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INRA Water Resource Management Research and EducationNeeds Assessment Project

Douglas B. Jackson-Smith
Utah State University

S. Marquart-Pyatt

C. Harris

A. Lovecraft

E. Shanahan

See next page for additional authors

Recommended Citation

Jackson-Smith, D.B., S. Marquart-Pyatt, C. Harris, A. Lovecraft, E. Shanahan, and P. Wanschneider. 2007. INRA Water Resource Management Research and Education Needs Assessment Project, Final Technical Report. Institute for Social Science Research on Natural Resources. Logan: Utah State University, November, 88 pages.

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Authors
Douglas B. Jackson-Smith, S. Marquart-Pyatt, C. Harris, A. Lovecraft, E. Shanahan, and P. Wanschneider

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Inland Northwest Research Alliance
Water Resources Research Consortium

Water Resource Management Research and Education

NEEDS ASSESSMENT PROJECT

FINAL TECHNICAL REPORT

Lead Author
Dr. Douglas Jackson-Smith
Dept. of Sociology, Social Work and Anthropology, Utah State University

Co-Authors
Dr. Sandra Marquart-Pyatt
Dept. of Sociology, Social Work and Anthropology, Utah State University

Dr. Charles Harris
Dept. of Conservation Social Science, University of Idaho

Dr. Amy Lovecraft
Dept. of Political Science, University of Alaska-Fairbanks

Dr. Elizabeth Shanahan
Dept of Political Science, Montana State University

Dr. Phil Wanschneider
Dept. of Economics, Washington State University

November 2007

Acknowledgements

This project was made possible by a grant from the U.S. Department of Energy, through the Inland Northwest Research Alliance.

Field interviews were conducted and interview transcripts were developed by several graduate students working with the principal investigators. These included:

Interviewers

Scott Hoffman *(Utah State University)*
Michael Halling *(Utah State University)*
Lauren Krueger, *(University of Alaska-Fairbanks)*
Sabine Hugger, *(University of Alaska-Fairbanks)*
Robin L. Crough, *(Montana State University)*
Erin Seekamp, *(University of Idaho)*
Barry Greene, *(Washington State University)*

Critical assistance with data coding, interpretation, and analysis was provided by

Analysts

Brian Jennings *(Utah State University)*
Joyce Mumah *(Utah State University*

The authors also wish to thank the many people who participated in the interviews.

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EXECUTIVE SUMMARY

Background

The Water Resources Research Needs Assessment team received funding in summer 2006 from the Inland Northwest Research Alliance (INRA) Water Resources Steering Committee to conduct a structured needs assessment study. The study was motivated by the desire to allow future INRA research and educational programs to meet better the needs of water resources managers in the five state INRA region.

This study was designed specifically to accomplish three core goals:

- Ascertain the concerns and perceived research needs of water resource managers and diverse stakeholders in this region,
- Condense this complex information into a format that can be shared with the INRA Water Resources Research Steering Committee, and
- Develop a realistic set of regional water resources research needs and priorities to help shape future INRA-funded research and education activities.

Methods

The Needs Assessment team began by developing contact lists of water resource management key informants in each state. These lists included administrators, technicians, staff and representatives from a diverse arrange of public and private groups and agencies. Specific key informants were selected to provide a diverse array of geographic, topical, and organizational experience in each state. A total of 165 key informant interviews – lasting from 60-90 minutes each – were conducted in the fall and winter of 2006-2007.

Results of the key informant interviews were summarized in written narrative reports and then analyzed using standard qualitative analysis approaches. The analysis focused on the identification of related themes or content clusters for each of the major research topics. These themes were then used to organize the results summarized in this report.

The results are not meant to be a statistically representative sample of all water resource managers or stakeholders. Rather, they should be interpreted as a comprehensive assessment of the types of issues, priorities, and concerns that are most common among the diverse non-university actors working on water issues in this region.

Key Findings

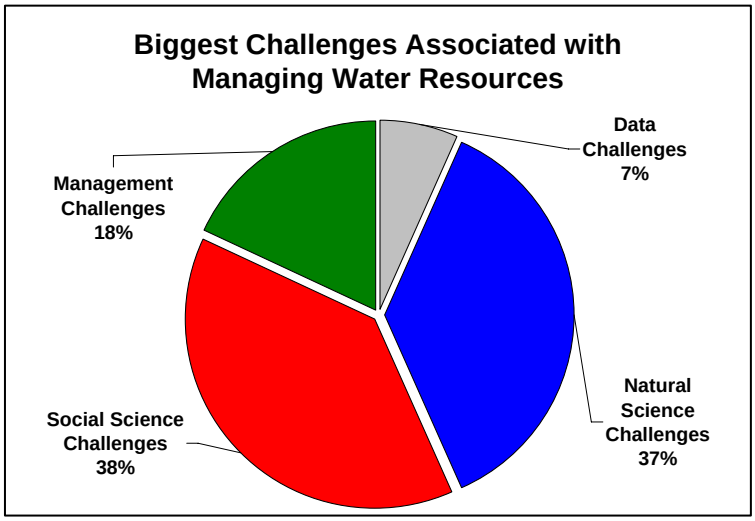
The key informants identified a very diverse set of research recommendations for possible future INRA-sponsored research. These differences reflect the particular information demands, data challenges, and analysis obstacles faced by people working on the front lines of water resource management in the West.

While there were many detailed recommendations included in each interview, it is possible to summarize the overarching findings for several core topics.

Biggest Challenges

All key informants were asked what the biggest challenges they faced in their efforts to manage water resources in the Inland Northwest. Responses were collapsed into four large categories (see Figure 1). Several conclusions are evident from the results:

- The biggest challenges facing water resource managers included both **social and natural science** topics.
- Limitations in the available basic science research base were not the key problem; rather they sought more **application of science to public policy problems**.
- **Administrative and management challenges** were common problems preventing respondents from doing their jobs effectively.



- A sizeable number of respondents indicated that the **current monitoring and data infrastructure is inadequate** to allow them to be effective in their work.

Understanding the Challenges Facing Water Resource Managers

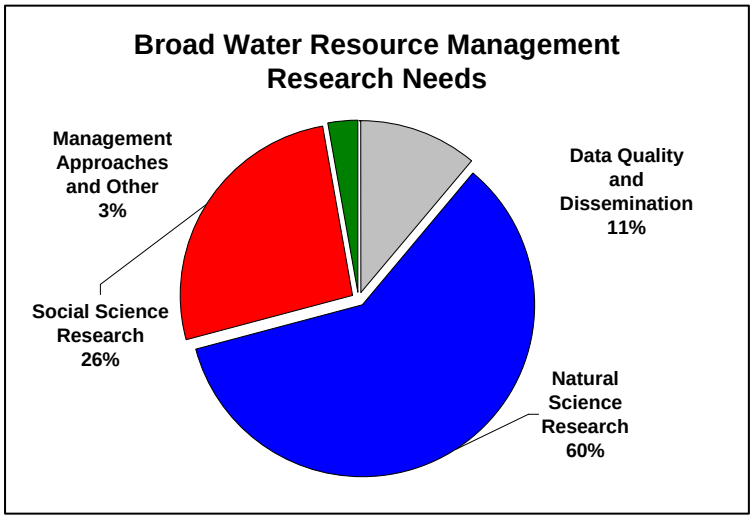
When asked what obstacles and challenges they face in their current jobs, water resource managers were equally likely to cite natural science and social science topics. The natural science challenges reflected a diverse set of topics (ranging from water quantity, water quality, climate and drought, to other natural systems concerns). Social science topics included challenges linked with water rights law and policy, inadequate funding resources, and pressures associated with rapid population growth and change. In many ways, these challenges overlap and intersect, posing future challenges, necessitating further scrutiny.

While most managers identified limitations in the available scientific research base as key challenges, they also discussed the importance of improving data management systems and the challenges associated with maintaining an effective water data collection and analysis infrastructure. Not surprisingly, for many respondents, improving existing types of water data and working to standardize and disseminate existing information are as important as developing new scientific models or understandings.

Some state-based differences were notable. Respondents in Montana, Idaho and Washington identified had relatively balanced sets of challenges (natural systems, human dimensions, management and data). In contrast, though human dimensions challenges were the largest category in both Utah and Alaska, the rank ordering for the other three categories differed. These similarities and differences should be explored in more depth in future studies.

Research Needs

In addition to highlighting the 'challenges' faced by water resource managers, the interviews invited respondents to identify areas where additional university research efforts would be most helpful. These questions generated almost 600 suggested research topics. The results were collapsed into four similar categories (see Figure 2). Some important findings from the detailed results include:



- The majority of recommendations were for **increased natural science research** (60% of total).
- While some suggested more 'basic' science (especially integrated studies of hydrologic systems), most natural science examples emphasized applied topics, particularly studies of the **impacts of social, economic, and land use changes on water quality and quantity.**
- A sizeable fraction (26%) of suggestions focused on **social science research** topics. These include socioeconomic baseline data, evaluation of different methods for changing public behaviors, help with public education and public input processes, and assessments of alternative policy options.
- Although not strictly a 'research' topic, a significant number of respondents identified **improvements to the quality and availability of water data** as a priority. Several suggested creating a data clearinghouse to make existing scientific research and monitoring data more readily available.

Because of the diversity of research needs suggestions, our team was able to subdivide these four main topics into several subareas. The distribution of these research needs subareas can be seen in Figure 3 below.

Within the large group of natural science research topics, most suggestions reflect concern with water quantity, water quality, and climate and drought issues. Within the social science category, responses are fairly evenly split between water consumption data, sociological factors, political factors, and economic factors.

A full description of each of these areas (complete with examples of the suggestions from the respondents) can be found in the full Final Technical Report.

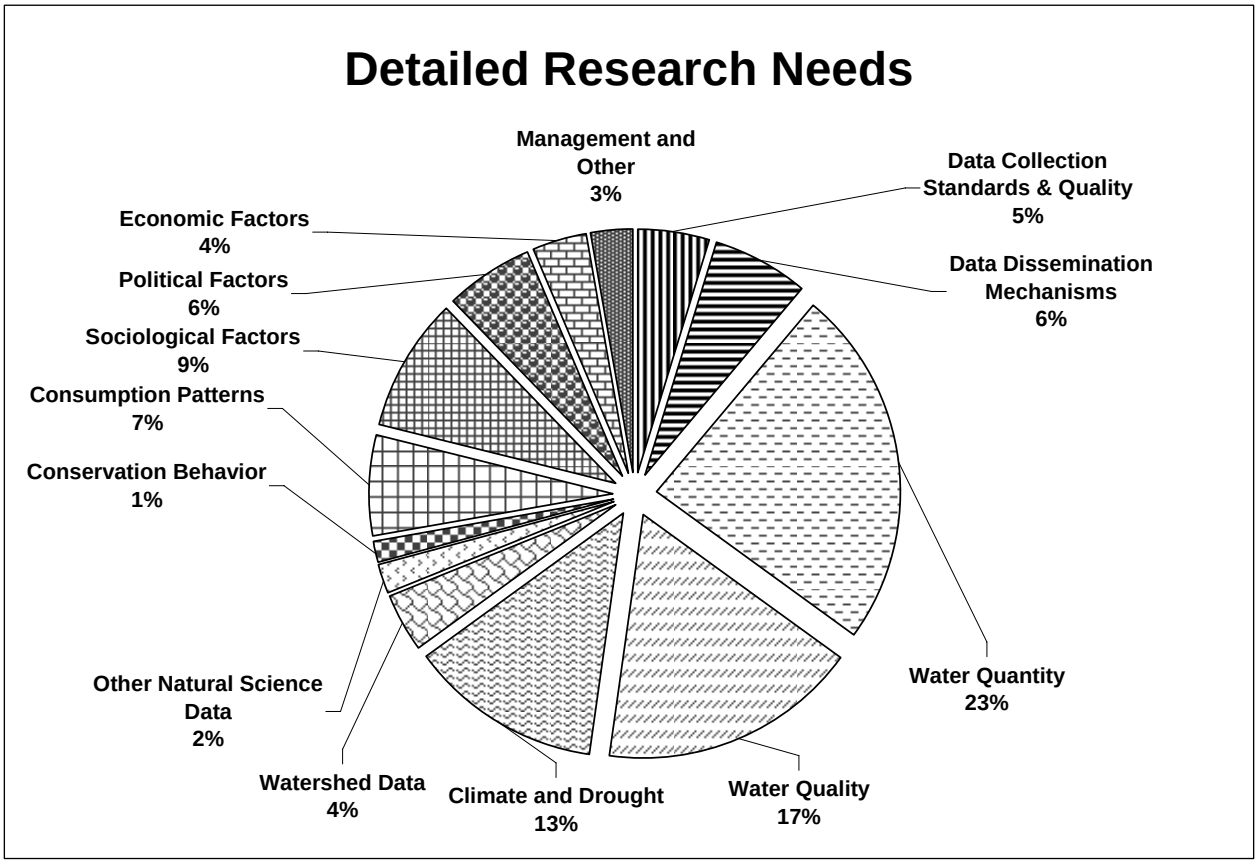


Figure 3. Detailed Research Needs

Interpreting Research Needs Suggestions

Overall, while basic natural science topics were not uncommon in our interviews, the dominant research priorities focused on more applied water science questions, including efforts to develop a better water monitoring and data collection infrastructure and the development of scientific models that can help explain impacts of human behaviors on hydrologic systems.

In the first instance, it is clear that there has been inadequate investment in the development and maintenance of water resource monitoring systems by state and federal governments. Many respondents felt that they had to make decisions in the context of inadequate basic data about local water use, water supply, and water quality conditions. Specific criticisms were lodged at the problems of inconsistent measurement techniques and schedules, uncoordinated data storage systems, a lack of locally specific data, irregular data collection schedules, and long time lags between data collection and the availability of the information.

Second, while many respondents did identify conventional basic natural scientific research as a priority, our interviews suggested a relatively high level of satisfaction with the existing natural science research programs in regional universities. When pressed to identify areas where additional research should be conducted, a large fraction of respondents emphasized that the greatest gap was in the intersections of traditional scientific disciplines – including interdisciplinary, cross-disciplinary, and systems-level research. In some cases, these

intersections involve various natural science fields; in others, they involve integrating social science perspectives and methods into studies of natural science phenomena.

The results suggest that many of the natural science puzzles – such as better information about the interactions between surface and groundwater systems – are most important to decision-makers *in the context of their applied water management problems*. Most of these problems are linked directly to social, economic, and land use changes associated with rapid population growth and the transfer of water from traditional agricultural sectors to urban or rural residential and commercial uses. Our interviews suggest that there is still a great deal that is not understood about human-driven changes taking place on the landscape and their associated effects on water use, water demand, and water quality in this region. Many of the research priorities summarized under the 'Human Dimensions of Water' label above fit into this category.

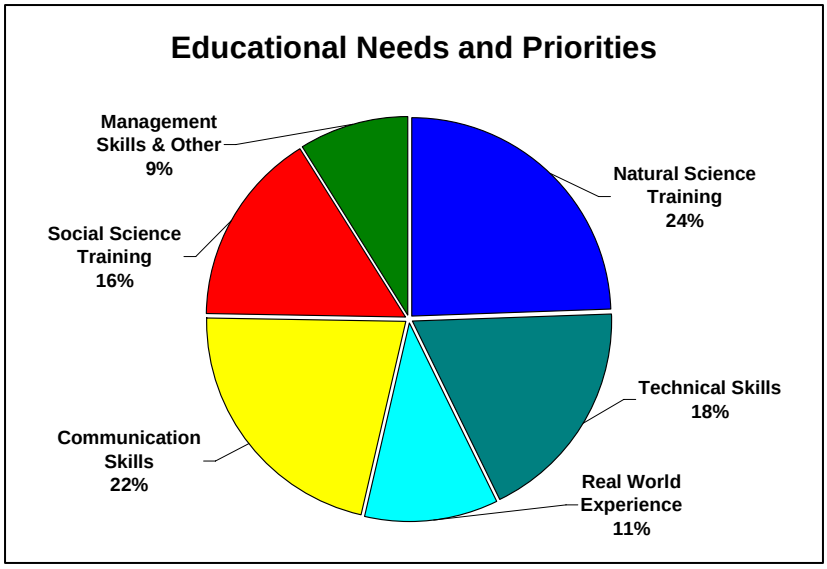
A significant number of our interviewees had responsibilities to educate the public about water quantity and quality issues. In most cases, these people felt that they would benefit from a deeper understanding of the techniques and tools available for communicating with the public. These tools might involve strategies for understanding the goals and experiences of diverse stakeholders, as well as efforts to change the behaviors of a broader mass of citizens.

A final insight from the research needs inventory is that there is considerable room for improving the quality and quantity of information that can be exchanged between the academic scientific community and the water resource managers included in our interviews. While not strictly a research priority, the interviews suggest that institutional barriers and time constraints have limited the potential for interaction and communication across these two social fields.

In sum, understanding water resources and issues requires an approach that acknowledges generalities as well as contextual differences that convey past, present, and future challenges for water professionals and practitioners. For instance, physical features of specific locations (such as geography, climate, and size) are integral to understating natural resources and their availability and spatial distribution. However, it is also important to understand how other issues intersect with these physical features, including population changes, pressures for economic development, and various legal influences linked with supply and demand. Indeed, a complex chain of mutually reinforcing issues, actors, and agencies can be identified, as can interrelations that posit unique causal pathways.

Education Needs

Interview participants were asked to evaluate whether the training received by students in INRA universities is adequate to prepare them for work in typical non-academic settings. Overall, most respondents felt that the eight INRA institutions were providing an excellent scientific and technical foundation for applied water resource management in this region. However, a significant number of respondents identified areas where additional training or education might be useful.



- Roughly half of the suggestions made were considered to be improvements on traditional water resource management training topics, including training in **basic disciplinary science and technical skills** (particularly research design, statistics, and GIS).
- A particular emphasis within these traditional categories was for more **interdisciplinary or cross-disciplinary training** and more opportunity for **real-world, hands-on experiences.**
- Another half of the educational program suggestions reflected what we considered to be "non-traditional' topics for training water resource management students. The most common examples included:
    - **Better oral and writing communication skills**
    - **Improved understanding of western water law, policy, politics**

Core Recommendations

As noted above, from water resource managers and stakeholders in this region provide a number of important suggestions that could be used to direct future INRA research and education funding. The recommendations outlined below are based solely on the feedback from our interviews. It is expected that the prioritization of new initiatives by INRA leaders will necessarily include consideration of other issues (e.g., scientific value, institutional capacity, the appropriate roles for universities, etc.). However, to the extent that the INRA effort is designed to encourage greater relevance of university research and training for regional water resource management, the suggestions below provide a useful roadmap for future work.

