Years 2–3: Clarifying issue criticality, vulnerability, regional climate sensitivity assessments; beginning vertical integration;

Year 4 and beyond: Fully integrating partnership networks and lines of communication and research developed in preliminary studies; standards and practices for vertical integration; collaborative development of tools for application.

Depending on the regional issues addressed, RISA research components include: statistical and dynamical climate analyses; hydrologic, agronomic, fisheries, forestry, or other impact modeling; reservoir operations modeling; stakeholder and researcher interviews and historical studies, surveys, institutional mapping, and policy analysis, economic and decision analysis, and vulnerability and evaluation studies. RISA knowledge assessments have been complemented by assessments of climate services provided and of the management systems involved in mediating climatic risks within their various portfolios (fisheries, water resources, forestry etc.). Each RISA activity has fulfilled these roles to varying degrees, depending on the respective start time, the relevance and visibility of impacts in the region, and scale of operation. Efforts are being made (see below) to draw tradeoffs and lessons between comprehensive assessments across a range of issues (such as in the Pacific Northwest and the Southwest) and the vertically integrated study of one or two particular questions (such as the early single sector focus on climate and agriculture in the Southeast).

18.4 Scientific achievements

Each RISA project has succeeded in developing pathways in integrated climate science and impacts assessment, awareness building, and decision support. RISAs have matured to the extent that they are creating linkages and acting as coordinators among federal, state, and local agencies in different regions to identify, undertake, and evaluate integrated research on climate-sensitive issues. Successful RISAs create science–society research elements that monitor interdisciplinary integration around impacts and elicit changing knowledge and perceptions among both stakeholders and researchers.

A useful illustration of the approach articulated above is provided by early research undertaken in the Pacific Northwest (CIG) and the Southwest (CLIMAS) that are still bearing fruit. Early studies are chosen for illustration since their impact and robustness may be better established than recent efforts. By integrating information about oceanic, atmospheric, ecological, and hydrologic processes, (employing monitoring, forecasting, and observational systems funded by NOAA) the Pacific Northwest RISA team (CIG) has led to a clearer understanding of "natural" versus human-caused fluctuations in Pacific salmon numbers. This issue has been a source of great conflict in the Northwest. In addition, their work in this area has successfully contributed to prioritizing the PDO as an important area of focus for basic research (Box 18.2).

Box 18.2

The Pacific Decadal Oscillation (PDO): an early and ongoing priority

The phrase "Pacific Decadal Oscillation" was first coined by Mantua *et al.* (1997), within the Pacific Northwest RISA Group. In its positive phase, the PDO is a pattern of Pacific sea surface temperature (SST), with cold anomalies in the central northern Pacific and warm anomalies along the eastern edges of the basin (i.e., the west coast of North America). The PDO was in the negative phase from 1900 (when the first reliable SST records are available) to 1925 and from 1945–1977 and in the positive phase from 1925–1945 and from 1977. The RISA team established that the PNW climate signal is dominated by a combination of the ENSO phenomenon (cool/wet, warm/dry) on a seasonal/interannual timescale, and the PDO. The most pervasive climate-driven impacts are generated by the PDO, and the impacts are magnified whenever the PDO and ENSO are in phase with each other. Annual streamflow is the single most sensitive terrestrial signal of climate variability in the PNW, and almost all climate impacts are mediated through the regional hydrology. Depending *solely* on whether the PDO is in the cool or warm phase, small changes in temperature ($-0.11\,^{\circ}$C to $+0.17\,^{\circ}$C) and precipitation (-4% to $+2\%$) generate large changes in: snowpack (-15% to $+17\%$), streamflow (-9% to $+6\%$), survivability of Washington coho salmon (-16% to $+19\%$), and frequency of forest fires (-49% to $+65\%$). Depending *only* on ENSO, the impacts are on snowpack (–14.7% to +9%) and streamflow (-12% to $+8\%$). When PDO and ENSO conditions are *in phase*, the impacts are enhanced for snowpack (-29.7% to $+26\%$) and streamflow (-17% to $+14\%$). More than half of the variations in annual salmon catch in the USA are associated with the PDO. The general pattern is that Alaskan fisheries do worse during the negative phase of the PDO (e.g., 1945–1977) and better in the positive phase (e.g., 1925–1945), while fisheries in Washington, Oregon, and California do worse during the positive phase and better in the negative phase. The implications of these findings are that management of many western salmon stocks is more vulnerable to (and constrained by) climate variations than managers had realized. These efforts of the Pacific Northwest Climate Impacts Group have fed directly into research priorities for the US Climate Variability and Predictability (CLIVAR) program.