Research Priorities:

Some core recommendations for INRA research priorities based on the needs assessment include the following broad topics:

- **Encourage investments in the water monitoring and data collection infrastructure.** While this may or may not include a role for INRA university institutions, there is clearly a perceived need among water resource managers and field-staff working on water issues for better water resource monitoring systems.
- **Encourage natural science research** on water quantity, water quality, and climate/drought issues.
- **Encourage applied scientific research** designed to illuminate the dynamics of water quantity and quality in the context of human-impacted environments.
- **Encourage human dimensions research** to help predict the impacts of future population growth, land use changes (such as the shift from agriculture to residential uses), and different water policies on patterns of consumption of and demand for water resources.

A much more detailed list of more specific research priorities were summarized above, though many of the substantive suggestions fit into these four categories.

Changes in the research priorities on INRA university campuses will be complicated by the fact that all universities are organized around traditional disciplines and there are strong career disincentives for students or faculty to engage in interdisciplinary or highly applied research. Seed monies and targeted research initiatives to attract this type of innovative research might well be required to fill some of the information gaps identified in our interviews. Similarly, investments in better communication between university and non-university actors is required to ensure that state-of-the-art scientific knowledge is made readily available to decision-makers (and that the problems faced by decision makers are communicated to public research scientists).

Education Priorities

The key informants in our study identified a set of core educational needs that could be addressed by future INRA-sponsored initiatives. Areas where supplemental training could make a difference include:

- **More interdisciplinary courses**
- **More systems-level or integrated water science courses**
- **More real world experience**
- **Better communication skills**
- **More awareness of social, economic and political dimensions of water problems**

While it is easy to identify areas where new educational programs should be developed, it does not follow that universities are well positioned (or even well advised) to undertake a dramatic reshuffling of their educational missions. For instance, it is important to recognize that many graduate programs are designed to train future academic scientists/professors. Similarly, many graduates of these programs may go on to different types of careers in the public or private sector. In each instance, broadening course requirements or changing training approaches may have inadvertent impacts on other groups of students.

It is encouraging that many INRA campuses are engaged n conversations about creating integrated water science degree programs or other interdisciplinary training programs that encourage or require students to build a broader understanding of the various water-related sciences as part of their training. There are also efforts to increase opportunities for students to get hands-on, real-world experiences through internships and partnerships with public and private organizations. It would seem appropriate to target some of INRA's future resources to support these initiatives.

1. BACKGROUND AND METHODS

1.1 BACKGROUND

The Inland Northwest Research Alliance (INRA) is a consortium of eight universities in the US Western region who received funding from the US Department of Energy to initiate a research and educational program related to drought and water resource management in this 'inland northwest' region. Among other tasks, the INRA Water Research Consortium has facilitated coordinated research and education programs related to the complex interactions between climate change, watershed and landscape changes, water supply and quality; ecosystems, and humans.

The current project was designed to identify high priority topics for future INRA research. Specifically, we gathered information from policymakers, elected officials, water users, and others with a stake in the Western water debates to identify their most pressing data and information needs. This structured needs assessment process is designed to provide a basis for future targeted research efforts to improve regional water resource management in the Inland Northwest region. Because of the recent years of low water supply in the West, one focus of our needs assessment was targeted toward an understanding of what types of research might facilitate water resource management during periods of drought.

The specific goals of the Needs Assessment project were to:

- Quickly ascertain the perceptions of diverse stakeholders in this region, and
- Condense this complex information into a format that can be shared with the INRA scientific panel, and
- Develop of a realistic set of research needs and priorities that can shape future INRA-funded research activities.

1.2 METHODS

The Research Team

Cooperating social science faculty were identified from one INRA institution in each of the 5 INRA states during the summer of 2006. The participating universities included the University of Alaska-Fairbanks, the University of Idaho, Montana State University, Utah State University and Washington State University. A number of graduate students were involved in the effort and are listed on page ii above.

Identifying Key Informants

Together this team developed formal research protocols for identifying and contacting a representative group of key informants in their respective states (Appendices I and II). A semi-structured interview schedule was developed and used by all interviewers involved with the project (Appendix III).

Prior to the fieldwork and interviews, project teams in each state conducted a review of the literature related to water resources and recent management activities. The purpose of this document was to begin identifying key contacts, current water management needs, geographic areas, and priorities. This 'water narrative' created a summary document for each state and helped to identify categories of key informants that needed to be represented in each state.

Key informants for the fieldwork were identified by each state from a master list of potential groups and organizations with links to water. Project teams first constructed a master sampling frame of potential key informants designed to encompass the breadth and depth of groups in conjunction with the water narrative. From this master sampling frame, a subset of individuals was selected for field interviews that were considered to be representative of water users in each state. Selecting this subset of individuals involved identifying diverse individuals who are knowledgeable about water issues and/or actively involved in water resource management in this region.

Potential individuals and/or groups to be included in the sample included knowledgeable agency or organizational representatives (analysts, staff, and decision-makers) as well as key stakeholders, including elected officials and representatives of relevant organizations. The list is broad in order to take into account variation across states. Example 'categories' span multiple levels of government, underscoring the breadth and depth noted above. General categories include federal agencies such as the Bureau of Reclamation and Fish and Wildlife Service; State Government divisions such as Water Resources Agencies (e.g. state engineers and water rights staff, water planning agencies, and water quality agencies), State Agriculture Department staff, and State Economic Development staff; and regional governments such as water conservancy districts. Additional governmental categories include county governments (e.g. county associations, county commissioners and executives, county water advisory boards, and county planners), city governments (e.g. city associations, city mayors and council members, and city planners, water departments, environmental departments), and tribal governments.

In addition to governments, the list included representative of non-governmental organizations and water users groups that were equally broad-ranging with regard to levels of interaction. Examples in this grouping include regional organizations like hydropower utilities (e.g., Pacificorp), and environmental, wildlife, and recreational organizations (Audubon/birders, Ducks Unlimited, salmon-advocacy groups, river rafters, lake boaters, etc.). Other examples include state non-governmental organizations (e.g. associations of water users like irrigation/canal groups and agricultural organizations like the Farm Bureau), and local organizations like irrigation districts, canal companies and local Chambers of Commerce. The master list was tailored to each state in order to take into account variation in governance among other criteria; thus this list served as a general organizing frame.

As noted above, a subsample of individuals was selected from this master list in order to create the list of individuals we refer to as 'key informants.' Project leaders in each state began by identifying key contacts in important statewide and regional agencies and organizations from a variety of sources, form personal contacts with university colleagues to internet searches of agency/organization website listings for staff and administrators. In many instances, snowball sampling was used, where we proceed through intra-agency/organization filters and ask those interviewed for additional contact information.

Where appropriate, we used purposive sampling. For example, for some categories (e.g. federal agencies, regional water conservancy districts, and county and city governments), we needed to identify a subset of the total universe of possible people (or places) that met our criteria. This strategy met the goal of having a sample that covered the diversity or range of water resource management challenges within each state.

In taking into account variation across states, we selected a subset of places/people in order to maximize coverage related to 1) previously identified key issues, 2) geographic regions, 3) examples of places with well-known debates or historical uniqueness, and 4) links with other intersecting dynamics (e.g. urban/rural interests and problems, agricultural vs. non-agricultural interests, government vs. non-governmental perspectives, Tribal vs. non-Tribal interests and problems, and economic vs. environmental perspectives).

The interviews thus proceeded in a series of stages, where teams strategically prioritized groups from these lists multiple times to yield state-specific lists of interviewees. From the master list, we prioritized specific names from organizations that were used in a first round of interviews. From the first round of interviews, a second round of contacts was selected to complement the first round.

Our interviews included detailed questions on the following topics:

- What are your greatest challenges for water resource management?
- What are the largest information gaps you encounter when managing water resources, and what are the most important research priorities for future water-resource research?
- What are the most important educational needs for people seeking to work in this area?
- Who are your most important partners for working on water resource management?
- What are your most important sources of information as you manage water resources?

Key informant interviews were conducted in the late summer and fall of 2006; a few were conducted in the early winter 2007. Contact was first made with each informant in a phone call, email, or letter. Background to the project and a copy of the key informant consent document was provided to each interviewee, a request was made to participate in the study, and – if the respondent was willing to participate – a time and place was determined for the interview. Most interviews were conducted with individual respondents, though in some cases small groups of persons working in the same department, agency or organization were interviewed at the same time.

In total, interviews were completed with 165 key informants. The distribution of responses by state is shown in Table 1.2.1.

In addition to information about water resource management challenges and needs, the key informants were asked a small number of structured questions designed to characterize their work organization, their role or responsibilities, and their background and expertise in this subject matter. A profile of the respondent characteristics is included in Table 1.2.2 below.

Table 1.2.1: Number of Interviews Completed by State and Major Topic

		Total # Cases Reporting Information on Each Major Topic				
State	Overall # Interviews	Greatest Challenges	Research Needs	Education Priorities	Partners	Information Sources
Alaska	30	30	28	29	29	29
Idaho	53	52	47	52	51	50
Montana	27	26	26	27	27	27
Utah	27	27	27	26	22	23
Washington	28	28	25	27	28	28
Total	165	163	153	161	157	157

Table 1.2.2: Characteristics of Respondents

	Number	Valid Percent
Job Description		
Elected Official	2	1.3
Administrator/Director	80	53.3
Technical Staff	35	23.3
Outreach Staff	6	4.0
Member of Organization	4	2.7
Other	23	15.3
Total Known	*150*	*100.0*
Organization Type		
Federal Agency	37	22.7
State Agency/Board	41	25.2
County Government/Board	17	10.4
City Government/Board	8	4.9
Tribal Government	8	4.9
Nonprofit Organization	15	9.2
Private Company	24	14.7
Other	13	8.0
Total Known	*163*	*100.0*
Scale of Responsibilities		
Local/County	47	29.2
Multi-County	34	21.1
Statewide	60	37.3
Multi-state region	15	9.3
Other	5	3.1
Total Known	*161*	*100.0*
Self-Described Expertise on Topic		
Very Knowledgeable	71	46.1
Knowledgeable	39	25.3
Moderately Knowledgeable	32	20.8
Slightly Knowledgeable	11	7.1
Not Knowledgeable	1	0.6
Total Known	*154*	*100.0*
Education Level		
< BS	11	7.7
BS	60	42.0
MS/MA/MPA/MBA	57	39.9
PhD or JD	12	8.4
Other	3	2.1
Total known	*143*	*100.0*
Years of Experience		
Under 5 years	30	20.8
5 to 9 years	24	16.7
10 to 19 years	31	21.5
20+ years	59	41.0
Total Known	*144*	*100.0*

By design, most of our key informants were career water resource management professionals. For example, 80 (or 55%) were administrators or directors of an organization or agency that addresses water issues in this region. Another 21% were technical staff in these groups. We did not select many elected officials to participate in this project because we believed that the views of applied managers would be most relevant for identifying key scientific research needs or topics.

Most of the respondents worked for public agencies – with 22 percent from federal agencies, 25 percent from state agencies or boards, and 16 percent from county or city government. A total of 8 interviews were conducted with tribal government representatives. Nonprofit groups and private companies comprised another 24 percent of our total respondent sample. Not surprisingly, our key informants worked on water issues across a variety of scales. Just over half worked at the local, county or multi-county level. Another 37 percent worked at the statewide level, with a small minority working at larger scales.

After each interview was completed, our field staff made a subjective assessment of the level of expertise or knowledge that each respondent seemed to have regarding water resource management issues. Three-quarters of all respondents were classified as knowledgeable or very knowledgeable.

By the same token, almost all respondents had higher education degrees. Almost 43 percent had a BS degree, another 37 percent had a master's degree, and 9 percent had a PhD or JD degree. Most respondents also had a significant number of years of work experience dealing with water resource management issues. Over 60 percent had worked for 10 or more years in this area.

Analysis of Interview Data

Interviews were summarized in a structured narrative form (see Appendix IV) and sent to Utah State for consolidation and analysis. The analysis strategy involved careful review of interview narratives and summary sheets submitted by each cooperating state. Interview information was transferred to spreadsheets and NVIVO 7®, qualitative analysis software that allows interactive coding and memoing of key themes in the narratives.

The respondent answers to these key questions were coded into clustered topics or themes using an inductive thematic coding process (Strauss and Corbin 1998; Flick 1998). This process involved identifying preliminary clusters of similar answers, then reviewing the resulting coding scheme for internal consistency, theoretical coherence and applicability to the overall research project goals. Several investigators and their graduate students reviewed the coding schema and individual answers were coded and recoded several times before producing the final version.

The coding schemas developed for each major type of question were summarized in descriptive statistical tables to identify the frequencies of major categories of answers. The answer patterns were also examined within important subgroups of respondents (state, type of respondent, type of agency where person works, etc.).

1.3 IMPORTANT WATER RESOURCE ISSUES IN EACH STATE

As part of the preliminary work to prepare for interviews with key informants, the research team in each state spent time gathering published reports, informal documents, web resources, and other information. This information was used to develop a list of important water resource issues for each state, and was summarized in a short narrative. These narratives provide a snapshot of the most prominent water resource challenges and issues faced by managers across this region. Condensed versions of narratives for three of our participating states are summarized below.

In sum, understanding water resources and issues requires an approach that acknowledges generalities as well as contextual differences that convey past, present, and future challenges for water professionals and practitioners. For instance, while physical features of locations such as geography, climate, and size are integral to understating natural resources and their availability and spatial distribution, of integral importance also are understanding how other issues intersect with these physical features, including population changes, pressures for economic development, and various legal influences linked with supply and demand. Indeed, a complex chain of mutually reinforcing issues, actors, and agencies can be identified, as can interrelations that posit unique causal pathways.

Water in Alaska

Understanding water in Alaska requires situating it within other characteristics that make it unique—including its vast size, physical separation from the contiguous 48 states, population composition and distribution, environmental attributes, and climate. Comprising over one-third of all of the fresh water in the US, water is abundant in Alaska. Yet in spite of its profusion, many issues exist that intersect in varied ways with its past, current, and future availability, use, and allocation. More specifically, Alaska has over 12,000 rivers and streams that total over 365,000 miles, at least 170 million acres of wetlands, over than a million lakes larger than five acres, and more than 44,000 miles of coastal shoreline.[1] And even in the so-called last frontier, interactions between natural resources and human populations can be noted, from issues related to development and recreation uses. Climate change holds the potential to uniquely influence Alaska's prolific water resources as well, through thawing of the permafrost and its resulting impacts such as an increase in wetlands in unanticipated areas and other bodies of water and waterways linked with them, all of which hold the potential to influence human populations and settlements (Hinzman et al. 2005). Moreover, this change does not take into account dramatic seasonal effects related to water availability and use which are only imperfectly understood given various unique aspects of Alaska's climate, linked especially with its vastness and numerous uncharted waters.

In many respects, water use remains highly concentrated in Alaska, as freshwater resource use occurs mainly in two major urban centers, Anchorage and Fairbanks, thus posing further challenges for smaller municipalities, rural villages (about 300), and Native villages (about 70), many of which do not have access to potable water distribution systems. Thus, coordination issues are considered to be focal, as spatial dynamics interact with these human-environment interactions.

[1] Governor Tony Knowles. October 2, 2002. "Administrative Order no. 200. " Retrieved from http://www.gov.state.ak.us/admin-orders/200.html on November 22, 2006.

For various legal reasons, water management issues continue to evolve, as a result of its history as a territory and also due to various natural resource-related sections of its constitution in 1956, prior to officially becoming a state in 1959. For instance, the Alaska Water Use Act, passed in 1966, applied to all surface and ground waters of the state (not subject to federal rights), and gave statutory definition to the prior appropriation doctrine (effectively converting all previously existing riparian rights to prior appropriation rights). As a result, under this act, water law is simple and straightforward, as a water source in Alaska is defined as a "substantial quantity of water capable of being put to beneficial use." Interactions and legislation related to water management issues take place at various scales including federal, state, borough and local levels of government, with considerable variation both across and within scales reflecting further complications to understanding water in Alaska.

Water in Idaho

Nowhere is the need for sustainable use of water and the current failure to achieve sustainability more evident than in the state of Idaho. Idaho's climatic patterns are complex given the state's diverse topographic features, with average annual temperatures and precipitation that vary by latitude and altitude. Highest temperatures occur in lower elevations of the Clearwater and Little Salmon River Basins and portions of the Snake River Valley. Large areas receive considerable precipitation (on average, at least 40 inches annually), including the Clearwater, Payette, and Boise River Basins; other areas receive little (on average, less than 10 inches annually; e.g., Upper Snake River Plains, Central Plains, and the lower Southwestern Valleys).

In the northern and western parts of the state, seasonal precipitation is at a maximum in winter months and a minimum during midsummer, while the reverse is true in eastern Idaho. Snow accumulations in the state's mountains are typically adequate to irrigate nearly two million acres -- mainly in the Snake River Valley – and rivers filled with this late spring melt-off supply an increasing amount of hydro-power. However, the infrastructure supporting water supply may be inadequate if climate change and climatic variability predictions are accurate. Idaho has over 92,000 miles of rivers and streams, over 100 lakes, and portions of 80 watersheds. Of Idaho's total surface water, 8 percent is designated as impaired or threatened: 670 rivers, streams and creeks, as well as 40 lakes and reservoirs, do not meet water quality standards.

Growing demand for water stems from habitat requirements, population growth, agricultural needs, tribal water development, energy demand, recreational use, and aesthetic values. Habitat needs are highlighted by the fact that freshwater fish are the single-most endangered vertebrate group in the U.S. The Columbia River basin is the primary source of hydroelectric power in the northwest, serving five states, numerous Native American Tribes, and two countries. The basin is home to twelve endangered salmonid populations, whose viability is threatened by barriers to migratory routes, dewatering, poor water quality, loss of habitat, competition from hatchery and exotic fish, and commercial fishing. Efforts to develop scientifically-based means to recover these species are currently grid-locked in court. The Idaho Water Resources Board administers a water banking system to provide minimum in-stream flows for fish habitat needs.

Water demand is increasing significantly with population growth, placing additional demands on already stressed hydrologic systems. Idaho had the third fastest population growth rate (2.4%) in the nation between 2004 and 2005, with eleven counties experiencing greater than 10 percent growth since 2000. That growth is projected to be over 50 percent in the next 25 years. Most

growth is in urban areas that compete for the same water resources needed for irrigated agriculture. Idaho leads the nation in per capita water consumption, using 19,500 million of gallons of water per day for a population of 1,429,096, or 13,645 gallons per capita per day. Of this water, 21 percent is groundwater and the remaining 79 percent is surface water. Only 1.3 percent of this water is consumed for public uses, with 87.7 percent for irrigation; industrial uses account for 11 percent, most of which is consumed by the aquaculture industry. Four percent of groundwater used comprises 95 percent of public drinking water, while 60 percent is used by agriculture (e.g., sugar beets, potatoes, and barley); the remaining 36 percent is used by industries (e.g., aquaculture, food processing, fertilizer production and high-tech manufacturing).

Historically, Idaho has had a water rights policy based on the prior appropriation doctrine, although this policy has become increasingly complex as supplies of water have decreased in the current drought and understanding of the connectivity of ground and surface waters has increased. Demand for water is increasing significantly in some regions of the state: in the Treasure Valley, for example, demand for nonagricultural water consumption is projected to increase by 74 percent by 2025.