The RISAs have also helped identify problems unrecognized or acknowledged by mission agency programs and disciplinary university structures. An example is synergistically blending the perspectives of many sciences on urban growth in the US Southwest and past changes in water supply reliability and future demand (Box 18.3).

RISA activities depend on innovative partnerships among a spectrum of interests (federal, state, local, and private etc.) to enable organizational capacity within a region to develop and test experimental climate information services delivery on an ongoing basis. As such, the RISA program relies heavily on consolidating the results and data from ongoing NOAA and other agency research already funded in a region, into an integrative framework. Table 18.1 shows the existing interactions and critical issues being addressed across the various climatic timescales within the Western Water Assessment (Webb and Pulwarty 2006).

These and other efforts at engaging stakeholders have led to what has best been described by RISA leadership as "A Sea Change in Perceptions." They have resulted in a dramatic change in stakeholder perceptions of the value and relevance of information about climate variability and change. Miles (personal communication), illustrates the evolution of awareness in (Pacific Northwest) Climate Impacts Group (CIG) case, as follows:

1995: few managers saw role for climate information, recognized predictability of climate, or possessed a conceptual framework for applying climate information;

1997–98: El Niño and concomitant media attention stimulated widespread interest in information about climate variability and in CIG; most stakeholders unfamiliar with potential impacts of climate change and unprepared to use such information;

2001: senior-level water resources managers recognize climate change as a potentially significant threat to regional water resources; acknowledge climate change information as critical to future planning;

2001/2: 50-year drought brings intense media attention to the issue and CIG's work → public and private pressure on state agencies to include climate change impacts in long-term planning → significant involvement of CIG in multiple planning(??) efforts;

2003 to present: continued significant breakthroughs with stakeholder groups.

As is widely acknowledged, single interventions do not settle problems once and for all, nor are credibility and relevance instant products of a workshop (or two). Key to the CIG's evolution has been a focus on the timing and form of climatic information (including forecasts) developed, providing access to expertise to help incorporate the information and projections in decision-making processes. In many instances the latter has been shown to be as or more important to individual users than improved forecast reliability (Pulwarty and Melis 2001; Orlove *et al.* 2004; Rayner *et al.* 2005).

Box 18.3

Sensitivities of the Southwest's urban water sector to drought: Arizona case studies

The CLIMAS project analyzed the water budgets of five Arizona cities to determine the degree of severity of impacts from the deepest one- (1900), five- (1900–1904), and ten-year droughts (1946–1955) on record. Case study sites included the Phoenix Active Management Area and the Tucson Active Management Area (AMA).

AMAs are areas in Arizona where stringent groundwater management is mandated under the 1980 Arizona Groundwater Management Act. The CLIMAS study showed that in each of these areas, even under assumptions of continuation of "average" climate conditions, issues persist regarding the possibility of achieving safe-yield (i.e., renewable supply and demand are in balance) by the year 2025, as articulated in the Act. The water sectors in the Phoenix and Tucson AMAs are constrained by availability of both surface water, including Colorado River water delivered via the Central Arizona Project (CAP), and groundwater resources. Phoenix continues to be one of the fastest growing urban areas in the country. Here, serious water conservation efforts are notably lacking, even in the context of a relatively arid environment and continued high population and economic growth. The Tucson AMA encompasses the second-largest population concentration in the state. This AMA remains reliant on groundwater, although much of the area is making the transition to blending recharged CAP water with groundwater. Groundwater levels have fallen as much as 60 m in the AMA since 1940.

In the Phoenix AMA, the capacity to draw upon multiple sources of surface water, groundwater, water banked under the Arizona Water Banking Authority, and (potentially) large amounts of effluent, provides an important buffer to drought. However, there are significant localized differences within the AMA. Each of the 31 large and nearly 80 small, water providers has a unique portfolio of water supply sources and customer base, as well as a more or less complex web of arrangements regarding treatment and recharge facilities. Longer-term, relatively severe droughts have potential to cause considerable problems in some areas, particularly those where groundwater pumping is the sole source of supply.