Drought has affected the West since the late 1990's, compounding stresses on aquifers and rivers from long-term groundwater pumping and changing irrigation practices. Drought has resulted in the Idaho Legislature's reconsideration of the best means for properly appropriating water claims, although Idaho has had a drought plan in place since 1990. Particularly complicating water rights policies are several situations in southern Idaho, with parties vying over waters shared by the Snake River and the Snake River Aquifer. For example, canal companies and trout hatcheries with prior water claims have not been receiving their allotted water stake from springs flowing from the aquifer, due to farmers with later claims irrigating with pumped groundwater. The economic ramifications associated with these claims are great. Also at stake are flow requirements for power generation by Idaho Power's dams.

Development of Tribal water resources in Idaho has lagged behind that of other governing entities; in recent decades, needed institutions and funding have been made available to the Tribes. Recently, ownership over the lower third of Lake Coeur D'Alene by the Coeur D'Alene Tribe was recognized, and the Tribe was given authority to set water quality standards for it. The Nez Perce Tribe recently reached an initial compromise on their claims to all water in the Snake River, although it has yet to be finalized. Successful water management efforts include administration of an environmental program by the Kootenai Tribe, which, in cooperation with Region 10 of the Environmental Protection Agency and Idaho's Department of Environmental Quality, is working to improve water quality in the Kootenai River Basin.

Five critical groundwater areas are located in Idaho and twelve groundwater management areas; these areas either have reached or are approaching insufficient groundwater supplies for irrigation or other uses at current or projected rates of withdrawal. All but two of the areas are located in the southern part of the state.

In northern Idaho, declining levels in the region's primary aquifers have local and state officials concerned about maintaining sustainable water supplies. One area in the north, the Rathdrum Prairie Groundwater Management Area, includes Idaho's only listed sensitive resource aquifer out of 70 -- the Spokane Valley-Rathdrum Prairie Aquifer – which is the primary source of drinking water for 400,000 residents in a 370 square-mile, two-state region between Coeur D'Alene, ID and Spokane, WA. The region's population has been rapidly growing, and

controversies facing this aquifer include rejected power plant proposals due to significant water needs and the need for bi-state management. Also, concern over depletion of two aquifers providing water for the Palouse region of northern Idaho and eastern Washington has increased, with a focus on new industrial developments and private lawn irrigation.

In southern Idaho, understanding and balancing physical, biological and legal aspects of the Snake River system is a primary challenge. Concern for the Mountain Home Aquifer not only includes significant deficits of groundwater pumping, but also contamination of water resources by existing and proposed dairies. In the Treasure Valley, municipal water companies such as United Water Idaho are considering buying water rights from farmers; and the Snake River Basin Adjudication project that began in 1987 is almost complete, with all water rights (owned consumption quantity quotas) in the Basin now being determined and a moratorium on new water rights declared for waters upstream in 1995.

The Bear River Basin serves a three state area where rural lands are rapidly being converted to residential developments; however, a moratorium prevents most new water claims. As residential growth expands in this area, demand will only increase in both Idaho and Utah for a fully appropriated water source; concern has increased in the current drought that low water levels in Bear Lake could compel the state of Utah to declare a water emergency and curtail water rights in Idaho.

Water in Montana

As was true in describing water in Alaska, understanding water in Montana requires a nuanced approach that enables researchers to take into account various local conditions, including geography and climate, and interactions with pressures from human populations and settlements as well. In addition, a recent period of drought in the state has further strained both water quality and quantity. Generally speaking, describing water is complicated by a number of factors.

Agriculture, domestic and commercial consumption, recreation, natural ecosystems, and industrial uses such as cooling water for energy generation or dust abatement at mine sites, are the primary water needs in Montana. Agriculture is the largest consumptive use category in the state. Irrigation is highly dependent on snowmelt runoff in the Rocky Mountains, which has been further complicated by loss of snow-pack over the last half century (Inland Northwest Research Alliance Water Research Consortium, 2005). Generally, almost half of the annual long-term average total precipitation falls from May through July, resulting in Montana as one of the largest producers of dryland grain crops (Western Regional Climate Center, n.d.). Additionally, Montana's primary water source comes from surface water (rivers, streams, and lakes) as opposed to groundwater (US Global Change Research Program n.d.). Regions of the state exhibit wide climatic variation, from wet in the west to arid in north central Montana, with the driest section in the state situated along the Clark Fork of the Yellowstone River in Carbon County (average precipitation for a 16-year period is only 6.59 inches).

Water quality and quantity issues are germane in Montana. According to the USGS, seven major issues concerning water resources in Montana are inextricably linked with consumption in various ways. These issues include both from human dimensions such as rapid population growth in western and south-central Montana (in areas surrounding Bozeman, Missoula, and

Kalispell) and development effects like those of abandoned or inactive mines in various places throughout the state and coalbed methane (CBM) development, especially drilling.

In addition, other issues pertain to gathering more detailed data and understanding of existing waters (e.g. stream-channel geomorphology and hydraulic analysis), improving and increasing surface water monitoring activities, hydrologic changes linked with fires, and dealing with drought in general (the most recent drought occurred for seven consecutive years from 1999 to 2005.

Water in Utah

As was the case with Alaska and Montana, understanding water resources and water issues in Utah requires situating it within various contextual factors. Both environmental and population dynamics make Utah unique relative to other states in the intermountain West. In average annual rainfall, for example, Utah ranks as the second driest state in the nation (after Nevada). Utah is also currently experiencing one of the highest population growth rates in the Intermountain West (ranking fourth) due to natural increase and migration. Utahns used an average of 4.76 billion total gallons of water each day in 2000, with around 81% used for irrigation (for agricultural purposes). With regard to municipal water consumption on a per capita basis, the average Utah resident used 293 gallons of water per day, around 65% of which was used outdoors (Utah Foundation 2004).

Water issues in Utah are varied and complex, and further complicated by various geographic attributes such as size, location, and topography, meaning that climates throughout the state are highly variable. For instance, average precipitation across the state ranges from five inches in desert regions to 60 inches or more in the higher mountainous regions, most of which comes from snowfall. As a whole, the state averages just thirteen inches of precipitation per year.[2] In addition to climate-related supply difficulties, Utah experienced a six-year drought between 1998 and 2004, placing further demands and strains on its water supply.[3]

To address questions of water use and supply, in 2001 the Utah Department of Water Resources developed a plan calling for:

1) Increased conservation from both agricultural and municipal users;
2) The transfer of agricultural water to municipal purposes as zoning changes from rural to urban;
3) The development of access to new water sources and rights that Utah has claims to; and
4) The maintaining and advancing of water storage techniques.[4]

These mutually influencing forces make issues regarding water utilization, water quality, and water conservation salient for all involved with water in Utah.

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[2] Utah Division of Water Resources, Long-term Water Supply Outlook
http://www.water.utah.gov/droughtconditions/WaterSupplyOutlook/default.asp July 12, 2006
[3] Utah Center for Climate and Weather
http://www.utahweather.org/drought_is_waning.html
[4] Utah Division of Water Resources, Utah's Water Resources: Planning for the Future
http://www.water.utah.gov/waterplan/uwrpff/TOC.htm

More specific examples of water issues in Utah include, for example, water development projects, water quality issues, and newsworthy items that demonstrate further complexities related to water resources, as many waterways cross state borders. With regard to water development projects, in 2006, state legislation concentrated on two major projects: The Lake Powell Pipeline and the Bear River Project. The former would secure additional water resources that would be targeted toward use for Utah residents, potentially alleviating pressure placed on management of water resources during prolonged periods of drought, such as those recently experienced in Utah. The second project also focuses on water supply, seeking to redistribute a proportion of water from the Bear River to four other conservancy districts in the state.

Given existing issues of natural resource-human population interactions, issues related to water quality are key concerns in the state. In addition to population growth dynamics mentioned earlier, issues of water quality highlight other development-related pressures that have consequences for natural resource availability and utilization. Examples include clean-up projects designed to mitigate previous groundwater contamination from various sources, including industrial sites, mining operations, and agricultural practices.

The final category mentioned above underscores how these issues cross natural and artificial boundaries in ways that further complicate the understanding of natural resource availability and use. Water rights issues are prominent with regard to appropriations and allocations, and have consequences beyond state borders as watersheds are not always neatly contained within a given state's boundaries.

2. RESULTS

2.1 GREATEST CHALLENGES

Overview

As the previous section suggests, various geographic attributes and unique characteristics of physical environments combine with a variety of other factors. These unique constellations of forces mean that water professionals face a number of challenges in their work. As might be expected by the broad range of concerns intimated by the state-based water narratives, individuals involved in water-related positions and professions echo many of these topics in the interviews conducted in this research. After asking about their background characteristics, respondents were asked a battery of questions related to water management challenges and information needs.

> *"**What are the 3 greatest issues or challenges for water resource management that you face in your work?**"*
>
> *For each of these three issues, the following questions were asked:*
>
> ***i.*** *"**Let's focus on (**Issue X**). In what ways is this issue challenging?***
>
> ***ii.*** ***How has this issue changed in recent years?***
>
> ***iii.*** ***What kinds of information are <u>most critical</u> to your ability to address this issue?***
>
> ***iv.*** ***What are the most important sources of information you use to address this issue?***
>
> ***v.*** ***How adequate is the existing information?***
>
> ***vi.*** ***In what ways could this information be made more useful?***
>
> ***vii.*** ***What new kinds of information would be most helpful to you as you address this issue?***

The following analyses presents the most common responses recorded in the interviews. Cumulatively, 495 responses were recorded from 163 interviews (See Table 2.1.1). As shown in the table, the largest number of interviews were completed in Idaho (32% of the total), and a large proportion of the greatest issues or challenges come from these interviews (a total of 167 needs, or 34% of the total, come from the Idaho interviews). The average number of 'challenges' reported per respondent was fairly consistent across the 5 states.

We begin our discussion of these results focusing on the aggregated responses in order to discern whether similar patterns can be identified regarding greatest issues or challenges across the five states. Following this discussion, we disaggregate them by state to highlight similarities and differences across the study areas in biggest challenges. This approach also allows us to see how information from the 'water narratives' intersects with the practice of water research, as communicated by respondents in this research.

Table 2.1.1. Number of Interviews Completed and Greatest Challenges Identified by State

	Overall # Interviews	Total Reporting Any Greatest Challenges	(%)	Total Challenges Identified	(%)	Avg. # Challenges Reported / Interview
Alaska	30	30	18.4	84	17.0	2.8
Idaho	53	52	31.9	167	33.7	3.2
Montana	27	26	16.0	78	15.8	3.0
Utah	27	27	16.6	99	20.0	3.7
Washington	28	28	17.2	67	13.5	2.4
	165	163	100.0	495	100.0	3.0

The 495 total greatest challenges identified in the individual interviews were analyzed for common themes and patterns. This permitted their subsequent organization into four major categories:

- Challenges related to Natural Science Topics
- Social Science Issues and Challenges
- Management Challenges
- Information-related Challenges, like data quality and dissemination issues

The total number of responses in each major category (as well as several subcategories, are listed in Table 2.1.2. Taken proportionally of all challenges identified by respondents, of foremost concern are natural science topics and social science issues and challenges, followed by management challenges, and, finally, those related to information or data issues.

Table 2.1.2. Distribution of Greatest Challenges by Four Major Categories

Topic	Subtopic	Frequency Topic	Frequency Subtopic	Percent Topic	Percent Subtopic
Natural Science Challenges		182		36.8	
	Water Quantity		91		50.0
	Water Quality		64		35.2
	Climate and Drought		19		10.4
	Other Natural Science Data		8		4.4
Social Science Challenges		190		38.4	
	Legal Challenges		36		18.9
	Policy Challenges		36		18.9
	Funding Challenges		28		14.7
	Sociological Challenges		17		9.0
	Educational Challenges		40		21.1
	Challenges of Population Dynamics		33		17.4
Management Challenges		90		18.2	
	Personnel/time/logistical challenges)		24		26.7
	Management needs in general		21		23.3
	Management Strategies		41		45.6
	Program Effectiveness		4		4.4
Information/Data Quality and Dissemination		33		6.7	
	Data collection standards and quality		19		57.6
	Data dissemination mechanisms		14		42.4
Total		495		100	100

Natural Science Challenges (36.8%)

Water professionals find topics related to natural systems to represent some of the greatest challenges that they face in their work. More than one-third of all greatest challenges identified fell into this category. Within this classification, four subtopics were identified: water quantity, water quality, climate and drought, and other natural systems concerns. Each of these categories can be subdivided into groupings that are more detailed as well. Because of the generality in the phrasing of the question, responses ranged quite broadly; thus we focus chiefly on summary statistics but also include examples from the interviews for illustrative purposes.

The most frequently cited subtopic in the natural systems challenges section involved water quantity topics, comprising slightly more than half of all responses. While we recognize that issues of water quantity are prominent for water professionals and are germane especially in the Intermountain West region, we also acknowledge that respondents did receive some background information related to our study involving a short discussion of the water resource management

issues in the region, with a particular focus on water supply and drought. That noted, however, since challenges related to natural science and social science are quite similar as proportions of the total, we do not anticipate that the background information primed the respondents in a manner that would question the results, given this roughly equal distribution.

Water Quantity Challenges

The water quantity subtopic issues were further subdivided into four subgroups, three of which were parsed into additional layers. These were overall water quantity assessments, groundwater challenges, groundwater/surface water interactions, and water availability and demand.

Overall Water Quantity Data/Assessments

The first subgroup included challenges representing overall water quantity data, assessment, and issues, comprising roughly 2.4 percent of all responses. Nearly all of the remarks dealt with issues of how the absence of data posed a challenge in various ways, from knowledge-based reasons to historical questions to specific projects related to water diversion. Some specific challenges included:

- "Knowing enough about how much water there is to allocate,"
- "Lack of data—groundwater and surface water,"
- "Water supply data"

A subtopic within this category included specific challenges related to stream gauges and flows, comprising roughly 3.4 percent of all responses. A time element was also apparent in some comments related to day-to-day, and both short-term and long-term planning. In addition to the absence of data posing a challenge, flow data were also linked with particular aspects of water like seasonal effects and downstream effects for fish populations and other bodies of water. Flow depletions were also mentioned. Some examples are as follows:

- "Estimating the timing of snow melt and stream flows,"
- "How to balance in stream flow needs and consumptive use demands,"
- "Water measurement of large water flows."

Groundwater Challenges

Challenges related to groundwater were mentioned in a few interviews, representing fewer than two percent of total challenges. Subtopics within this group included general groundwater data and assessments and aquifer resources.

Another subtopic mentioned as a challenge was groundwater/surface water interactions. These ideas comprise one and a half percent of all challenges mentioned.

Water Availability and Demand

About ten percent of the challenges identified were subsumed under the category of water availability and demand, which included a subclassification related to historical issues and allocation. Some responses focused on issues related to water use either in and of themselves, or linked with other changes such as those in land use generally and more specifically related to agriculture, municipalities or processes of urbanization.

Specific challenges for suggestions for water availability and demand included the following examples:

- "Water availability due to changing climate and demographics, and recent drought,"
- "The changing needs of water resources - moving from agriculture to recreation and residential development uses,"
- "Changing land use and uncertainties related to water right conversions,"
- "Changing water uses related to changing land use,"
- "Trying to determine how much water is actually available,"
- "Inefficient use of water for agricultural production,"
- "Finding new sources of water,"
- "Dealing with urbanization of rural areas,"
- "Water use efficiency for environmental concerns,"
- "Adequate municipal water supply given population growth-conversion of ag land to residential and effects on water supply,"
- "Insufficient water supply for current and future demands (population growth) ,"
- "Adequacy of water infrastructure and supply to meet multiple and competing demands by 2036,"
- "Water supply-maintaining it,"
- "Availability of water,"
- "Creating water resources to meet growth demands,"
- "Water demand is increasing via urbanization,"
- "Urbanization and the need for domestic commercial municipal and industrial water,"
- "Summer time and meeting peak demand, as agriculture puts a heavy load on existing infrastructure,"
- "Water accounting accuracy,"
- "Adequate information concerning water resources,"
- "Accuracy on water usage,"
- "Forecasting of water availability,"
- "Increased pressure on the resource (water)."

Water Quality Challenges

Like those linked with water quantity, water quality challenges were further subdivided into a number of additional layers. These five groups include better data, research on pollutants, relationships to the surrounding ecosystem, links with development processes, and how policy affects water quality. In total, water quality issues represent more than a third of total challenges within the natural science classification.

Data Issues

Representing 3.2 percent of total challenges, data issues linked with water quality focused on improvements that could be made to existing data from groundwater to surface water to drinking water. Also noted were challenges related to consistency issues regarding data already in place in numerous agencies that also represent various locations. Quality concerns included those linked with health of waters, the influence of temperature, and waterways generally in terms of baseline data.

Research on pollutants

A second subcategory related to water quality challenges dealt with contaminants in a broad sense and various pollutants linked with specific activities such as agriculture, livestock, mining, and particular types of companies (e.g. pharmaceuticals). Particular pollutants were also mentioned within this subset including nitrates, acidity from mining activities, toxic metals, and iron. These challenges represented four percent of the total. In many respects, these concerns were localized, linked with a specific organization or issue.

Relationship to surrounding Ecosystem

The third group in this subheading related to how water quality linked with the surrounding ecosystem, comprising only 1.4 percent of total challenges conveyed by the respondents. For instance, interrelationships among agricultural operations, land cover, and wetlands with respect to water quality could be noted in the responses.

Development's Impacts on Water Quality

Processes related to development were mentioned as challenges in about three percent of all challenges. Land use issues tended to be expressed in these responses, in some instances also taking into account intersections and interactions with population shifts. Municipal concerns were also reported, in addition to general processes of urbanization.

Policy Effects on Water Quality

As 1.6 percent of the total challenges, how policy affects water quality were also responses related to various challenges water professionals reported facing in their work. These comments vary widely with regard to the scale of the policy, from federal regulations to watershed-based concerns to issues linked with infrastructure that can intersect in various ways with the above.

Climate and Drought Challenges

Aside from water quantity and quality topics within the overall category of natural systems challenges, climate and drought issues were also mentioned as posing some of the greatest challenges for water professionals in their work in about nine percent of this group overall. As a whole, these comprised less than three percent of the total. The three subgroups are drought effects on water resources as pertains to management decisions, climate change factors and resulting effects, and general concerns linked with modeling climate change. As examples, comments subsumed under these headings included:

- "Water scarcity related to climate change (reduced storage via snowpack)"
- "Not as much snow cover, moisture—how do we adjust and compensate,"
- "Variable climate regimes,"
- "Drought and the pressures put on managers due to water shortages,"
- "Forecasting precipitation events,"
- "Climate change and the problems this creates for long-term planning."

Other Natural Systems Challenges

Though mentioned in fewer interviews as posing a substantial challenge, a handful of other responses represent overall data on natural systems in a general sense. In many respects, these responses did not fit neatly into the other categories, yet needed to be incorporated into the analysis and discussion. Responses included a number of data absence concerns related to consistency of data gathering across time and space, the absence of specific types of data, navigational questions, and issues of scale (e.g. how watersheds intersect with other data gathering techniques and measurements).

Social Science Issues and Challenges (38.4%)

As the largest category proportionally of greatest challenges, topics related to social science or human dimensions were prominent for water professionals. Close to forty percent of responses citing greatest challenges related to issues pertaining specifically to social science topics, or 190 comments out of the total of 495. Put another way, 3.8 out of ten challenges mentioned related to these issues. Within this classification, six subtopics were identified (count following type in parentheses): legal challenges (36), policy challenges (36), funding challenges (28), sociological challenges (17), educational challenges (40), and challenges of population dynamics (33). As percentages within this category, they represent 18.9 (legal), 18.9 (policy), 14.7 (funding), 9.0 (sociological), 21.1 (educational), and 17.4 (demographic), respectively.

How these groupings were further subdivided is detailed below. We address each in turn. As was noted earlier, because of the generality in the phrasing of the question, the responses ranged quite broadly; thus we focus primarily on summary statistics but also include examples from the interviews for illustrative purposes as appropriate.

Legal Challenges

Water professionals noted a number of legal challenges that they face while involved with their work. Two main subgroupings emerged: those linked with water laws (14) and those linked with water rights (22). With regard to the former, comprising three percent of total challenges named, issues related to enforcement of existing water laws, knowledge of existing statutes related to various groups (e.g. irrigated landowners, agency managers, public), and information dissemination strategies generally designed to communicate technical and legal language in a format easily grasped by all groups involved. Issues related to coordination and interpretation were also expressed.

Some examples include:

- "Helping the public to better understand water law,"
- "Communication of the complexities of state water laws to the general public,"
- "Enforcement of water laws."

In terms of the latter, water rights, these comprised slightly more than four percent of all challenges verbalized. Enforcement issues were also raised, as were expressions related to knowledge in general terms and under specific circumstances (unfulfilled water rights and treaties). Some comments also illustrated how water rights are communicated and understood by various groups, including the general public and other users. Data concerns regarding completeness and accuracy of rights were also noted.

- "Water rights adjudication,"
- "Trying to get a handle on water rights,"
- "Capacity of the agency to deliver service regarding water rights to the public,"
- "Lack of knowledge of water rights by the public."

Policy Challenges

As a group, policy challenges comprise 18.9 percent of human dimensions challenges, and represent 7.2 percent of total challenges expressed in the interviews. Thus, they represent the second largest subcategory of human-dimensions related responses. Three subcategories were noted in the coding: adequacy (1.8%), political/community dynamics (2.8%) and regulatory issues (2.6%). Adequacy concerns linked with regulatory aspects related to public officials in a general sense and also with government structures overall and those associated with specific economic facets. One noted a general disconnect between perceptions of the public, specific public policies, and water law. Another focused on planning or vision capacities of agencies.

Political and community dynamics illustrate, in various ways, how different groups perceive the actions and intent of others involved with a particular issue as linked because of a certain shared resource. Some examples include responses relaying how local landowners mistrust the government, a mismatch between existing data and political expectations, how resource conflicts emerge and are effectively played out in different arenas, how politics are infused in issues of water use and distribution, and water politics in general.

The third subgroup includes responses that communicate how compliance with regulations takes place related to state and federal guidelines, including existing and newly introduced ones.

Planning concerns were also expressed in relation to compliance with current and future laws and how to accomplish such goals in the face of uncertainty.

Funding Challenges

As a whole, resource or funding related challenges comprised 5.7 percent of total challenges across all mentions in the interviews. From general expression of funding to funding limitations or a lack of funds, including those linked with projects generally, others mentioned ties to specific activities and projects. For instance, some responses included:

- "Funding resources required to meet new regulation standards and time frames,"
- "Lack of funding not allowing expertise in field to be developed,"
- "Finding funding to pursue the projects the community needs,"
- "Funding for data management and data collection."

Sociological Challenges

The subcategory of sociological challenges includes two further subgroups: organizational or institutional dynamics linked primarily with agencies (12; 2.4%) and managing with consideration given to social components (5; 1.0%). Combined, they represent just 3.4 percent of total challenges mentioned. These responses describe interrelations among various actors (e.g. municipalities, county agencies and private water companies), along with people in the industry overall. Other examples include fostering links among government, universities and local populations, and encouraging practitioners to find ways to communicate. Other concerns include management issues that cross state and federal boundaries and span various scales of interaction. Some remarks also called for taking multiple perspectives into account in decision-making processes.

Educational Challenges

Taken as a group, educational challenges comprised 8 percent of total challenges across all mentions in the interviews, and 21.1 percent within the human dimensions subgroup. As such, they represent the largest segment of human dimensions-related challenges. Two additional layers to this category emerged: public education and community outreach (20; 4.0%) and conservation education (20; 4%). Examples related to public education and community outreach can be considered in the following two groupings. The first related to general interactions and highlights information and involvement challenges:

- "Dealing with the public,"
- "Public ignorance, or lack of willingness to get involved,"
- "Lack of public participation,"
- "Lack of understanding about water by public,"
- "Adequately informing the public on what needs to be done concerning water resource protection,"
- "Public buy-in-convincing/educating the public that certain actions need to take place."

A second sub-grouping highlights resource and outreach issues:

- “Public outreach, (e.g. water management, grazing issues, recreational use of lands, and the affordability of technology),”
- “Question of how to reach all the varied groups of water users in the region, and how best to develop tools that are effective at reaching the different groups,”
- “Lack of outreach regarding incentive and rebate programs,”
- “Community outreach and awareness about the watershed and water quality,”
- “Getting resources out to the villages,”
- “Education and outreach on connection of people's daily lives to health of the watershed,”
- “Promoting use of safe water in Native communities,”
- “Lack of public education about farming due to financial burden (advertising) and current biased info that public receives,”
- “Creating awareness of Nitrate Priority Areas,”
- “Public education of environmental protection and restoration,”
- “Getting landowners to listen to all sides of the issues.”

Challenges of Population Dynamics

As a whole, these demographic challenges comprise just under 7 percent of total challenges noted by our survey respondents. Six subgroups were identified: population and growth projections (2.4%), population change and water demand (2.4%), population change and consumption patterns (0.4%), population change and flooding (0.2%), population change and culture (1.0%), and other growth-related topics (0.6%).

Management-related Challenges and Concerns (18.9%)

The third broad group of greatest challenges that emerged from the qualitative analysis of the interviews related to management challenges and concerns. As a whole, they represent nearly nineteen percent of the total challenges relayed by those in our sample of survey respondents. Within this group, although we show four subcategories in Table 2.1.2 (personnel/time/logistical challenges, general management needs, management strategies, and program effectiveness), in the original analyses, seven subcategories were identified. These subgroups were personnel and time management/logistical challenges, management needs in general, management regimes (e.g. restoration, stormwater, storage, etc.), biological/wildlife management, holistic management, and program effectiveness.

Challenges subsumed under the first category include those of staffing like hiring processes, a general lack of resources for getting things accomplished, attempts at efficiency gains, establishing links among diverse user groups, and various demands placed on organizations that highlight difficulties associated with existing resources and the utilization of existing channels. Time management issues and person-power issues were also comments made regarding this subcategory. These constituted nearly five percent of the total challenges.

Related to the second subcategory, management needs in general, various responses were conveyed suggesting knowledge gaps, how to contend with issues of communication and coordination, and general sustainability concerns. Representing 4.5 percent of total challenges,

these responses include a mix of local and more expansive scales, illustrating complexities related to management strategies over particular spatial arrangements and institutional realms.

Conjunctive management challenges were mentioned 11 times, representing 2.2 percent of the total. Responses included general issues related to conjunctive management (e.g. uncertainty linked with it), as well as more specific applications and general groundwater/surface water interrelations. Similarly, management regimes, with 10 comments, were 2 percent of the total, including restoration, stormwater, storage, and general data concerns, sometimes linked with specific events like floods.

Biological and wildlife management challenges also reflected broad-based and locally-specific concerns, and represent 2.4 percent of total challenges. For example, fish passage related to hydropower was mentioned generally, as were more specific examples of salmon populations including how such efforts link with the Endangered Species Act. Holistic management challenges incorporate those related to competing groups and achieving balance in complex decision-making environments, comprising under two percent of the total. Rounding out this category are four responses linked with program effectiveness and specifically economic analyses conducted to determine such impacts.

Concerns with Information, Data Quality and Dissemination (6.7%)

The final category related to the greatest challenges that water professionals face included responses that link with how existing data is gathered, organized and disseminated. Representing 6.7 percent of the total, these challenges focused on data collection standards and quality, data dissemination mechanisms, and conveying information in formats that make them accessible to the lay public, and were relatively equally split among these concerns, as shown in Table 2.1.2.

Generally, these suggestions are not focused on a need for new data, but instead highlight strategies for communicating and integrating existing sources in a manner that improves accessibility and has a potentially broader audience. 33 responses were categorized into this topic, which included four subtopics: utilization of existing data or the creation of a central repository, a lack of adequate or high quality data, specific types of data needs, and formatting issues related to conveying materials to the general public.

Examples of responses in the first subtopic focused on issues of data management, particularly in terms of having it be centralized to improve its accessibility. A standardized database was suggested that would serve as a repository for data that has already been collected in order to facilitate information transfers. This data sharing would involve various groups involved with water-related issues, such as agencies, universities and the lay public. A web-based delivery system was also advanced as a possible centralized, data storage location.

The second subtopic's responses concentrated on issues related to the absence of particular types of data, data quality concerns, and a general lack of data collection. Comparability of data was also expressed in relation to the number and frequency of data points being gathered. Concerns related to data standards were also included, along with the issue of the absence of historical data availability. Maintaining high quality data standards over time were also included.

A subset of responses within the broader category of information, data quality and dissemination focused on specific types of data like the need for real time data and how geological factors shape the ability or inability to gather proper data. One response linked specifically with how fire impacts soil hydrologic functioning. A final challenge related to gathering data at the watershed level as a concern.

The final cluster of responses in this category honed in on issues related to data accessibility. Examples included calls for more efforts to translate technical scientific data into terms and products that are applicable to a range of audiences such as extension agents, managers, stakeholders, and the lay public. These challenges cut across various outputs, from written reports to particular programs, with one calling for a reduction in jargon in order to facilitate information transfers within and between agencies, academia, and the public.

State Differences in Reported Biggest Challenges

In examining the greatest challenges by state in order to discern whether particular patterns may be notable, we found a number of intriguing results. For instance, using the four broad categories of data, natural systems, human dimensions, and management, the distribution of responses across and within states, shown in Table 2.1.3, a perusal of the frequencies suggests similarities as well as differences.

Though differing in actual percentages, the patterning of responses is similar in Montana, Idaho and Washington. In Montana, for example, natural systems challenges comprise the largest category of responses with 52.5 percent, followed by human dimensions challenges (29.6 percent), management (10.2 percent), and data with less than 8 percent. In Idaho, natural systems challenges represent just under 39 percent of all challenges reported by respondents, with human dimensions (33.5 percent), management (20.4 percent) and data (7.2) following, respectively. For Washington, though the patterning is the same, the percentages differ, as natural systems and human dimensions are quite similar (at 44.8 and 44.7 percent respectively), followed by management with 9.0 and data with only 1.5 percent.

Greatest challenges differ in Utah and Alaska, though human dimensions challenges represent the largest category in both states. For instance, in Utah human dimensions constitute the largest category with half of responses, followed by management (25.3 percent), natural systems (20.2 percent), and general data (4 percent), respectively. An even different proportional ranking can be seen for Alaska, as even though human dimensions represent the greatest number of challenges by responses, they are only 37 percent of the total, followed by natural systems (31 percent), management (20.2 percent), and data with 11.9 percent.

Table 2.1.3. Greatest Challenges Water Professionals Face by State

Type of Topic	AK	ID	MT	UT	WA
Natural Science Challenges					
Water Quantity	9.5	22.2	17.9	13.1	28.3
Water Quality	16.7	10.8	27.0	3.0	12.0
Climate and Drought	1.2	4.2	7.7	3.0	3.0
Other Natural Science Data	3.6	1.8	0.0	1.0	1.5
Natural Sciences Subtotal	*31.0*	*39.0*	*52.5*	*20.1*	*44.8*
Social Science Challenges					
Legal Challenges	1.2	4.2	6.4	5.1	26.9
Policy Challenges	10.7	13.2	2.6	3.0	0.0
Funding Challenges	11.9	4.2	2.6	6.1	4.5
Sociological Challenges	3.6	2.4	3.9	5.0	3.0
Educational Challenges	6.0	3.6	7.7	17.2	9.0
Challenges of Population Dynamics	3.6	6.0	6.4	14.1	1.5
Social Sciences Subtotal	*37.0*	*33.6*	*29.6*	*50.5*	*44.7*
Management Challenges					
Personnel/time/logistical challenges	6.0	3.0	3.8	9.1	3.0
Management Needs in general	6.0	3.6	3.8	5.1	3.0
Management Strategies	8.3	8.3	3.6	7.1	3.0
Program Effectiveness	0.0	0.0	0.0	4.0	0.0
Management and Other Subtotal	*20.3*	*14.9*	*10.2*	*25.3*	*9.0*
Data Challenges					
Data collection standards and quality	8.3	6.0	5.1	2.0	0.0
Data dissemination mechanisms	3.6	1.2	1.6	2.0	1.5
Data Subtotal	*11.9*	*7.2*	*7.7*	*4.0*	*1.5*
TOTAL	100	100	100	100	100

2.2 RESEARCH NEEDS

Overview

After asking about the challenges they face in managing water resources in their job, respondents were asked:

> *"Thinking back over the last 5 years, can you think of any specific instances in which you did not have the information you needed to make good decisions about water resource management? If you can think of several, pick the most important or most common type of situation."*
>
> *And*
>
> *"Of all the specific types of information gaps that you've mentioned, could you rank each one as a potential focus for future university research, with "1" being the highest priority area?"*

The most common responses were recorded and used in the analysis below. All told, 574 responses were recorded from 153 interviews (See Table 2.2.1). The largest number of interviews were completed in Idaho (31 percent of the total), and each Idaho interview recorded an average of almost 7 key research needs (a total of 319 needs, or 56 percent of the total). While some of the results discussed below include the aggregated totals form all interviews, we also examine patterns by state to highlight ways in which the priorities and perceived needs differ across the study areas.

Table 2.2.1. Number of Interviews Completed and Research Needs Identified by State

	Overall # Interviews	Total Reporting Any Research Needs	% Respon-dents	Total Needs Identified	% Items	Avg. # Needs Reported / Interview
Alaska	30	28	18.3	61	10.6	2.2
Idaho	53	47	30.7	319	55.6	6.8
Montana	27	26	17.0	66	11.5	2.5
Utah	27	27	17.6	84	14.6	3.1
Washington	28	25	16.3	44	7.7	1.8
Total	165	153	100.0	574	100.0	3.8

The 574 total research needs identified in the interviews were analyzed for common themes and patterns, and then were organized into four major categories:

- Need for Better Data Coordination and Dissemination
- Need for Natural Science Research
- Need for Social Science Research
- Need for Management Resources and Strategies

The total number of responses in each major category (as well as several subcategories, are listed in Table 2.2.2.

Table 2.2.2. Distribution of Research Need Priorities by Major Categories

		ALL REASONS LISTED				ONLY TOP 3 REASONS			
		Frequency		Percent		Frequency		Percent	
Topic	Subtopic	Topic	Sub-topic	Topic	Sub-topic	Topic	Sub-topic	Topic	Sub-topic
Data Quality & Dissemination		**60**		**11.0**		**29**		**8.2**	
	Data collection standards and quality		26		4.8		15		4.3
	Data dissemination mechanisms		34		6.2		14		4.0
Natural Science Research		**328**		**60.0**		**221**		**62.8**	
	Water Quantity		131		23.9		89		25.3
	Water Quality		94		17.2		64		18.2
	Climate and Drought		70		12.8		43		12.2
	Watershed data		21		3.8		16		4.5
	Other Natural Science		12		2.2		9		2.6
Human Dimensions Research		**144**		**26.5**		**89**		**25.2**	
	Conservation Behavior		7		1.3		4		1.1
	Consumption Patterns		37		6.8		16		4.5
	Sociological factors		48		8.8		29		8.2
	Political factors		32		5.9		25		7.1
	Economic factors		20		3.7		15		4.3
Management Approaches		**15**		**2.7**		**13**		**3.7**	
	Management needs (general)		3		0.5		1		0.3
	Management training		7		1.3		7		2.0
	Funding concerns		3		0.5		3		0.9
	Other		2		0.4		2		0.6
Total		**547**		**100.0**	100.0	**352**		**100.0**	100.0

Because some states allowed many respondents to list more than three top research priorities, we also ran an analysis that limited the data to the first three responses per person. The results are shown in the right half of Table 2.2.2. While there are some modest shifts in proportions of answers in specific categories, the overall patterns remain substantively the same. This suggests that multiple responses from certain respondents (or states) are not driving the patterns in our research needs database. In the sections below, we will be reporting on results from the full dataset that includes all suggested research needs and priorities.

Ensuring Data Quality and Dissemination (11%)

The first major category included all of the responses that emphasized ways to better gather, organize, and disseminate existing types of scientific data about water resources. Just over 10 percent of the total research needs fell into this topic category. In a sense, most of these suggestions do not call for new basic or applied scientific work, but rather organizational and institutional innovations that might make existing scientific knowledge more accessible and widely used. The 60 responses in this category were broken into two subtopics – requests for better data quality, and requests for systems to better disseminate the available data.

Examples of responses in the first subtopic included a call to standardize data collection and reporting protocols (to enable comparisons of data across time and space). This was particularly true for water quality datasets. There were also concerns that basic types of water resource data (particularly stream flows, climatic events, water quality measurements, and reservoir/lake levels) should be made available to resource managers in real-time.

The responses in the second subtopic focused on problems related to the access, sharing, and dissemination of existing water resource datasets. There were three main types of suggestions. Most common was a request for some type of digital data clearinghouse (cited by 18 respondents) where researchers and managers could go to get systematic data across a range of parameters. Examples of the types of data that would be appropriate include:

- "Centralized database with links to climate and population data,"
- "…database to store all agency-collected water data,"
- "Coordination techniques for consistent monitoring and evaluation data collection…and the creation of a database to store collected monitoring data," and
- "Establishment of an aerial photo library or guide to accessing historical aerial photos."

Some of those interested in a data clearinghouse pointed at the need to develop techniques or software that can inventory and integrate disparate types of water data from multiple sources. Others sought direct links to mapping software that help display spatial patterns and relationships.

Other responses in the data dissemination subtopic addressed institutional changes that are required to better facilitate data sharing and communication across different government agencies, and between universities and public or private water resource managers. One Montana respondent called specifically for "Universities to help agencies develop: 1) analytical techniques, 2) better monitoring and efficiency in monitoring system design, 3) richer data, 4) partnerships with universities to provide more research angles, 5) sampling designs, and 6) hardware."