Unlike the situation in the Phoenix AMA, changes in water management in the Tucson AMA promise a decrease in the rate of groundwater overdraft anticipated in the near future. However CAP water is expected to account for most of this progress toward achieving safe-yield. As is abundantly clear from both paleo and historical records, the Southwest and Colorado River streamflow are characterized by very high degrees of climatic variability over annual and decadal timescales. Even if agriculture were eliminated and aquifer overdraft cut by half, withdrawals would continue to exceed renewable supplies under the drought scenarios used in this study. These results became a major point of attention by the Arizona Department of Water Resources and the Governors Planning Commission in revising and reauthorizing the State Groundwater Management Act.

Table 18.1. *Western Water Assessment partners and products across the continuum of climate timescales.*

Event characteristics	Objectives: understand, explain, predict, assess, communicate, evaluate	Climate processes	With whom does WWA work?
Short-term extreme events	Develop experimental forecasts, monitoring, and application products. Experimental attribution assessments of regional extremes.	Sub-seasonal variability, Arctic outbreaks, monsoon, floods, heat waves, tornados, hurricanes.	Reclamation, Fish, and Wildlife Service, CBRFC, Office of Hydrology, CPC, HPC, regional councils, wildfire managers.
Drought: seasonal to multi-year	Develop drought forecasts, monitoring, paleoclimate reconstructions, and application products. Assess social, environmental, and economic impacts.	Flash droughts, snowpack evolution, soil moisture evolution, El Niño and La Niña, multi-decadal ocean variability.	Western Governors Association (WGA), NIDIS, NWS, RFCs, NCDC, RCCs, NDMC, USDA, NRCS, USGS, NASA, regional councils, state and municipal agencies.
Decadal climate variability	Develop experimental monitoring, attribution, and application products. Assessments of regional trends and risks to inform adaptation strategies.	Pacific decadal variability, Atlantic multi-decadal variability, short-term influences, regional trends.	Regional councils, wildfire managers, NCAR, regional watershed councils, municipal agencies (e.g., Denver).
Climate change	Develop experimental attribution assessments of hemispheric to regional trends. Assess social, environmental, and economic risks (e.g., Colorado Compact).	Observed, current and evolving trends, enhanced hydrologic cycle, high elevation change.	CCSP, Reclamation, EPA, USGS, IPCC, NCAR, NASA, regional watershed councils, municipal agencies.

In 2007, the CIG produced an "Adaptation Guidebook" (CSES/CIG, 2007) in the context of climate change impacts. The observed acceptability of such a book, focused on a particular region and co-produced with non-academics, could only have resulted after years of engagement in studies on extremes and variability, studies on the impacts of salient events, and on maintaining necessary partnerships and social interactions at stakeholder driven meetings and events.

The RISAs continue to play significant and steadily increasing roles regionally, nationally and to some extent internationally. This is evidenced by the substantial contributions of RISA members to the IPCC Fourth Assessment, in Congressional and other briefings on the status of climate risks and adaptation options, and the development of state and utility drought and watershed plans (see for example Cayan *et al.* 2003; Colby *et al.* 2005; Brekke *et al.* 2007). They also contribute to fundamental research on the environment–society interface (Orlove *et al.* 2004; Dow and Carbone 2007). Recently, several RISA researchers and managers were recognized formally by the State of California for their roles in facilitating climate services delivery.

18.5 What is being learned by the RISA teams?

RISAs have proven to be particularly innovative at organizing the dialogue between scientists and practitioners (see Ingram *et al.* 2006 for an example from agriculture) and identifying critical entry points for information through the various calendars of decision making (Pulwarty and Melis 2001). RISAs have experimented with public fora, regular and sustained meetings, proactively seeking opportunities to participate in technical or professional meetings, one-on-one technical assistance, working with research partners who sit in resource management agencies, disseminating material through web sites, local and national media targeted publications, among other techniques.

Insistence by program managers that the research team members would be primarily resident in their region of study, so that they were also seen as stakeholders (albeit non-decisive ones), contributed to their understanding of context and their acceptability. Participatory, integrative social science that fully includes stakeholders requires commitment of resources and client-agency interest towards the development of reciprocal partnerships with stakeholder communities (Box 18.4). This provides the foundational elements from which usable research and successful awareness-building projects subsequently emerge. The process often involves or requires transcending existing bureaucratic boundaries, such as those between federal agencies, a notably difficult task.