The final cluster of responses in this category included calls for more efforts to translate technical scientific data into terms and products that are accessible to politicians, managers, and the lay public. These responses echo some suggestions for better public education that will be discussed in more depth in the sociological research section below.

Natural Science Research (60%)

By far the most common suggestion for further university research addressed natural biophysical science topics. Sixty percent of the total research needs fell into this category. Because of the diversity of the specific suggestions, we divided this category into four major subtopics (which, in turn, can be subdivided into more detailed groups). Before examining each subtopic, it is worth noting that most of our natural science research suggestions did not specify a particular discipline or basic science topic, but rather were phrased as applied scientific questions focused on particular management problems.

As such, our four subtopics include: Water Quantity data and research, Water Quality data and research, Climate and Drought data and research, and a final group of diverse other topics.

Water Quantity Research Needs

The most frequently cited subtopic in the natural science research needs category involved water quantity topics. Almost a quarter of all responses mentioned issues in this category. Because the background on our study provided to respondents involved a short discussion of the water resource management issues in the region, with a particular focus on water supply and drought, it is not surprising that respondents directed a large share of their attention toward these topics.

The water quantity subtopic suggestions were further subdivided into several different subgroups (see Table 2.2.3). These were titled: surface water, ground water, surface and groundwater interactions, and studies of water availability and storage.

Surface Water Research

The first subgroup included data on surface water conditions (roughly 6 percent of all suggestions). Almost all of these identified a need for better stream flow data monitoring and reporting systems. Specific suggestions included:

- "Increased monitoring and gauging,"
- "More stream gauging data," or "Greater coverage of stream flow gauges"
- "Increased flow data, inclusive measurement of low stream flows…timing of peak flows,"
- "Timely stream and canal flow measurements,"
- "In-stream flow data… and inflow forecast anomalies"
- "Timely site specific stream flow and precipitation gauges to model storm events."

Other suggestions for surface water research included better data on stream channel dynamics, improved understanding of the ecosystem impacts of changes in stream flows, and development of technologies that make more efficient use of surface water resources.

Table 2.2.3: Detailed Water Quantity Research Needs

Type of Research Need	Number of Respondents	Percent of Water Quantity Suggestions
Water Quantity Research Needs	131	
Overall water quantity data, integrated hydrologic assessments	***15***	***11.5***
Surface water data	2	1.5
Stream gauges and flows	20	15.3
Stream channel dynamics	2	1.5
Ecosystem effects of flows	6	4.6
More efficient uses of surface waters	1	0.8
Subtotal (surface water data)	***31***	***23.7***
Ground water data	17	13.0
Groundwater withdrawals	8	6.1
Aquifer models	15	11.5
Spring flows	3	2.3
Recharging models	6	4.6
Subtotal (ground water data)	***49***	***37.4***
GW and SW Interactions	***15***	***11.5***
Water availability, utilization and storage	1	0.8
Estimates of water availability	5	3.8
Water storage and conjunctive management	13	9.9
Flood control	2	1.5
Subtotal (water availability and storage)	***21***	***16.0***

Groundwater Research

The most common subgroup in the water quantity subtopic involved suggestions for more research on groundwater availability and dynamics. Almost 50 responses (or 10 percent of all research needs) fell into this area.

Specific suggestions for groundwater research topics included the following examples:

- Increased data on groundwater levels
  - "More groundwater monitoring locations dealing with depth to water table,"
  - "Research on the location of groundwater resources,"
- More detailed data on groundwater usage and withdrawals
  - "Better measurement of groundwater usage (quantity and efficiency),"

    - "Determination of adequate spacing between domestic wells,"
    - "Long-term measurement of groundwater withdrawals,"
    - "Policies for regular reporting of pumping records, diversions and return flows,"
    - "A statewide study of the net impact of domestic wells,"
    - "Regulation and monitoring of domestic and agricultural groundwater use."
- Improved basic understanding of aquifer resources and dynamics
    - "Map aquifers," "Aquifer mapping," "Aquifer data," "Delineate aquifers,"
    - "Assess the size of groundwater reservoirs and the quantity of useable water within the reservoirs,"
    - "Research the extent, boundaries, and behavior of aquifers"
    - "Long-term sustainability of aquifer (quantity level to sustain),"
    - "Technical information to create broad conceptual model of the aquifer,"
- Better understanding of aquifer recharge dynamics
    - "Identify aquifer recharge locations,"
    - "Transmissivity of aquifer recharge and timing of discharge"
    - "Assessment of key locations for aquifer recharge so that flood control can take advantage of subsurface storage of excess flows,"
    - Identification of natural recharge locations (both shallow and deep aquifers) and identification of potential enhancement locations.
- Better understanding of spring flows

Interactions of Surface and Groundwater Resources

The third subgroup in this section included suggestions for more research explicitly targeted at understanding the interactions between surface and groundwater resources. Cited by almost 6 percent of respondents, examples of the suggestions included:

- Better basic science understanding of these interactions
    - "Increased understanding of surface/groundwater interactions"
    - "Modeling of ground and surface waters in tributary valleys,"
    - "Development of groundwater and surface water models"
    - "Basic understanding of groundwater – assessing where and how groundwater is recharged by surface water and creating a model that takes into account both ground/surface waters that will enable better predictions of water levels,"
- Applied science understanding the impacts of water use on ground and surface waters
    - "Groundwater pumping and how it affects surface water flows in the pumping timeline,"
    - "Better understanding of the interrelations of ground and surface waters, accounting for diversions and pumping,"
    - "Tributary underflow, return flows from canals, and precipitation in non-irrigated lands and their relationships to groundwater-surface water models,"

Water availability, utilization and storage

The final subgroup of water quantity topics included applied studies of water availability and options for increasing storage capacity for sustained water use. Examples of suggestions in this section included the following:

- Estimates of water availability
  - "Quantification of how much water is potentially being used, and how much actually exists,"
  - "Better tools and methods for water supply forecasting,"
  - "Determine the yields (sources) and uses of water, and address the question: 'where is water coming from and how is it being managed?'"
- Studies of water storage alternatives
  - "Is there more water available for more dams?"
  - "Assessments of the current status of dams (need to fix or alter to increase capacity – including assessments of sedimentation, toxicity, and potential removal and reuse projects."
  - "Study of the storage needs to meet requirements for agriculture and wildlife,"
  - "How to secure water (storage) for supplemental use during shortages and recharge,"
- Scientific studies to support conjunctive water storage management approaches
  - "Data to assist conjunctive management,"
  - "Better understanding of conjunctive management,"
  - "Techniques for integrated water management,"
  - "Policy strategies for conjunctive management,"
  - "How to conjunctively manage ground and surface water users' rights,"

<u>Climate and Drought Research</u>

Aside from water quantity topics emphasizing the study of ground and surface water resources, many respondents identified climate and drought topics as a high priority for future university research. In total, we classified 70 research needs (or 12.8 percent of the total) into this subtopic category.

While it was difficult to draw clear-cut lines, the specific suggestions for research in this area fell into the following major topic areas:

- Improved data on climate and weather
- Drought specific research topics
- Studies of climate change
- Prediction and modeling of climate and drought
- Studies of Policies and BMPs designed to address climate change and drought

Improved data on climate and weather

A sizeable group of key informants felt that the development of a better system of baseline data on climate and weather would be a priority for future INRA work. Examples of comments included people who indicated a desire for the following types of data:

- "Basic hydrological data including snow pack, precipitation cycles, soil moisture, lake levels, climatic influences, and stream flow,"
- "better data on solar radiation,"
- "increased quantity and accessibility of SNOTEL sites,"
- "historic snowpack and climate conditions," "snowmelt rates," "understanding snowpack levels," "additional research on snowpack and meteorological data and their interpretation,"

Drought science

Because many states in this region have experienced recent prolonged periods of drought, the research instrument asked all respondents whether or not they felt there was adequate scientific information regarding the prediction and impacts of droughts on water resource management. Suggestions included research that would lead to: "better definitions of drought," "understanding the precursors of drought," and "developing a new way to determine soil moisture."

Climate Change Science

Given the intense public and scientific attention to the topic in recent years, it was not surprising that a number of our respondents felt that more research should be done on the nature, causes, and impacts of global warming and climate change. Of particular interest to these informants would be further study of the following topics:

- "Impact of climate change on water resources," "Effects of global climate change on hydrology," "Analysis of the impacts of global warming on water availability," "Global warming research, especially impacts on drinking water sources," "Climate change effects on water supply,"
- "Global warming research as it relates to fish and waterways,"
- "Predictive modeling of vegetative structure changes related to climate change,"

Modeling and Forecasting Science

Aside from better data on weather, climate, drought, and climate change impacts, many key informants identified a need for better climate models that help predict changes and provide short- and medium-term forecasts to assist water resource planners. Suggestions included:

- "Better weather and climate forecasting," "Improved weather predictions,"
- "Development of better forecasting models," "Greater spatial and temporal resolution of weather predictions,"
- "Increased accuracy and timeliness of weather and water supply predictions,"
- "Increased accuracy of weather predictions to reduce the uncertainty in water supply and shortages (e.g., water use, flooding, and drought),"
- "Models with increased capabilities to incorporate wind and solar radiation data."
- "Better drought management predictions,"

- “Knowledge as early as possible regarding the conditions (drought or surplus) of the coming year,”
- “Better long-range drought forecasting,”
- “Predictions of the effects of drought on the water supply,”
- “Early drought predictions and the provision of that information to farmers,”
- “Linking groundwater data to stream flow data in drought predictions.”

Policies and BMPs to address Climate Change and Drought

The final cluster of research needs in this section relate to specific management or technological solutions to climate change and/or drought. Specific suggestions were:

- “Development of a response plan for drought,” “Collaborative watershed plans for drought management,”
- “Methods/tools/policies to plan for multiple drought years (fish and irrigation) with an emphasis on leaving water in-stream during drought
- “Unified, statewide public awareness of drought and water quantity issues,”
- “Development of drought tolerant crops,” “Development of drought management Best Management Practices (BMPs) that are holistic,”
- “Cloud seeding research,” “What is the impact of cloud seeding in the basin? Do we know what we are doing?”

Water Quality Research Needs

Although studies of water quantity dominated the natural science research needs in our interviews, there were a sizeable group of respondents (17% of all suggestions) who felt that more research should be done on water quality issues.

Water Quality Monitoring

As with water quantity topics, a large number of suggestions focused on ways to improve the general monitoring infrastructure and data reporting network. Specific comments included:

- "More and better water quality monitoring data,"
- "Baseline data on water quality parameters," "Baseline water quality data to understand influences at multiple scales"
- "A network of water quality monitoring stations – specifically designed to make determinations of beneficial use for the TMDL process"
- "Data on surface water quality," "Data on nutrients, temperature, and sediments in surface waters,"
- "more sediment gauges on rivers,"
- "Temperature data from USGS gauging stations," "Assessment of current stream temperatures with quantification of the effects of human activities on stream temperatures."

Sources, impacts and dynamics of specific pollutants

Other suggestions focused on enhancing our understanding of the processes associated with particular types of water pollutants.

Some suggested the need for an overall assessment of the relative levels and impacts of different types of pollutants as a first step. Typical comments were:

- "Which are the worst bodies of water and why? Chemicals, nutrients, sediments, pharmaceuticals?"
- "Technologies to better define and isolate TMDL problems," "Applications of current technologies (e.g., GIS) to better understand and holistically plan the management of TMDLs."
- "Localized research on discharge (e.g. temperature, metals and nutrients) on impacts on aquatic species and downstream water users"

Others identified particular pollutants as a specific priority for future research. Among these, the most commonly mentioned were:

- Nutrients and sediments
- Metals
- Pharmaceuticals, personal care products, and other inert ingredients

Relationships between land use changes and water quality impacts

While the above suggestions focused on measurements of water quality parameters, there were a cluster of others that suggested a broader data collection approach designed to link changes in the larger landscape to changes in water quality in surface and groundwater resources. Examples included studies of the impacts of the following changes in land uses:

- Logging
- Off-road vehicle use
- Septic systems
- Urban development and construction activity
- Stormwater runoff
- Wastewater and stormwater

Development of technologies to mitigate water quality problems

A final cluster of water quality suggestions focused on engineering, management, and technical innovations that might provide solutions to water quality problems. Again, the particular water quality issues of interest to our respondents were quite diverse, so their suggestions represented a wide sweep of potential Best Management Practices (or BMPs). Examples included:

- Better erosion and sediment control techniques
- Better water treatment options – particularly with emphasis on treating nitrogen and phosphorus in wastewater
- Assessment and quantification of the pollutant reductions associated with specific BMPs already available
- Development of tools to support water resource management approaches that incorporate a wider range of water quality issues into decision-making

Other Natural Science Research Needs

While water quantity and quality issues dominated the natural science research suggestions among our respondents, we did gather a number of responses that did not fit neatly into any previous category. The two largest examples in this group include studies of watershed scale dynamics, and studies of fisheries. In the case of watershed studies, there were several respondents who identified a need for better fine-grained spatial datasets at the watershed scale. These data might be used for a variety of interrelated purposes, including

- Delineation of basin and subbasin boundaries
- Mapping changes in terrain and erosion
- Improved land classification systems that reflect water uses
- Data on human modifications of water systems that facilitate comparisons of natural and human modified flows
- Development of historic vegetative data sets at the watershed scale
- Securing funding for integrated multi-disciplinary and long-term studies of selected watersheds

In the case of fisheries research, most of the emphasis focused on (a) salmon enhancement and recovery issues, and (b) stream restoration techniques with an eye toward re-establishing fish habitat.

Human Dimensions Research (26%)

Human dimensions issues were directly or indirectly mentioned in a number of the natural science research topics listed above, but were also the primary focus for a large cluster of suggestions in this section. Overall, topics classified as social science research comprised roughly a quarter of all research needs suggestions. These were then broken into four major categories (see Table 2.2.4):

- Conservation and consumption – (8%)
- Sociological (sociological baseline data; community and stakeholder relationships, educational programs, institutional/organizational factors) – (9%)
- Political (water rights, water law, policy impacts on water resources) – (6%)
- Economic (CBA/prices) – (4%)

Table 2.2.4. Detailed Description of Human Dimensions Research Needs

Type of Research Need	Number of Suggestions	Percent of HD Suggestions
Human Dimensions Research Needs	147	
Water Conservation and Consumption		
Conservation practice effectiveness	2	1.4
Development of new conservation practices	5	3.4
Improved/standardized data on water consumption	16	10.9
Ag vs. domestic water use studies	8	5.4
Water use demand info and data	6	4.1
Population growth impacts on water demand	7	4.8
Subtotal (water consumption and conservation)	***44***	***29.9***
Sociological Research		
Basic socioeconomic data	13	8.8
Stakeholder input and public information dissemination	18	12.2
Public education / research on best approaches	18	12.2
Organizational dynamics	1	0.7
Subtotal (sociological processes)	***50***	***34.0***
Policy Research		
Water rights issues	11	7.5
Legal concerns	7	4.8
Understanding impacts of policy on water resources	6	4.1
Political influence on science and policy	9	6.1
Subtotal (political processes)	***33***	***22.4***
Economic Research		
Cost benefit analyses	14	9.5
Analysis of market prices and solutions	6	4.1
Subtotal (economic processes)	***20***	***13.6***

Water Conservation and Consumption Patterns

Research needs associated with water consumption patterns were difficult to categorize. We grouped 44 suggestions into a water conservation and consumption category that included calls for the following types of research:

- Research into new technologies to reduce water demand,
- Improved approaches to measuring different types of water use, including a desire for
    - Better historical data,
    - Better metering, and
    - More remote sensing data,
- Standardization of reporting techniques related to water use data (several people emphasized problems with comparing estimates of per capita water use across states and jurisdictions),
- Detailed studies of agricultural irrigation water use (including a focus on whether or not changing irrigation technologies and pricing systems affect irrigators' water use behaviors),
- Detailed studies of urban water use, including
    - a focus on the impacts of different settlement patterns and types of growth on residential water use, and
    - better projections of water demand needs associated with population growth
- Detailed studies of the rate and character of transferring water rights from traditional agricultural uses to new urban/domestic consumption uses.

Sociological Research

A significant number of respondents identified human dimensions problems that we classified as "sociological" in nature. These fell into two main categories:

- Better socioeconomic data, and
- Improved techniques for working with the public.

Examples of suggestions in the first subcategory emphasized the importance of more accurate population projections and more detailed (finer-scale) socioeconomic data. Several respondents indicated a desire to know more about where development is most likely to occur, and what this growth will mean for water demand. In addition, there was an interest in more research into cultural attitudes toward water and water use. In every case, these forms of sociological research were designed to help understand current and future patterns of water use.

Most of the sociological research suggestions were in the second subcategory. Examples fell into three clusters – public input and participation, public education, and behavioral modification strategies. Some illustrative phrases used in the interviews were:

- Ways to increase public involvement in decisions
    - "Acquisition of skills to successfully incorporate public involvement,"
    - "Ways to incorporate communities into the research being done there,"
    - "Negotiations of how society should respond to drought,"
    - "Increased public involvement in water quality rule-making,"
    - "Public assessments of technical information regarding aquifer status,"
    - "Getting input from all parties and stakeholders in making management decisions."

- Ways to better get information out to the public
    - "Communication to and education of the public on research trends'"
    - "What are the most effective training programs for teaching regulated entities what is expected of them?"
    - "Unified statewide public awareness of water quality issues,"
    - "Information dissemination to the public about contaminants,"
    - "Communication strategies for effective dialogue when resources cross state or jurisdiction boundaries,"
- Behavioral modification strategies
    - "How to convince people not to over-irrigate,"
    - "Public education and promotion of conservation / reuse methods and tools,"
    - "Education and training on conservation measures,"
    - "Best ways to educate the public about conservation."
    - "Education and communication strategies to inform irrigators of conservation practices,"
    - "Determining a way to improve how people use water."

Policy Research

Roughly 6 percent of responses identified legal and policy issues as an area where further research was warranted. Many of these suggestions focused on the unique aspects of water rights law in the American West that shape the management of water resources. Others emphasized a need to understand the impacts of specific policies on water resources.

Some specific examples of policy research suggestions include:

- Water rights and other legal issues
    - "Real time water rights accounting data,"
    - "Mapping of water rights into a GIS database,"
    - "Development of technologies that better display existing water rights,"
    - "More information about what water rights are available and how they are used,"
    - "Development of a water rights manual to inform the public,"
    - Finding an alternative to Western Water law,"
    - "Need for research to support the strengthening of water quality law,"
    - "Clarity of the management of irrigation canals and ditches,"
    - "Management of regional water systems for salmon recovery under ESA,"
- Policy assessments
    - "Research to determine policies for holding power companies accountable for environmental and recreational damages caused by dam operations,"
    - "Sociological analysis of water rights holders behaviors under different forms of regulation,"
    - "Cost sharing alternatives and the political/legal frameworks of water administration across states/national jurisdictions,"

A final cluster of suggestions reflected concerns that politics (and perceived "biases") play too much of a role in water management research, and thus the 'need' was to have more unbiased and apolitical research.