A key issue within the RISAs was to establish a dialogue of risk communication that would be richer than the traditional model of providing information and data without considerations of context or interpretation or the model of a consultancy-based two way approach of attempting to provide only what is requested. As illustrated by the RISA experience the information supply and demand model applied by some (see, for instance, McNie *et al.* 2007) is a limited construct in complex situations where the demand is not always well-defined and learning processes and fora are needed for conducting collaborative framing and implementation exercises.

Box 18.4

The RISA teams have uncovered or confirmed many important insights about research–stakeholder partnerships

- Development/maintenance of stakeholder partnerships can only take place with researchers at the local to regional level.
- Partnerships cannot focus on climate variability alone: efforts must be interdisciplinary and focused on the integration of the multiple stresses relevant to the stakeholder and the region.
- Stakeholder partnerships, once established, must be sustained; failure to do so will jeopardize the partnership and reduce hard-earned credibility.
- Stakeholders cannot be considered solely as individuals or only within the context of single economic sectors; regional assessments must be able to accommodate integration across individuals and sectors.
- Stakeholders need demonstration that their needs, ideas, and concerns are central to problems investigated in regional climate assessment and science.
- Stakeholders need the guarantee that the quality of climate knowledge, particularly at their regional- to local-scales of interest, will be ever-improving; regional stakeholder-driven science represents a major gap in climate funding.

As the individual RISAs mature, they have adopted a project-by-project mode in order to refine their work vertically and at specific entry points of interest to stakeholders. More mature RISAs move toward horizontal integration across sectors and/or sets of stakeholder issues. However, defining measurable goals and targets has not been adequately stressed within the projects (see below). It remains a difficult avenue to pursue given limited resources, ongoing events, and rising stakeholder demand for new information. RISAs have, however, achieved one of the program's major goals, which was to demonstrate in practice the potential utility of climate information in very specific contexts. Through this vehicle they have empirically demonstrated the value of a sustained regional focus in revealing environmental uncertainties most critical to decision making. As anticipated (or more accurately "hoped"), many of the assessment projects themselves are becoming more successful at garnering support from regional constituents for cooperative research and applications. A more rigorous understanding of their successes and failures will require a concentrated effort on evaluation (both internal and external) than has yet been undertaken.

18.5.1 Potential pitfalls in the RISA approach: a risk assessment

In this section the authors hope to offer some brief insights into the difficulties and possible limitations of taking the above approach. It is important to note that the authors, as active and former administrators of the RISA program, recognize the pitfalls of concluding on the efficacy of interventions in which they are engaged, and which, to some extent, they advocate.

Individual RISA projects were and are purposely initiated with relatively modest funding in order to focus on the proof of concept within any given region, to encourage the establishment of key relationships with a small number of stakeholders, and to derive clear and hopefully replicable lessons for practice. One innovation was the emergence of certain efficiencies once a core number of centers were established. In other words, expertise in fire risk, or climate–hydrology interactions, or water banking analyses could be tapped into rather than having to develop locally or from fundamentals in every instance. The RISAs have also become fairly skilled at attracting federal and in some cases state funds outside of NOAA. From its inception, the program envisioned NOAA support as providing integration and seed resources upon which the teams would leverage other resources. While this may represent success on their part, it may imply a certain failure in the federal context to support these kinds of assessments commensurate with their acknowledged value in a truly cross-agency framework. Each federal agency has its core missions, and a regional approach (as opposed to sectors or topics) is harder to reconcile i.e., maintain autonomy and accountability, within those missions.

The RISA program managers worked from the onset to forge partnerships with the emerging research teams and deliberately create an environment of experimentation and learning. While some RISA team members are based at government research facilities and non-profit organizations, the research team members are primarily based at universities. Barriers to interdisciplinary research and problem-oriented approaches within university settings have been well documented (Brewer 1999; Guston and Sarewitz 2002). Yet, strong interdisciplinary programs are built from the foundations of strong disciplinary programs. Many of the difficulties lie in the "intransigencies" of the research setting (Campbell 1969). Political realities also mitigate against thorough or critical evaluation of risks and reforms (Brunner and Ascher 1992). NOAA program management understood that the initial projects could not have gotten off the ground through traditional means of scientific advisory bodies and an open competition around questions defined a priori. Program managers needed to outline an acceptable process (to academic partners and federal offices) for experimenting with both interdisciplinary integration and stakeholder engagement.