Economic Research

About 4 percent of the suggested research needs identified topics focused on the economics of water use and water policy. These mainly fell into two clusters – cost/benefit analysis of alternative programs and policies, and studies of market-based solutions to water management challenges.

Examples of economic research topics that respondents would find useful include:

- Cost-benefit analyses
    - "Risk evaluations to prioritize spending scarce dollars,"
    - "Economic analysis of most appropriate forms of regulation to encourage conservation,"
    - "Expectancy-value studies that result in behavior changes related to water consumption."
    - "Costs and benefits of moving toward larger economies of scale,"
    - "Clarification of benefits water user receive by adopting conservation practices,"
    - Better analysis of cost-feasibilities for water reduction and conservation programs,"
    - "Cost-benefit analysis of xeriscaping,"
    - "Develop cost effective approaches to effecting changes in water use behaviors,"
    - "What are the costs and benefits of water development? Will bringing water to the community bring more money to local governments?"
- Market solutions
    - "Studies of the successes made by other states in terms of water valuation using market prices,"
    - "New economic analyses of tiered water rate structures,"
    - "Research on water marketing"
    - "Case study assessments of market trading policies and strategies,"
    - "Pricing of water,"
    - "Predictions of future resource markets."

Management Research – (3%)

The final group of suggestions were management systems needs, most of which focused on a desire for better guidance in making well-informed decisions on water resource management. This section also included several comments indicating frustration with the adequacy of funding and staffing resources for water resource management at various scales. Some of the more useful suggestions (for prioritizing INRA research efforts) might be:

- "Techniques for making better decisions with not enough information,"
- "Education and training on the technical aspects of water operations,"
- "Water resource planning research (tools, model development, interactive models, adaptive management models, modeling scenarios),"
- "Application of more recent research and analysis tools,"
- "Development of a funding database,"
- "Development of infrastructure (such as gauging stations) and methods for sustainable funding for such projects,"

Research Needs Priorities by State

Because of the diverse biophysical, socioeconomic, and policy settings across the five INRA states, it was expected that there would be some particular research topics that would rise (or fall) in prominence in the different states. The results in Table 2.2.5 below reflect the percent of respondents in each state who suggested research topics in each of the major categories discussed above.

Table 2.2.5: Research Need Priorities by State

Type of Topic	AK	ID	MT	UT	WA	Total
Data collection standards and quality	4.9	5.7	4.5	3.6	0.0	4.8
Data dissemination mechanisms	1.6	8.0	2.3	4.8	6.8	6.2
Data Subtotal	*6.6*	*13.7*	*6.8*	*8.3*	*6.8*	*11.0*
Water Quantity	**31.1**	**24.2**	**18.2**	**21.4**	**22.7**	**23.9**
Water Quality	**14.8**	**14.6**	**43.2**	**20.2**	6.8	**17.2**
Climate and Drought	**11.5**	**12.7**	**13.6**	7.1	**25.0**	**12.8**
Watershed data	**11.5**	3.2	0.0	0.0	9.1	3.8
Other Natural Science Data	6.6	1.3	0.0	1.2	6.8	2.2
Natural Science Subtotal	*75.4*	*56.1*	*75.0*	*50.0*	*70.5*	*60.0*
Conservation Behavior	0.0	1.0	0.0	4.8	0.0	1.3
Consumption patterns	0.0	8.9	4.5	7.1	2.3	6.8
Sociological factors	6.6	9.6	6.8	**11.9**	2.3	8.8
Political factors	1.6	5.7	2.3	6.0	**15.9**	5.9
Economic factors	1.6	3.5	2.3	8.3	0.0	3.7
Social Science Subtotal	*9.8*	*28.7*	*15.9*	*38.1*	*20.5*	*26.3*
Management needs (general)	0.0	0.3	0.0	1.2	2.3	0.5
Management training	4.9	1.0	0.0	1.2	0.0	1.3
Funding concerns	1.6	0.3	0.0	1.2	0.0	0.5
Other	1.6	0.0	2.3	0.0	0.0	0.4
Management and Other Subtotal	*8.2*	*1.6*	*2.3*	*3.6*	*2.3*	*2.7*
TOTAL	100	100	100	100	100	100

Note: Top 3 ranked needs in bold.

The findings suggest that natural science research is the overwhelming priority for water resource managers in Alaska (over 75 percent of suggestions were in this category) and Washington (71 percent). Social science research is perceived as a higher priority in Idaho and Utah, where 29 and 38 percent of suggestions, respectively, highlighted human dimensions research as a top priority. Within these broad categories, it is clear that water quality research was an unusually strong priority in Montana, while climate and drought research and water rights law were much more common themes in Washington. Concerns about the adequacy of the water resources data infrastructure were highest in Idaho, since it was cited at nearly double the rates in most of the other states.

Research Needs and Priorities by Respondent Characteristics

A final analysis was conducted that examined possible relationships between the type of organization where a respondent worked and the types of research needs that they perceive as high priority. The results are shown in Table 2.2.6 below.

Table 2.2.6: Major Research Needs by Type of Organization

	Type of Organization Where Respondent Works			
Major Type of Research Need	Federal Agencies	State Agencies	Local City or County Government	Other (Private, Tribal, Nonprofit)
	Percent of total by Type			
Basic Data Infrastructure	12.8	7.8	6.9	13.5
Natural Science Research	71.6	70.2	61.1	47.0
Human Dimensions Research	11.9	19.1	27.8	37.8
Management Challenges	2.8	2.1	4.2	1.7
Total	100.0	100.0	100.0	100.0

The results suggest that Natural Science research topics are viewed as higher priorities by persons who work in state and federal agencies. By contrast, human dimensions research topics were more frequently cited as higher priority needs by persons working in local government, tribal government, or in the private nonprofit or business sector. There was a notably higher level of concern about the adequacy of the water resources data infrastructure among federal agency staff and persons working in the private sector.

2.3 EDUCATION NEEDS

Overview

After being asked about the challenges they face in managing water resources in their job and information needs related to their employment, respondents were asked a number of questions related to educational needs. In particular, respondents were queried about INRA University Consortium's plans to develop a training program for graduate students in "integrated water sciences" that related to the following seven questions.

a. *What do you feel are the most important skills someone in your position should have?*
b. *If you were to do it over, what training or skills do you wish you had received while in college/graduate school?*
c. *Are there any water resource management topics on which you would like to receive updated training or knowledge?*
d. *How successful has your agency/organization been at identifying and hiring qualified people with the skills needed to work on water resource issues?*
e. *Do you feel that people graduating from regional universities have the right mix of education and skills to work well in this area?*
f. ***What are the specific types of knowledge, training, or skills that are most lacking among recent graduates?***
g. ***Are there any other suggestions you might have for INRA universities regarding the training of water resource management professionals?***

The discussion here focuses especially on f and g above. Responses to these questions were aggregated from each state and interview texts were inductively analyzed in order to determine common themes.

The respondents identified an average of 3.6 types of 'educational needs' in each of our interviews. It is worth noting that respondents were not asked 'what should university degree programs teach?' Rather, they were asked what skills graduates of these programs should have if they seek employment in water resource management agencies and organizations. The results below should be read with this particular focus in mind.

Respondents in Utah and Idaho typically recommended the most needs, while the rate of reporting was lowest in Alaska (see Table 2.3.1). The largest number of respondents with suggestions for the training of new water science graduates was found in Idaho.

Table 2.3.1. Number of Interviews Completed and Research Needs Identified by State

	Overall Number of Interviews	Total Reporting Any Educational Training Needs	Percent of Respon-dents	Total Needs Identified	Per-cent of Items	Avg. # Needs Reported / Interview
Alaska	30	29	18.0	82	14.1	2.8
Idaho	53	52	32.3	219	37.6	4.2
Montana	27	27	16.8	85	14.6	3.1
Utah	27	26	16.1	113	19.4	4.3
Washington	28	27	16.8	84	14.4	3.1
Total	165	161	100.0	583	100.0	3.6

After reviewing the various items mentioned by respondents, we identified two broad categories of educational needs:

- Those related to **traditional skills** learned in water resource management-related science fields, and
- Those related to **non-traditional skills** not commonly included as formal components of water-resource training programs (i.e., communication skills, social science training, and administrative skills).

Our analysis focuses on these two broad subcategories, as well as three subareas within each subcategory (natural science training, technical skills, real world experience, in the first instance; and communication skills, social science training, and administrative skills in the second).

Table 2.3.2 shows the breakdown of the 583 responses as a percentage within the two broad subcategories (first column of percentages) and as a percent of all responses (the second column of percentages). While educational needs are broad-ranging, in the following paragraphs we provide detail about each category to show how respondents view these areas in conjunction with one another.

Table 2.3.2 Areas where Increased Education and Training would be Useful

Types of Educational Needs	Number of Responses	Percent of Subcategory	Percent of Total
Traditional Water Resource Manager Skills			
Natural Science Training (overall)	**141**	**45.0**	**24.2**
Hydrologic Sciences	38	12.1	6.5
Interdisciplinary Science Training	31	9.9	5.3
Disciplinary Natural Sciences	28	8.9	4.8
Engineering	21	6.7	3.6
Applied Natural Sciences	19	6.1	3.3
Other	4	1.3	0.7
Technical Skills (overall)	**108**	**34.5**	**18.5**
Decision-Making Skills	27	8.6	4.6
Research Design and Analysis	21	6.7	3.6
Computer Skills	22	7.0	3.8
General technical knowledge	19	6.1	3.3
Math/Statistics	15	4.8	2.6
Other	4	1.3	0.7
Real World Experience (overall)	**64**	**20.4**	**11.0**
Real World Experiences	33	10.5	5.7
Internships	4	1.3	0.7
Field Smarts	27	8.6	4.6
Subtotal	**313**	**100.0**	**53.7**
Non-Traditional Skills			
Communication Skills (overall)	**129**	**47.8**	**22.1**
Communication Skills	70	25.9	12.0
Public Education	27	10.0	4.6
Teamwork	19	7.0	3.3
Conflict Management	13	4.8	2.2
Social Science Training (overall)	**91**	**33.7**	**15.6**
Water Law and Policy	61	22.6	10.5
Other social sciences	30	11.1	5.1
Administrative and Management Skills	**27**	**10.0**	**4.6**
Miscellaneous	**23**	**8.5**	**3.9**
Subtotal	**270**	**100.0**	**46.3**
Total	**583**		**100.0**

Traditional Water Resource Manager Training (54%)

Natural Science Training (24% of total)

Interestingly, only about 24 percent of respondents identified natural science training as a problem in current regional graduate training programs. The general sense from the interviews was that natural science training is critically important, and provides important background for water resource managers. However, most felt that the available natural science training programs were providing an adequate disciplinary science base for their graduates.

About half of the natural science educational needs focused on two topics: deeper training in hydrology and hydrogeology, and broader interdisciplinary training that integrates the various disciplinary sciences.

Hydrological sciences was a diverse category, including basic knowledge of hydrology, a focus on complete hydrologic systems, awareness of the role of water law, water conservation behaviors, water storage and availability, etc. Some specific examples of educational needs that we coded as "hydrology" included:

- basic understanding of hydrology,
- better understanding of surface and groundwater interactions,
- hydrogeology, and
- fluvial geomorphology

Examples of interdisciplinary training needs were diverse. Some focused on the integration of the natural sciences. Others emphasized the need to bridge the basic sciences, technical skills, and social and legal forms of knowledge. A sample of specific comments includes:

- "Cross-discipline training," "Interdepartmental training," "Multidisciplinary approaches," and "Interdisciplinary education,"
- "A general understanding of biology and chemistry for engineers, and a better understanding of basic engineering principles for scientists and a better understanding of policy for all,"
- "Multidisciplinary nature, need the technical (ecological, engineering) as well as the social,"
- "Broad background/perspective (technical, economic, political, and social expertise),"
- "Solid training in physics, chemistry, surface and ground water quality, and hydrology,"
- "Integration of policy, hydrology, ecology, engineering,"
- "Solid foundation in technical/natural/biological sciences, and water law, legislation, and regulation,"
- "Knowledge in soils, physiology, hydrology, sociology, economics, psychology, biology, botany, natural science, anthropology, GIS, Remote sensing, water law," and
- "Technical knowledge and skills (hydrology, hydraulic engineering, geomorphology, riparian botany, aquatic ecology, fish biology)."

About 5 percent of all educational needs listed specific disciplines in the natural sciences, while 4 percent cited engineering training as a priority. A set of 'applied' natural sciences – including irrigation technology, watershed management, and public health topics included 19 suggestions.

Technical Skill Training (19% of the total)

While there is obvious overlap with the 'applied' and 'interdisciplinary' natural sciences listed above, we grouped 108 responses in a 'technical skills training' category. About half of the suggestions in this category addressed the development of applied research and data analysis skills. For example, many respondents indicated that recent graduates needed to receive better training in applied research design, data collection, data management and data analysis skills. One respondent remarked that it's being able to "…see the forest, not the tree." Other comments mentioned the need to develop an ability to:

- "conduct experiments and write up results,"
- "understand and synthesize available data,"
- "critically evaluate data," or "discriminate important from unimportant information,"
- "make defensible estimates,"
- "critical thinking and analytic/reasoning skills"
- "make science applicable to decision-making"
- "ability to problem solve with limited information"
- "decision-making skills,"

At the same time, there were numerous general suggestions calling for more "basic technical skills" or "technical education, coursework, and knowledge." Some specific types of technical skills that were mentioned by significant groups of respondents as areas where graduate education could be improved include:

- GIS skills
- math and statistical skills
- practical water use knowledge
- water use measurement techniques

Real World Experience (11%)

A sizeable number of respondents felt that graduates of regional universities had insufficient real world experience to be effective in their water resource management roles. As such, there were many who wanted more "real world experiences" to be integrated into graduate training. These experiences range from hands-on skill building, practical field training and experience, and formal internships with public and private sector clients.

A flavor for the 64 comments in this section can be captured in the following quotes:

- "Ability to address real life concepts,"
- "Analysis of real world case studies,"
- "field experiences," "field classes," "hands-on experience"
- "practical experience" or "practical application of basic science skills,"
- "knowledge of agriculture, water use groups, utility industry,"
- "a desire to work in the field,"
- "field smarts," "field techniques,"
- "Internships," "partnerships," "professional work-related practical experiences," and "on-the-job experiences gained outside the classroom."

Non-Traditional Water Resource Manager Skills (46%)

Our results suggest that training in natural sciences disciplines, research and technical skills, and real world applied experiences are all areas where improvements can be made in regional graduate school programs. However, these topics are common parts of most undergraduate and graduate training programs and the suggestions reflect incremental refinements and modest curriculum design changes.

By contrast, roughly forty six percent of suggested educational program improvements identified topics that are not as commonly found in standard university training programs. These 'non-traditional' skills are broken into three broad categories: communication skills, social science training, and administrative or management skills.

Communication Skills (22%)

The largest non-traditional category, communication skills, was suggested by almost one-fourth of all respondents. In addition to basic verbal and written communication skills, it consists of various subcategories, such as teamwork, conflict management, and public education skills.

The largest subgroup in this category was "basic communication skills." This category included general suggestions for "better communication skills", as well as people whom specifically identified non-technical writing and public speaking as particular skills that were lacking in many recent graduates. The focus of most comments was to emphasize the need for water resource management staff to be able to communicate their work with their colleagues, policy-makers, key stakeholders, or the general public. One respondent's reply succinctly put it into words as "…being able to communicate at a range of technical levels, from a farmer in a field to a researcher at a university." A similar response was, "…to be able to communicate with both peers and academics, as well as with water users."

A related, though distinct, subcategory was public education. Suggestions in this subtopic were specifically geared toward techniques for disseminating information to broader audiences through public relations plans, as well as educating the public on technical issues related to water use, conservation, and management. A smaller subset of this section included the need for better training in techniques for 'stakeholder assessment' and 'public input' processes.

Two subtopics in this section emphasized the need for better teamwork and conflict management skills. The first reflects interpersonal skills necessary for working in multi-disciplinary teams and/or projects that require professional scientists to work closely with persons who have less formal training. The second involves learning techniques for managing public discussions or meetings on contentious topics. In both cases, it appears that some recent graduates have not been exposed to or trained in modern techniques for these types of group processes.

Social Science Training (16%)

The category social science training taps into water law and policy in addition to general social science, business and economic dimensions, and city and regional planning.

The largest component of this subtopic emphasized training in water law and policy. The suggestion was frequently made that technically trained graduates of regional universities do not often have a sophisticated understanding of the legal issues surrounding water resource management in the west. Similarly, they have little understanding of the perspectives of various competing water user groups, and the sensitive cultural and political aspects of making water resource allocation decisions. A handful of comments also identified parallel issues with respect to the legal and social context of water quality regulations and programs.

Some illustrative quotes on these topics include:

- "Introductory water law course," "water law and water rights," "Legal knowledge,"
- "Indian water law,"
- "Ability to understand the effects of politics in water management,"
- "Appreciation for policy and regulatory development," "Understanding government structures,"
- "Broad-based understanding of current laws, standards, and regulations,"
- "Clean Water Act information," "Endangered Species Act,"

Other social science training that was felt to be lacking included the ability to "…understand the big picture", or the "unique constellation of science, politics, and public policy," in applied water resource management. More specific suggestions illustrated training programs that enhanced student's understanding of the following topics:

- "The role of Indian tribes in water resource management,"
  "The social dynamics and cultural sensitivity of water use in the west,"
- "Knowledge of the social, legal, and historic aspects of the human-water interface,"
- "Training in the socioeconomic aspects of working with water resources,"
- "Business and economic aspects of water resource management,"

Administrative and Management Skills (5%)

A final set of suggestions emphasized the need for some graduates to have better administrative or management skills, comprising roughly five percent of the total. The main examples included:

- Public administration
- Project management and project administration
- Financial skills and fiscal management
- Management skills (personnel, finances, construction and facilities)
- Organizational skills (including multi-tasking)

Education Needs by State

A final analysis of the educational needs of INRA-region university graduates disaggregated the responses by state. The results are shown in Table 2.3.3 below.

Table 2.3.3: Perceived Education or Training Needs by State

Type of Education Need	AK	ID	MT	UT	WA	Total
Traditional Skills						
Natural Science Training	**32.9**	**22.4**	**20.0**	**26.5**	**21.4**	**24.2**
Technical Skills	**17.1**	16.4	**23.5**	**20.4**	**17.9**	**18.5**
Real World Experience	**15.9**	8.2	11.8	11.5	11.9	11.0
Subtotal Traditional	*65.9*	*47.0*	*55.3*	*58.4*	*51.2*	*53.7*
Non-Traditional Skills						
Communication Skills	9.8	**26.5**	**32.9**	**19.5**	15.5	**22.1**
Social Science Training	13.4	**17.4**	7.1	14.2	**23.8**	15.6
Administration and Management	8.5	5.5	2.4	2.7	3.6	4.6
Miscellaneous	2.4	3.7	2.4	5.3	6.0	3.9
Subtotal Nontraditional	*34.1*	*53.0*	*44.7*	*41.6*	*48.8*	*46.3*
Total	100.0	100.0	100.0	100.0	100.0	100.0

Top three needs for each state are noted with bold text.