A major risk in RISA initiation in the early days was that capacity might not yet exist in a particular locale, or that there was not a community of decision makers interested in climate information. As noted above, that landscape is changing rapidly. Another risk was (is) that it is difficult for many university-based investigators to invest in the long start-up time of a project like RISA. In addition, for other than the most advanced in their careers, many academics may not find it sufficiently professionally rewarding to embed themselves in the applied research and stakeholder processes, necessary for informing adaptation practice. Many in academic settings, of necessity, find themselves leveraging support from several sources to meet the needs of particular projects, with attendant divided attention among projects.

A major issue surrounding evaluation has been the inability to fully articulate the end-to-end utilization of information on a particular problem. This has usually been the result of the proprietary nature of information and its use. More effective and formal mechanisms for acknowledging and documenting information importance, use, and outcomes are needed. While there has been increasing focus on the processes by which knowledge has been produced, less time has been spent examining the capacity of audiences to critically assess knowledge claims made by others for their reliability and relevance to those communities. Finding outside evaluators from the resource management and other relevant communities has proven even more difficult, but this is slowly changing.

Although the experimental approach was key to the success of the program it also resulted in a lack of program specificity about project goals early in the process. RISA programs have not yet been wholly successful at developing effective feedback and lesson drawing mechanisms into the larger monitoring and research programs, i.e., the strategic components, of the federal enterprise. Maintaining coordination within interagency groups is widely acknowledged to be important but can conflict with mission agency priorities and has not been as fruitful as program management anticipated. It is clear that the climate information services in support of adaptation must sustain an ongoing and well-coordinated suite of regional, sectoral, national, and global-scale assessment activities to meet statutory, programmatic, and scientific requirements.

18.5.2 Team leadership

A notable gap in most studies of assessments has been in elucidating the critical area of within-team leadership (see NRC 2007). Many scientific researchers may underestimate or fail to comprehend the need for management and may actually conclude that it is beneath their level of attention. It is however, where things (read "integration") fall apart. The integration of multiple disciplines (beyond academic exercises) and multiple perspectives remains challenging to generate and sustain in practice. Much of this has to do with how individuals are recognized, rewarded, and reinforced within academic settings. While this appears to be evolving, the changes are driven by particularly resourceful and innovative individuals (the RISA team leaders) and not by a "sea change" in academia. That being said, several RISA leaders may now be able to offer insights to the broader assessments community on overcoming this long-standing problem. All RISA-type activities have been shown to require the integrative leadership of a talented individual (in RISA and in the program agency). Most importantly, a leader defines a broad scope of work to allow the salient problems to emerge and also to maintain a level of independence from the client-agency and even from stakeholders to avoid pressures to produce desired answers. The leader ensures the continuity of relations with clients and his/her team to develop trust and a deeper understanding of the problem being faced.

As in other adaptive assessments (Walters 2007), the RISA team leaders have been individuals who: (i) have a broad overview of the decision making and implementation process, along with intimate knowledge of administrative details involved in each step; and (ii) are persistent in the face of lack of early interest (or after a missed forecast). Most importantly, they are willing to devote a significant portion of their careers to the implementation process, and to create attractive career paths for team members. This is also true for the program managers involved in the client-agency, a usually underappreciated fact.

Based on the above discussion, academic settings, by themselves, may prove to be sub-optimal for conducting and sustaining assessments in the context of decision support for numerous stakeholders. They are credible but not necessarily legitimate (as in meeting legal requirements) purveyors of risk-based information in the public domain. Universities do, however, allow expanded commitments to the education and training of scientists and stakeholders. RISA members have come to include State Climatologists, Regional Climate Center members, and extension specialists, among others. Where the university-based researchers have, over time, partnered with operational agencies, including the research branches of these agencies or with extension networks, tangible contributions to specific management goals have been documented. However, it is clear that much more needs to be done to incorporate the operational arms of federal, state, and tribal entities (and the private sector) to transition research and applications technologies into day-to-day operations, early warnings, and long-term capacity building. RISAs have provided informed pathways, but it is clearly up to the governance infrastructure (local, tribal, state, and federal) to support and advance the RISAs goals while being informed by their ongoing discoveries and mistakes.

18.6 RISAs and climate services: what are the lessons?

The orientation towards providing an informed basis for "services" is one of the major distinctions between RISA efforts and the experience of previous climate impact assessments beginning with the SCOPE (1986) "Report on Climate Impacts

Assessments" (Gilbert White, personal communication, 2002). RISAs are experiments in the design and implementation of climate and environmental services. They are not the service itself. They do however provide useful insights for climate services implementation (see below). Implementation of service activities relies upon the specific programs and activities derived from the mission responsibilities and unique assets and experience of the climate and global change programs member agencies. At present (spring 2009) there are several Congressional Bills advocating the formation of a National Climate Services or at least a better infrastructure for delivering accountable decision support. The first National Climate Program Act was introduced in 1978 (US Congress 1978).

The National Research Council defines "Climate Services" as *"The timely production and delivery of useful climate data, information and knowledge to decision makers"* (NRC 2001). To achieve such a service the NRC further recommends that relevant agencies develop "regional enterprises" designed to expand the nature and scope of climate services, a much larger construct than "decentralized policy experiments." The RISAs have, importantly, expanded the "climate services" concept to include a network of activities that maintain well-structured paths from observations, modeling, and research to the development of relevant place-based knowledge and usable information.

Miles *et al.* (2006) effectively expands on the RISA themes and experience to outline the functions of a National Climate Service, as follows:

- integrate global, national, and regional observations infrastructure to produce information and assessments of use to stakeholders and researchers;
- develop models for decision support; perform basic and applied research on climate dynamics and impacts relevant to stakeholder interests;
- create and maintain an operational delivery system and facilitate transition of new climate applications products to NCS member agencies;
- develop and maintain a dialogue among research teams, member agencies, and stakeholders for developing information relevant for planning and decision making;
- identify climate-related vulnerabilities and build national capacity to increase resilience;
- represent regional and national climate issues and concerns in regional and national policy arenas and facilitate regional–national communications on NCS needs and performance;
- outreach to stakeholder groups.

Creating acceptability of a new services design requires moving beyond a flow chart of institutional components, especially if those institutions were not involved in the design. The RISA experiments illustrate that at a minimum such a framework should:

(a) produce practical and acceptable design principles and a coordination framework for regional climate services;

(b) be credible and acceptable to private and public partners and to NOAA leadership by being both academically and institutionally sound;
(c) if possible achieve consensus on evaluation requirements and strategies to maximize the applicability of results and to foster program improvement.

RISA contributions have been to attempt to bridge, directly, the inadequate fit between what the research community knows about the physical and social dimensions of uncertain environmental hazards and what society chooses to do with that knowledge. An even larger challenge has been to consider how different systems of knowledge about the physical environment and competing systems of action can be brought together in pursuit of resilience and other diverse and competing goals that humans wish to pursue (Jasanoff 1996; Mitchell 2006). A more systematic RISA contribution towards understanding how such a service for a complex system would be governed and implemented involves:

- developing a mixed portfolio of products research, communication approaches, and applications credible to scientific and operational communities;
- assessing impediments to the flow of knowledge among existing components (RISAs, Regional Climate Centers, NWS Field Offices, State Climatologists, and extension arms of other agencies etc.);
- assessing policies and practices that can give rise to failures of the component parts working as a system;
- assessing opportunities for and constraints to learning and institutional innovation;
- developing capacity for local actors to design their own institutions and partnerships "public entrepreneurship";
- identifying transactions costs involved in implementing service components including international and national assessments activities.

The RISAs may over time contribute, beyond their list of risk assessment and management "projects," to a broader dialogue on constitutive issues surrounding the development of information services in the context of adaptation to global change. Understanding how "learning" is documented and becomes incorporated into practice is not a straightforward task. To set this goal in the larger context requires an understanding of the conditions governing the continuity or transformation of social systems and structures (Giddens 1986). As noted some time ago it is easier to evaluate abrupt and decisive interventions since a gradual response may be indistinguishable from the background secular change (Campbell 1969). Behind the specific questions of the transparency of risk, are broader questions about the public sphere (Jasanoff 1996; Mitchell 2006): What public goods will be provided by governments (and how will they be funded), what public goods will be provided by private organizations in civil society, what will and will not be provided to market actors? How do we move beyond framing outcomes in terms of winners and losers to securing partnerships in knowledge production and use?