The overall patterns did not vary dramatically by state, suggesting that the development of new educational programs or initiatives throughout the region might emphasize a similar set of issues. The main difference noted here is that water resource managers in Alaska were more focused on improving natural science training skills than in the other states. By contrast, respondents in Idaho and Washington had higher rates of concern about the adequacy of training in the social sciences, especially water law and policy issues.

2.4 PARTNERS AND INFORMATION SOURCES

Overview

Respondents also were asked to think of the kinds of water resource management work that they had done over the previous year and to name the three sources of information they used most frequently in their work. A total of 442 responses were received, which were organized into eight major categories.

The respondents also were asked to report the three partners, agencies, groups or stakeholders with whom they had interacted most frequently during the same period when working on water resource management issues. A total of 450 responses were received, which were organized into five major categories.

Information Sources

As Table 2.4.1 shows, nearly half of the kinds of information sources cited by respondents across all of the states were categorized as public officials/staff personnel (47%), followed by double-digit proportions of responses indicating published data sources (nearly 15%), literature/publications/reports (13%), and Internet sources (11%). Roughly 8 percent of respondents cited groups and associations as major sources of information, while less than three percent cited meetings, conferences, legal advisors, or the general public.

The results suggest that applied water resource decision-makers and managers rely on personal contacts in state or federal agencies as sources of basic information more frequently than on published data sources, peer-reviewed publications, or the internet. This suggests that senior agency staff (as were more likely to show up in our interview samples) rely heavily on individuals to serve as a conduit for scientific data and information regarding water resource management decisions. For university scientists seeking to get existing scientific findings into the hands of senior managers, it is worth devoting time to figure out the appropriate people working at different levels who might be important parts of the information chain.

Table 2.4.1: Most Frequently Mentioned Information Sources

Type of Information Source	Frequency	Valid Percent
Public Officials, Staff, Personnel	208	47.1
Published Data Sources	64	14.5
Literature, Publications, and Reports	57	12.9
Internet Sources	49	11.1
Groups and Associations	35	7.9
Meetings, Conferences, Forums	12	2.7
General Public, Local Communities	9	2.0
Legal Sources	8	1.8
Total	442	100

An analysis by state (Table 2.4.2) indicates that the most important information sources for respondents across all states were public officials and agency personnel (between 42 and 52 percent). Published data sources were reported as another important source of information in Montana (27%) and Utah (20%). Literature (including reports, journals, and books) was least likely to be used in Utah (9%) and Washington (9%), and most frequently cited in Alaska (18%). The use of the internet was most common in Idaho (15%) and least common in Montana (4%). Interestingly relatively few people in any state listed the general public or local communities as an important source of information about water resources.

Table 2.4.2. Percentages of Most Frequently Mentioned Information Sources, by State.

	Percent by State					
Type of Information Source	AK	ID	MT	UT	WA	Total
Public officials, staff, personnel	49.4	47.1	49.4	42.2	51.6	47.1
Published data sources	10.4	6.9	26.6	20.0	3.1	14.5
Literature, Publications, and Reports	18.2	16.1	13.9	8.9	9.4	12.9
Internet sources	13.0	14.9	3.8	11.9	10.9	11.1
Groups and Associations	6.5	6.9	2.5	8.1	17.2	7.9
Meetings, conferences, forums	0.0	6.9	1.3	2.2	3.1	2.7
General Public, Local Communities	2.6	1.1	2.5	1.5	3.1	2.0
Legal sources	0.0	0.0	0.0	5.2	1.6	1.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

Important Partners

The vast majority of partners cited by respondents across all of the states were government agencies and their staff, with over seventy percent of responses (Table 2.4.3). The remaining responses were mostly divided among three groups: quasi-governmental organizations (mainly water districts and watershed groups), private sector actors (irrigators associations, landowners, and consultants) and non profit groups (environmental groups, professional associations, etc.). Given that most of our respondents were public officials, it is perhaps not surprising that they would consult with one another on water issues. However, the relatively low frequency of regular working partners outside of the state or federal agencies might lead to a degree of insularity and prevent water resource managers from regular contact with stakeholders and/or the university research community.

Table 2.4.3. Most Frequently Mentioned Partners

Type of Partner	Frequency	Valid Percent
Federal Agencies	131	29.1
State Agencies	145	32.2
Local Governments	26	5.8
Tribal Governments	13	2.9
(All Government Agencies)	*318*	*70.7*
Conservancy Districts, Water Boards	39	8.7
Non-Governmental Organizations	31	6.9
Private Sector Actors	43	9.6
Universities	17	3.8
Other	2	0.4
Total	450	100.0

Interestingly, the most frequently mentioned kinds of partners varied noticeably among the states (see Table 2.4.4). Water managers in Utah, for example, were much less likely to report public agency officials as important partners in their work. Instead, they interacted more frequently with private sector actors, non-governmental groups, and quasi-public water districts and boards. By contrast, nearly all partners reported in Alaska (83%) were agencies/public officials, with six percent linking with universities and five percent interacting with NGOs.

Table 2.4.4. Percentages of Most Frequently Mentioned Partners, by State.

	Percent by State					
Type of Partner	AK	ID	MT	UT	WA	Total
Federal Agencies	33.7	32.4	36.8	13.8	23.8	29.1
State Agencies	37.3	33.1	39.5	18.5	29.8	32.2
Local Governments	6.0	3.5	3.9	9.2	8.3	5.8
Tribal Governments	6.0	2.1	0.0	1.5	4.8	2.9
(All Government Agencies)	83.1	72.5	80.3	44.6	66.7	70.7
Conservancy Districts, Water Boards	3.6	6.3	10.5	18.5	8.3	8.7
Non-Governmental Organizations	4.8	4.9	1.3	13.8	11.9	6.9
Private Sector Actors	2.4	11.3	6.6	16.9	10.7	9.6
Universities	6.0	4.9	1.3	3.1	2.4	3.8
Other	0.0	0.0	0.0	3.1	0.0	0.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

In Montana, the vast majority of the kinds of partners reported (80%) were agencies/public officials as well, with over 10 percent reporting water conservancy districts and 7 percent listing private sector actors. Idaho's respondents reported somewhat similar proportions as Montana's for agencies/public officials and private/quasi-public groups, but nearly double the proportions found for other states in terms of Idaho's mentions of irrigators/water companies (over 4%) and of the general public (nearly 3%).

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 OVERVIEW

As outlined above, this needs assessment project was designed to identify high priority topics for future INRA research and to inform the design of potential new educational programs. The overriding objective was to document the perspectives of policymakers, elected officials, water users, and others with a stake in the Western water debates.

Because the vast majority of water scholars and research scientists tend to work in academic settings, it can be a challenge to direct university training programs and academic scientific research projects toward the needs of applied water resource management decision-making at the local, state and federal levels. Like anyone, university faculty members and graduate students respond to the incentives and rewards provided by their departments, institutions, and professional organizations. The imperatives in this system tend to reward the pursuit of cutting edge and basic scientific questions, the development of core theories and conceptual models, and the publication of scientifically rigorous, peer-reviewed journal articles. The success of the American university scientific model is well documented and highly regarded across the world.

While this system of university scientific research has been critical to the continued development of our understanding of hydrologic processes and trends in the West, the results have not always been readily available or easily applied to the practical problems faced by water resource managers in the region. The Inland Northwest Research Alliance Water Resources Research Consortium was created in part to help bridge this gap by taking several important steps:

1) To encourage the sharing of the latest scientific findings with the applied water management community,
2) To encourage the development of new research programs designed explicitly to help answer critical questions and fill information gaps that prevent the effective and efficient management of water resources, and
3) To develop innovative educational initiatives for both undergraduate and graduate degree programs to help train future professional water resource managers and scientists.

The results presented above provide some general guidance and specific suggestions for areas that might be fruitful targets for future INRA research and educational initiatives. These suggestions reflect the expert judgment of the needs assessment team and are based on both the statistical summaries presented above as well as a comprehensive evaluation of the detailed interview narrative transcripts.

However, they are intended to stimulate further conversation and exploration, and should be tempered by the expertise, experience, and perspectives of the water research scientific community and the public and private actors who are making day-to-day decisions regarding the allocation and management of water in the American West.

Importantly, recommendations for future INRA water resources research and educational initiatives will need to balance the views and priorities of applied water managers with the important core scientific and training missions of the eight INRA universities.

3.2 CHALLENGES FACING WATER RESOURCE MANAGERS

When asked what obstacles and challenges they face in their current jobs, water resource managers were equally likely to cite natural science and social science topics. The natural science challenges reflected a diverse set of topics (ranging from water quantity, water quality, climate and drought, to other natural systems concerns). Social science topics included challenges linked with water rights law and policy, inadequate funding resources, and pressures associated with rapid population growth and change. In many ways, these challenges overlap and intersect, posing future challenges, necessitating further scrutiny.

While most managers identified limitations in the available scientific research base as key challenges, they also discussed the importance of improving data management systems and the challenges associated with maintaining an effective water data collection and analysis infrastructure. Not surprisingly, for many respondents, improving existing types of water data and working to standardize and disseminate existing information are as important as developing new scientific models or understandings.

Some state-based differences were notable. Respondents in Montana, Idaho and Washington identified had relatively balanced sets of challenges (natural systems, human dimensions, management and data). In contrast, though human dimensions challenges were the largest category in both Utah and Alaska, the rank ordering for the other three categories differed. These similarities and differences should be explored in more depth in future studies.

3.3 RESEARCH NEEDS AND PRIORITIES

Overall, while basic natural science topics were not uncommon in our interviews, the dominant research priorities focused on more applied water science questions, including efforts to develop a better water monitoring and data collection infrastructure and the development of scientific models that can help explain impacts of human behaviors on hydrologic systems.

In the first instance, it is clear that there has been inadequate investment in the development and maintenance of water resource monitoring systems by state and federal governments. Many respondents felt that they had to make decisions in the context of inadequate basic data about local water use, water supply, and water quality conditions. Specific criticisms were lodged at the problems of inconsistent measurement techniques and schedules, uncoordinated data storage systems, a lack of locally specific data, irregular data collection schedules, and long time lags between data collection and the availability of the information.

Second, while many respondents did identify conventional basic natural scientific research as a priority, our interviews suggested a relatively high level of satisfaction with the existing natural science research programs in regional universities. When pressed to identify areas where additional research should be conducted, a large fraction of respondents emphasized that the greatest gap was in the intersections of traditional scientific disciplines – including interdisciplinary, cross-disciplinary, and systems-level research. In some cases, these intersections involve various natural science fields; in others, they involve integrating social science perspectives and methods into studies of natural science phenomena.

The results suggest that many of the natural science puzzles – such as better information about the interactions between surface and groundwater systems – are most important to decision-makers *in the context of their applied water management problems*. Most of these problems are linked directly to social, economic, and land use changes associated with rapid population growth and the transfer of water from traditional agricultural sectors to urban or rural residential and commercial uses. Our interviews suggest that there is still a great deal that is not understood about human-driven changes taking place on the landscape and their associated effects on water use, water demand, and water quality in this region. Many of the research priorities summarized under the 'Human Dimensions of Water' label above fit into this category.

A significant number of our interviewees had responsibilities to educate the public about water quantity and quality issues. In most cases, these people felt that they would benefit from a deeper understanding of the techniques and tools available for communicating with the public. These tools might involve strategies for understanding the goals and experiences of diverse stakeholders, as well as efforts to change the behaviors of a broader mass of citizens.

A final insight from the research needs inventory is that there is considerable room for improving the quality and quantity of information that can be exchanged between the academic scientific community and the water resource managers included in our interviews. While not strictly a research priority, the interviews suggest that institutional barriers and time constraints have limited the potential for interaction and communication across these two social fields.

In sum, understanding water resources and issues requires an approach that acknowledges generalities as well as contextual differences that convey past, present, and future challenges for water professionals and practitioners. For instance, physical features of specific locations (such as geography, climate, and size) are integral to understating natural resources and their availability and spatial distribution. However, it is also important to understand how other issues intersect with these physical features, including population changes, pressures for economic development, and various legal influences linked with supply and demand. Indeed, a complex chain of mutually reinforcing issues, actors, and agencies can be identified, as can interrelations that posit unique causal pathways.

3.4 EDUCATION NEEDS

Interview participants were asked to evaluate whether the training received by students in INRA universities is adequate to prepare them for work in typical non-academic settings. Overall, most respondents felt that the eight INRA institutions were providing an excellent scientific and technical foundation for applied water resource management in this region. However, a significant number of respondents identified areas where additional training or education might be useful.

Among natural science topics, the main emphases for improved education reflected a desire for (a) more interdisciplinary or systems-level integrated science training, and (b) more applied and hands-on experiences that make basic science knowledge more relevant for addressing actual water resource management problems and challenges. At the same time, there was a call for more technical skills in research design, data collection and analysis, statistics, and GIS.

One of the most striking patterns in the interviews was the strong emphasis on the need for training in more 'non-traditional' topics. Specifically, the lack of adequate communication skills among natural science program graduates is seen as a serious problem by a wide range of interviewees. Similarly, there is a desire to expose science and engineering students to the complexities of water law and policy debates in the West before they arrive on the job market.

3.5 CORE RECOMMENDATIONS

As noted above, from water resource managers and stakeholders in this region provide a number of important suggestions that could be used to direct future INRA research and education funding. The recommendations outlined below are based solely on the feedback from our interviews. It is expected that the prioritization of new initiatives by INRA leaders will necessarily include consideration of other issues (e.g., scientific value, institutional capacity, the appropriate roles for universities, etc.). However, to the extent that the INRA effort is designed to encourage greater relevance of university research and training for regional water resource management, the suggestions below provide a useful roadmap for future work.

RESEARCH PRIORITIES

Some core recommendations for INRA research priorities based on the needs assessment include the following broad topics:

- **Encourage investments in the water monitoring and data collection infrastructure.** While this may or may not include a role for INRA university institutions, there is clearly a perceived need among water resource managers and field-staff working on water issues for better water resource monitoring systems.
- **Encourage natural science research** on water quantity, water quality, and climate/drought issues.
- **Encourage applied scientific research** designed to illuminate the dynamics of water quantity and quality in the context of human-impacted environments.
- **Encourage human dimensions research** to help predict the impacts of future population growth, land use changes (such as the shift from agriculture to residential uses), and different water policies on patterns of consumption of and demand for water resources.

A much more detailed list of more specific research priorities were summarized above, though many of the substantive suggestions fit into these four categories.

Changes in the research priorities on INRA university campuses will be complicated by the fact that all universities are organized around traditional disciplines and there are strong career disincentives for students or faculty to engage in interdisciplinary or highly applied research. Seed monies and targeted research initiatives to attract this type of innovative research might well be required to fill some of the information gaps identified in our interviews. Similarly, investments in better communication between university and non-university actors is required to ensure that state-of-the-art scientific knowledge is made readily available to decision-makers (and that the problems faced by decision makers are communicated to public research scientists).

EDUCATION PRIORITIES

The key informants in our study identified a set of core educational needs that could be addressed by future INRA-sponsored initiatives. Areas where supplemental training could make a difference include:

- **More interdisciplinary courses**
- **More systems-level or integrated water science courses**
- **More real world experience**
- **Better communication skills**
- **More awareness of social, economic and political dimensions of water problems**

While it is easy to identify areas where new educational programs should be developed, it does not follow that universities are well positioned (or even well advised) to undertake a dramatic reshuffling of their educational missions. For instance, it is important to recognize that many graduate programs are designed to train future academic scientists/professors. Similarly, many graduates of these programs may go on to different types of careers in the public or private sector. In each instance, broadening course requirements or changing training approaches may have inadvertent impacts on other groups of students.

It is encouraging that many INRA campuses are engaged n conversations about creating integrated water science degree programs or other interdisciplinary training programs that encourage or require students to build a broader understanding of the various water-related sciences as part of their training. There are also efforts to increase opportunities for students to get hands-on, real-world experiences through internships and partnerships with public and private organizations. It would seem appropriate to target some of INRA's future resources to support these initiatives.

APPENDIX I: Sampling Protocol

SUGGESTED SAMPLING METHODOLOGY

Needs Assessment Interviews of
Elected Officials, Policy Makers and Major Water Stakeholders

Dr. Charles Harris and Dr. Douglas Jackson-Smith
July 12, 2006 version

Purposes of Fieldwork:

1. **Identify research and information needs** to address regional problems of drought, water shortages and water supply in the face of regional growth and changing demands for water; assess current situations and patterns of change in water availability, demand and use.

2. Conduct focused interviews to **elicit specific researchable topics** towards which INRA Water Resources Consortium research efforts can be directed

Fieldwork Procedures

1. **Conduct a review of literature** on water resource issues for each state and recent water management activities -- to begin identifying key contacts, current water management needs, geographic areas and priorities.

2. **Construct a master sampling frame** of potential key informants. This sampling frame list will be used to select a subset of individuals for the fieldwork interviews. This involves identifying diverse individuals who are knowledgeable about water issues and/or actively involved in water resource management in this region.

    a. These will include knowledgeable agency or organizational representatives (analysts, staff, and decision-makers) as well as key stakeholders, including elected officials and representatives of relevant organizations. Example 'categories' that were outlined in our original proposal include:
    - Federal Agencies
        - Bureau of Reclamation
        - Fish and Wildlife Service
        - Others?
    - State Government
        - Water Resources Agencies
            - State engineers and water rights staff
            - Water planning agencies
            - Water quality agencies
        - State Agriculture Department staff
        - State Economic Development staff

- Regional Governments
    - Water conservancy districts
    -
- County Governments
    - Association of counties
    - County commissioners and executives
    - County water advisory boards
    - County planners
- City Governments
    - Association of cities
    - City mayors and council members
    - City planners, water departments, environmental departments
- Tribal Governments
- Non Governmental Organizations and Water User Groups
    - REGIONAL?
        - Hydropower utilities (e.g., Pacificorp)
        - Environmental and Wildlife Organizations
            - Audubon/birders, Ducks Unlimited, Salmon groups,
        - Recreation Organizations
            - River rafters, lake boaters, etc.
    - STATE?
        - Associations of water users (irrigation/canal groups)
        - Agricultural organizations (Farm Bureau, Others)
    - LOCAL?
        - Local irrigation districts and canal companies
        - Local Chambers of Commerce
    - Others?

b. Begin by identifying key contacts in important statewide and regional agencies and organizations – Agency, NGO, etc.
    i. Use university colleagues and other key individuals to identify who are important actors/players within each category
    ii. Supplement these lists with internet searches of agency/organization website listings for staff and administrators
    iii. Use snowball sampling ---
        1. Begin by contacting a person high up in an organization or agency and ask them to identify the individuals in their organization who are the best resource people for our purposes
        2. As we conduct interviews, be sure to conclude each interview by asking the informant if they can think of other individuals who would be good to contact

c. For some categories, we will need to identify a subset of the total universe of possible people (or places) that meet our criteria. The goal would be to have a sample that covers the diversity or range of water resource management challenges within each state.
    i. Examples of situations where we will need to purposively sample include:
        1. Regional water conservancy districts
        2. County governments
        3. City governments
        4. Local irrigation companies or water user groups
    ii. In cases where there are many potential people or places that qualify, we will select a subset of places/people that maximize the following things:
        1. Ensure coverage of the full diversity of current, recent or potential water supply/demand and water management issues in each state; this means picking at least one place that is a good representative of each type of issue
        2. Ensure coverage of diverse geographic regions (represent the full diversity of current recent or potential water supply/demand and water management issues
        3. Include examples of places where there are well-known water-resource policy debates or water resource data needs, or that are engaged in significant water management efforts (e.g., comprehensive basin planning, conservation programs, etc.); these areas would include cities and counties, as well as larger watersheds and basins.
        4. Where possible, consider balancing the selected places to ensure that we learn about the different data / research needs of places that are:
            a. Urban vs. rural interests and problems
            b. Agricultural vs. non-agricultural interests
            c. Government vs. non-governmental perspectives
            d. Tribal vs. non-Tribal interests and problems
            e. Economic vs. environmental perspectives

3. **Prioritize which key informants to contact first**. Once we have a master frame of potential informants in each state, we should prioritize specific names to use in a first round of interviews. Based on the results of this first round of interviews, we can then strategically pick a second round of contacts to complement those already completed.

APPENDIX II: Key Informant Interview Contact Protocol

INTERVIEW and ANALYSIS METHODOLOGY

Needs Assessment Interviews of
Elected Officials, Policy Makers and Major Water Stakeholders

Douglas Jackson-Smith and Chuck Harris
July 14, 2006 version

ARRANGING INTERVIEWS

Once you have a set of names selected for interviews, you will need to contact these potential informants and arrange a time to conduct the interview. We suggest a progressive contact approach that might include all or some of the following steps:

1. Send a pre-contact letter

   Before each interview, it is desirable that every respondent know a certain amount about the goals of our project, be made aware of any risks or benefits associated with the research, and have a chance to think about the specific questions we intend to ask. As such, it makes sense to try to send every potential respondent a precontact letter and a copy of the "Informed Consent Information Sheet" that you developed for your particular state/institution.

   A copy of a draft cover letter and the Utah version of the informed consent sheet are appended below. Note that the cover letter includes examples of the key questions we might ask.

2. Contact key informant by telephone, arrange the interview

   The goal of the telephone contact is to (a) answer any questions the informant might have about the study, and (b) make an appointment for the actual interview. Tell them that interviews should take between 30 minutes to an hour (we may change this estimate after some fieldwork experience…!)

   Depending on your situation ($$, travel logistics, etc.) you might arrange any of three kinds of interviews:
   - individual face to face interview
   - individual telephone interview
   - group interviews

   It may even be best for the respondent to conduct the interview during your initial phone contact, and you should be prepared to accommodate them if it makes sense.

CONDUCTING INTERVIEWS

Each interview situation might be a little different, but the basic steps involved will include several steps. However, there are general principles of effective interviewing that might be worth reviewing. These include:

THE INTERVIEWER'S REPERTOIRE

- preparation = key (know your instrument inside and out)
- have answers prepared to common questions (why are we doing this…?)
- think about probes ahead of time
- strategies for eliciting details (when you get initial short/shallow answers)
    - the anticipation pause (wait 10 seconds to create mildly uncomfortable silence)
    - the simple probe (say "…go on"...) -- echoing (convey you are hearing what they say)
    - the assertive probe (say "can you say more about that?")

TEN COMMANDMENTS OF INTERVIEWING

1. Never begin an interview cold (warm up with small talk)
2. Remember your purpose (keep your eyes on the prize, stay on track)
3. Present a natural front
4. Demonstrate aware hearing (sit up, look at them, respond to their comments with appropriate body language or verbal cues)
5. Think about appearance
6. Interview in a comfortable place (quiet, confidential, uninterrupted)
7. Don't be satisfied with monosyllabic answers (see strategies above)
8. Be respectful
9. Practice, practice, practice
10. Be cordial and appreciative

SPECIFIC GUIDELINES

1. Personal interviews (face to face with an individual)
    - Confirm appointment by phone, email or mailed letter (if possible)
    - Record the interview (with the permission of the informant) for future reference and analysis
    - Write rough notes during the interview
    - Synthesize the interview notes as soon as possible (using a word processor) in the formats suggested below.

2. Telephone interviews (with an individual)
    - Confirm appointment by phone, email or mailed letter (if possible)
    - Record the interview (with the permission of the informant) for future reference and analysis – you may need special equipment to record a telephone call
    - Write notes during the interview
    - Synthesize the interview notes as soon as possible (using a word processor) in the formats suggested below.

3. GROUP interviews
    - BACKGROUND and WARNINGS
        - Only use these if there are significant advantages (in terms of travel logistics, scheduling people, or unique opportunities to get access to multiple people at a pre-arranged event).
        - Note that formal 'focus group' methodology requires that the participants be relatively homogenous or similar in most important respects. The point of a focus group is to encourage informants to feed off of one another's comments, and to gain greater depth in their answers. To be successful, it helps to
            - have folks who share certain types of experience (most likely relative to water resource management), AND
            - have a group that does not include people who have different status or rank relative to one another – specifically avoid situations where some of the participants might be reluctant to speak openly because of the presence of another particular person in the room
    - LOGISTICS
        - Confirm date/time of the meeting with all participants in advance (if possible)
        - Review the confidentiality agreements and ground rules for the group interview before you begin
            - Note that you will be the moderator and notetaker
            - Tell them to be respectful of one another
            - encourage everyone to participate equally
        - Record the session (if everyone gives permission) for future reference
        - Write up your notes in a way that allows you to distinguish between different individual participants in the group (with particular attention to the individuals' key attributes or job/role as it might affect our interpretation of their feedback)
        - Synthesize your notes and type up using one of two forms
            - A set of separate individual interview summaries, or
            - An amalgamated 'group' summary

EXAMPLE PRE-CONTACT COVER LETTER

DATE

XXXXXXX
Address
City, ST Zip

Dear XXXXXX,

You have been recommended (by _____) as someone able to offer some insights into water resource management in this region. I am writing to ask if you are willing to be interviewed as part of a study of funded by the U.S. Department of Energy that seeks to **identify high priority data and information needs for water resource management** in this area. Researchers at 5 public universities in Alaska, Idaho, Montana, Utah and Washington are collaborating on this study. The results will help direct future research dollars to high priority areas.

We particularly are interested in your views on the challenges faced by those trying to manage water resources during periods of drought, climate volatility, population growth, and economic transformation, and your suggestions for what kinds of new information or data could improve management of water resources in this region.

I will be contacting you by phone in the next week to arrange a time for an interview.

To help you prepare for the interview, we thought it would be helpful if you knew some of the questions that we will be asking. These include:

- What are the greatest issues or challenges for water resource management that you face?
- What kinds of data or information do you regularly use to address these issues? How adequate is the existing data or information?
- What new kinds of data or information would be most helpful as you address this issue?
- Thinking back over the last 5 years, can you think of any specific instances in which you did not have the data or information you needed to address this issue?
- Do you feel that people graduating from regional universities have the right mix of education and skills to work well in this area?
- What specific types of knowledge, training, or skills do recent graduates lack?

I want to emphasize that **participation in this study is voluntar**y and if you agree to participate in this study, your comments and opinions will be kept **strictly confidential**. You are able to stop the interview at any time or refuse to answer any questions that might make you uncomfortable. No names or information that identifies study participants will be included in any findings reported from this project without the expressed permission of the participant.

Again, I look forward to contacting you by phone in the next week to see if we can arrange a time for an interview.

Sincerely, XXXXXXXXXXXX,

INFORMED CONSENT STATEMENT

Water Research Needs Assessment

Inland Northwest Research Alliance Water Research Consortium

Overview of the Study

This project is being conducted by researchers at 5 Western Universities: Utah State University, the University of Idaho, Washington State University, the University of Alaska-Fairbanks, and the Montana State University. The project is sponsored by the Inland Northwest Research Alliance (INRA) -- a consortium of 8 universities in the region who received funding from the US Department of Energy to initiate a research and educational program related to drought and water resource management in this 'inland northwest' region. Over the next few years, the INRA Water Research Consortium will perform research related to the complex interactions between climate change, watershed and landscape changes, water supply and quality; ecosystems, and humans.

The current project is designed to identify high priority topics for future INRA research. Specifically, we plan to consult with policymakers, elected officials, water users, and others with a stake in the Western water debates to identify their most pressing data and information needs.

How were you chosen?

You have been recommended as someone able to offer some insights into water policy issues in this region, with a focus on the challenges faced by those trying to manage water resources during periods of drought, climate volatility, population growth, and economic transformation in the American West. We hope to interview 30-40 people per state for this project.

What kinds of information do we want to gather?

We will gather information about the important water resource management issues in your area. Of particular interest will be your ideas regarding the adequacy of existing data and information resources, and your recommendations for high priority areas toward which future water-related research might be directed. We are also interested in learning about the job skills and competencies that might be required of future graduates from our institutions seeking employment in the water management area.

Information will be gathered in personal and group interview settings using a semi-structured interview schedule. Interviews may take from 30-120 minutes.

Is your participation required?

Your participation in this study is entirely voluntary. Specifically, you have the right to terminate participation for any reason at any time without penalty. In addition, you have the right to refuse to provide specific information or answer questions that you are not comfortable sharing with us.

Possible risks and benefits associated with the study

We believe there are very minimal risks associated with participation in this project. None of the topics listed should be sensitive, and efforts will be made to respect your privacy.

Throughout our work, we will take steps to ensure that your identity is kept confidential. . Respondent answers will be recorded using written notes and (with permission) audiotape recordings. The audiotapes will used to verify any quotations used from the interviews, and facilitate possible graduate thesis or dissertation research on water research needs in this region (under the supervision of one of the principal investigators). Individual respondents will be tracked using ID numbers, rather than names or other identifying information. If we do wish to use direct quotes from your responses, **we will contact you for permission before using your name or identity in any of our reporting of the results**. All of our original interview notes and tapes will be will be stored in a secure manner and will not be shared with any other researchers, organizations, or agencies. To further protect respondents, we will destroy the list of participant IDs within 1 year, and the audiotapes within 3 years.

The benefits of this project could be significant. The information you provide will help us determine how to target future research and educational programs to be most useful to water managers, officials, and water user groups in this region. We strongly believe that the voices of potential data users and stakeholders should shape the prioritization of future research efforts and the design of innovative educational programs. We hope that our efforts will lead to the development of actual resources that can assist your own work on water issues.

A summary of the findings from this study will be provided to you at the conclusion of the project if you would like.

Contacting the researchers

If you have any questions or concerns about this study at any time, we encourage you to contact the scientists who are leading this project. The lead investigator in Utah is:

Utah State University
Dr. Douglas Jackson-Smith
ph: (435) 797-0582
email: douglasj@hass.usu.edu

If you wish to directly contact the Utah State University Institutional Review Board regarding this project, you should call or write to: True Rubal at (435) 797-1821, 1450 Old Main Hill, Logan, UT 84322, or by email at true.rubal@usu.edu.

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By signing below, the lead researchers agree to abide by the terms of this document. Your participation in this interview will be treated as evidence that you have read the above information and are willing to participate in this study under these terms.

____

Dr. Douglas Jackson-Smith

APPENDIX III: Key Informant Interview Instrument

INRA Water Research Consortium
Needs Assessment Project

KEY INFORMANT INTERVIEW SCHEDULE

FINAL VERSION

Information about our project to be read (or summarized) to the respondent before each interview

This project is being conducted for the Inland Northwest Research Alliance – a Consortium of 8 public universities in Alaska, Idaho, Montana, Utah, and Washington.

The group was created by Congress to conduct coordinated multidisciplinary research on water resource management challenges facing this region, with particular interest in the impacts and management of periodic droughts.

A critical component of this project is a "Research and Information Needs Assessment."

This Needs Assessment involves detailed conversations with policy makers, elected officials and diverse water user groups to determine the information and data needs that future INRA research could address.

The results of our assessment will help determine priorities for the allocation of future research dollars and identify specific data or information needed to improve water resource management in this region.

We will also use your feedback to help design an multi-institutional graduate training program at the INRA universities that will focus on integrated water sciences.

Before we start, do you have any questions about this project?

2. <u>Background and Context</u>

a. **What is your position or official job title?**

b. **How would you describe your own work or activities with respect to water resource management** in (Alaska, *Idaho, Montana, Utah, Washington*)

c. **How long have you worked in this capacity?**

d. **How did you get into this type of work?**

e. **What types of formal and informal training have you had that has prepared you for your work with water resource issues?** *(if they don't volunteer it, also ask about their highest level of formal education and specialization)*

f. **Are you originally from this area?** (If not,) how long have you lived here?

NOTE: if you are working in <u>a group interview situation</u>, you might simplify this first page by asking everyone present to go once around the group and introduce themselves by talking specifically about:

- *who they are*
- *what they do in their work*
- *what kinds of background, training or experience they have had in this area*

In these settings, you might also back off worrying about the individual demographic information in the summary templates.

When you are addressing a <u>larger meeting or group</u> (not in a formal interview context), you might limit this to asking people to briefly introduce themselves and explain what they do in their work. The core questions you might ask a large (non-interview) group are highlighted in yellow on the next two pages.

3. Water Management Challenges and Information Needs

a. What are the 3 greatest issues or challenges for water resource management that you face in your work?

1) _____

2) _____

3) _____

b. Probe for each type of issue:

- **i. Lets focus on (*Issue X*). In what ways is this issue challenging?**
- **ii. How has this issue changed in recent years?**
- **iii. What kinds or information is most critical to your ability to address this issue?**
- **iv. What are the most important sources of information you use to address this issue?** *(Be sure to get as specific as possible about the type of information and the source of the information).*
- **v. How adequate is the existing information?**
- **vi. In what ways could this information be made more useful?**
- **vii. What new kinds of information would be most helpful to you as you address this issue?**

c. **Thinking back over the last 5 years, can you think of any specific instances in which you did not have the information you needed to make good decisions about water resource management?** *If you can think of several, pick the most important or most common type of situation.*

- **i. What was the problem you were trying to address?**
- **ii. What kinds of information did you need?**
- **iii. Where did you try to find information?**
- **iv. What did you find?**
- **v. What kinds of information were you unable to find?**
- **vi. Do you think this type of information exists? If so, where?**

d. *(If drought has not been discussed by this point – ask:)* **Thinking specifically about periods of drought – what are some of the most notable information gaps that affect your ability to make informed drought management decisions?**

e. *After reviewing all the various types of information needs mentioned by the respondent, ask….***Of all the specific types of information gaps that you've mentioned, could you rank each one as a potential focus for future university research, with "1" being the <u>highest priority</u> area?** *(for large groups:* **what are the top priorities for future university research on water resource topics?**

f. **Before I change topics, are there any other suggestions or comments that you would like to share regarding areas where better science or information sharing could improve water resource management in this area?**

4. <u>Education Priorities</u>

Preamble Aside from generating research that can meet the needs of water resource managers in this region, the INRA University Consortium plans to develop a training program for graduate students in "integrated water sciences." I now want to ask you a few questions that might help us design this training program.

a. What do you feel are the most important skills someone in your position should have?

b. If you were to do it over, what training or skills do you wish you had received while in college/graduate school?

c. Are there any water resource management topics on which you would like to receive updated training or knowledge?

d. How successful has your agency/organization been at identifying & hiring qualified people with the skills needed to work on water resource issues?

e. Do you feel that people graduating from regional universities have the right mix of education and skills to work well in this area?

f. What are the specific types of knowledge, training, or skills that are most lacking among recent graduates?

g. Are there any other suggestions you might have for INRA universities regarding the training of water resource management professionals?

5. <u>Networking and Information Sources</u>

a. Think of the kinds of water resource management work that you have done over the last year. **What THREE sources of information did you use most frequently in your work**? *(Possible sources could be individual people, agencies/organizations, sources of specific data, journals/publications, websites, etc.)*

b. **During the same period, what THREE partners, agencies, groups or stakeholders did you interact with most frequently when working on water resource management issues?**

6. **FINALLY: can you think of one or more key individuals who might be a good person for us to talk with for this project?** *(If yes – get name & contact information)*

NAME:	Contact information
______________________________	____
______________________________	____
______________________________	____
______________________________	____
______________________________	____
______________________________	____

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I want to thank you for taking the time to provide feedback for our needs assessment project.

Do you have any questions you want to ask me before we finish?

Would you be interested in seeing the results of our study? (We expect to have a final report in the winter or early spring).

APPENDIX IV: Key Informant Interview Narrative Summary Template

Interview Summary Information: ID#: _____

INTERVIEW NARRATIVE (1-2 pgs)

- include description of interviewee and interview context
- include discussion of challenges
- include discussion of info gaps and research priorities
- include discussion of education needs
- include discussion of info sources and key partners
- include key quotations and any other relevant info

INTERVIEW SUMMARY:
Short sentences/bullets in each category; be as specific as possible
For group interviews, note areas of agreement and disagreement

- Respondent's Role/Job (or describe all individuals in group interview):
- Biggest Challenges
- Information Gaps (Any mentioned)
- Research Needs (Rank Ordered)
- Education Priorities
- Top Information Sources
- Top Partners/Collaborators/Stakeholders

INTERVIEW CODING

Check all that apply

Total interview time: _____minutes **Was recording made?** ☐ **yes** ☐ **no**

Comments on how interview went:

_____

_____

_____

Organization Type:

- ☐ Federal agency
- ☐ State agency/board
- ☐ County government/board
- ☐ City government/board
- ☐ Tribal government
- ☐ Nonprofit organization
- ☐ Private company
- ☐ Other: _____

Scale/Region of Work:

- ☐ Local/county
- ☐ Multi-county region
- ☐ Statewide
- ☐ Multi-state region
- ☐ Other: _____

INDIVIDUAL CHARACTERISTICS

(perhaps ignore for group interview settings)

Job Description:

- ☐ Elected official
- ☐ Administrator/Director
- ☐ Technical staff
- ☐ Outreach staff
- ☐ Member
- ☐ Other: _____

Highest Degree and Training

- ☐ < BS
- ☐ BS
- ☐ MS/MA/MPA
- ☐ PhD
- ☐ JD
- ☐ Other: _____

Discipline/Specialization (highest degree)

Describe: _____

Years experience working on WRM:

_____

Our own subjective assessment of respondent's WRM expertise

- ☐ Very knowledgeable about or experienced with water management issues
- ☐ Knowledgeable or experienced on water management issues
- ☐ Moderately knowledgeable or experienced on water management issues
- ☐ Slightly knowledgeable or experienced on water management issues
- ☐ Not knowledgeable or experienced on water management issues
- ☐ Other: _____

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