Though the RISAs constitute only a small subset of a much larger climate research enterprise, and an even smaller subset of the human resources needed to produce and convey usable climate information, they demonstrate the profound importance of investment in the spaces between how we experience climate, what we know about it, and the varieties of responses.

18.7 Conclusion: a continuing voyage of discovery

An oft-heard assumption is that increases in knowledge about environment–society interactions will result in improvements in the quality of public and private decisions (a decidedly idealized view). Much recent work has shown that this expectation is most difficult to meet when decision stakes are high, uncertainty is great, technologies are new, experience is limited, and there are unequal distributions of burdens and benefits. Enabling successful information interventions at any point in time requires a critical mass of accessible, credible, and legitimate information and the capacity to apply knowledge and evaluate consequences of its use. The goals and successes of the RISA program are and have been in informing the development of place-based decision support and services by expanding the range of practical choices available to those affected by climate-related risks and environmental stresses, exacerbated through human activities or otherwise.

The RISAs continue to draw lessons from a variety of sources and events, such as from the 1997–1998 and other ENSO events, from Endangered Species Act declarations, the National Assessment, wildfire events, the IPCC process, and from multi-year droughts. Their experience shows that effecting change in risk management is most readily accomplished when at least three conditions are met: (1) a focusing event (climatic, legal, or social) occurs and creates widespread public awareness and calls for action; (2) leadership and the public become engaged; and (3) *a basis for integrating monitoring, research, and management is already established and supported.*

The RISAs have proven themselves to be more than just a client-based consultancy seeking to answer received questions. RISA projects do not necessarily advocate one set of policy options over another but seek to evaluate and make transparent the implications of different choices under varying and changing climate conditions (see the Appendix). Assessment of critical climate-sensitive issues, in this setting, is the iterative process of integrating interdisciplinary knowledge and experience about risks and vulnerabilities in a region commensurate with the design and support of effective responses. Such activities require innovative partnerships among a spectrum of interests (federal, state, local, and private, etc.) to enable organizational capacity within a region for developing accurate balanced syntheses (i.e., identifying risk characteristics, uncertainties, critical knowledge and data gaps, social and environmental vulnerability) and services.

The RISA experiment, because of its evolutionary approach to learning and implementation, offers unique opportunities to continually assess and construct post-audits of evolving events to inform longer-term risk reduction strategies. It is our contention that evolutionary or learning-based approaches to "assessment" as designed and developed by RISA-type programs are more effective at entering into national, regional, and local plans of action for responding to complex environmental problems than traditional, periodic integrated knowledge assessments.

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Appendix

Acronyms

ACCAP	Alaska Center for Climate Assessment and Policy
AO	Arctic Oscillation
CAP	California Applications Program
CBRFC	Colorado Basin River Forecast Center
CCSP	Climate Change Science Program
CIG	Climate Impacts Group
CISA	Carolinas Integrated Sciences and Assessments
CLIMAS	Climate Assessment for the Southwest
CPC	Climate Prediction Center
ENSO	El Niño Southern Oscillation
EPA	Environmental Protection Agency

HPC	NOAA Hydrologic Prediction Centers
IPCC	Intergovernmental Panel on Climate Change
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NDMC	National Drought Mitigation Center
NGO	Non-governmental Organization
NIDIS	National Integrated Drought Information System
NRCS	USDA Natural Resources Conservation Service
NOAA	National Oceanic and Atmospheric Administration
NAO	North Atlantic Oscillation
NWS	National Weather Service
PDO	Pacific Decadal Oscillation
RCC	Regional Climate Center
RISA	Regional Integrated Sciences and Assessments
SECC	Southeast Climate Consortium
BoR	US Bureau of Reclamation (Department of the Interior)
USDA	US Department of Agriculture
USGCRP	US Global Change Research Program
USGS	US Geological Survey
WGA	Western Governors Association
WWA	Western Water Assessment