EFFICIENTLY TRANSLATING RESEARCH INTO PRACTICE: OKLAHOMA'S CONTRIBUTION THROUGH THE SOUTHERN CLIMATE IMPACTS PLANNING PROGRAM

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The University of Oklahoma hosts the Southern Climate Impacts Planning Program (SCIPP). SCIPP uses an applied research model emphasizing collaboration between academic and non-academic stakeholders. The goal is to conduct research that produces data and tools useful to practitioners for increasing resiliency for weather and climate extremes. Over 15 years, SCIPP has communicated research results that influence policy decisions and improve planning, mitigation, adaptation and response efforts. Engaging stakeholders and communicating usable research findings are often implementation challenges. We examine how knowledge management practices can strengthen SCIPP's collaborations and turn research results into action. SCIPP offers an example of how bridges are being built between academic research and practical applications to inform policy decisions and improve community resilience and preparedness practices. Documenting the results of SCIPP's applied research model can inform policymakers about how to structure collaborations in other policy arenas. Tightly aligning political intent and accountability expectations with engaged research processes will improve results from public funding and enhance Oklahoman's quality of life.

INTRODUCTION

In this paper, we analyze how knowledge management processes can increase the efficiency of research translation. Research into weather and climate extremes could function more like translational medical research. Adopting a multi-stage approach that integrates medical research findings and social science research results can more quickly move medical research discoveries into practical testing in real world settings. Translational research identifies barriers and facilitators to moving promising medical lab results into human testing (https://accelerate.ucsf.edu/about/clinical-and-translational). When successful, communication and implementation of best practices in disease prevention and treatment is faster. The result of this is that winning strategies are moved forward while strategies with a very low likelihood of success are "winnowed out" (Krutz 2005) and disappear from the research agenda.

Sharing research results is critical to this process. It can guide the choice of future research projects more likely to have enhanced practical applications. Scholars have examined how communication technology enables collaboration. Some researchers focus on Information and Communication Technologies (ICT) as a digital means of providing infrastructure that supports transparency and accessibility (Clark, Brudney, and Jang 2013). We focus on the human infrastructure necessary for communication and collaboration to translation promising practices for increasing resilience to and preparedness for weather and climate extremes. The utilization of knowledge management practices in public organizations is low (Ferguson, Burford, and Kennedy 2013). Scholars suggest that the complexity of inter-governmental relationships makes public organizations unsuitable to real knowledge management. However this assumption is insufficiently tested (Blackman et al. 2013).

To test this assumption, we analyze the Southern Climate Impacts Planning Program (SCIPP) to find out how the organization manages the knowledge its researchers create. When well managed, the organization can better communicate results to improve practice and

inform policy decisions. Our results may suggest how knowledge management practices could increase the translational efficiency of SCIPP. When this occurs, communities are better prepared to respond to weather and climate extremes. If successful in the climate science research arena, then research translation in other policy arenas might also become more efficient.

SCIPP'S ROLE IN CREATING RESILIENT COMMUNITIES

In 1999, NOAA's Climate Program Office (CPO) created ten Regional Integrated Science Assessments (RISA). Found throughout the nation, the RISAs were tasked with fostering collaboration between researchers and regional stakeholders, especially policymakers and practitioners. According to the 2003 national Climate Change Science Program (CCSP), successful collaboration was necessary to address societal challenges related to weather and climate extremes and implementation goals were written.

As one of 10 RISAs, SCIPP seeks to increase the resiliency and level of preparedness of the a six-state region in the south central U.S. (Oklahoma, Texas, Kansas, Louisiana, Tennessee, and Mississippi). SCIPP was selected for funding in 2008 because "According to the Federal Emergency Management Agency (FEMA), SCIPP states are among the most disaster declared in the United States. As of early 2013, all six SCIPP states were ranked within the top 15 most disaster declared states across the country, with four of those states being ranked in the top 10" (www.southernclimate.org). The impacts of weather and climate extremes in Oklahoma makes SCIPP an ideal case for our analysis.

SCIPP's mission is "to increase resiliency and preparedness for weather and climate extremes now and in the future across the south central United States." They accomplish this by:

1. Increasing the awareness of and preparedness for south central U.S. climate hazards for both present day and future climate conditions;

2. Actively engaging stakeholder groups to promote two-way knowledge transfer between climate scientists and decision makers;
3. Providing local, state, and regional decision makers with climate hazard data that are comprehensive, accurate, and easily accessible; and
4. Identifying new, critical areas of applied climate research for the south central U.S. as technologies, research, and knowledge evolves. (www.southernclimate.org)

SCIPP combines the expertise of climate scientists, meteorologists and geographers with the everyday experience-based knowledge of decision makers and planners. Research collaborations regularly include researchers, faculty and students housed at academic institutions and personnel from government, for-profit and non-profit organizations. Interactions in workshops, meetings, and one on one conversations communicate needed research and foster the transfer of research results and data tools to decision makers and practitioners. They also offer the opportunity for stakeholders to reveal their challenges, concerns, and needs for climate hazard information (www.southernclimate.org).

There are two kinds of stakeholders engaged in SCIPP's applied research model. The first kind of stakeholder are the climate science partners who collaborate on the research projects. These include the Oklahoma Climatological Survey and South Central Climate Science Center at the University of Oklahoma, the Department of Geography and Anthropology and Southern Regional Climate Center at Louisiana State University, the Department of Geography at Texas A&M University, and the National Drought Mitigation Center. Together, these institutions and organizations combine their expertise in climate science, outreach, education, data quality and dissemination, and mapping to address the issues of weather-related hazards.

The administrative core supporting these research collaborations is quite small. There are two principal investigators on SCIPP's federal grant. The lead principal investigator is at OU and has primary responsibility for the administrative functions (submitting research funding requests, reporting research activities and results to the funders, overseeing all financial activities, personnel, information technology, etc.) associated with running the SCIPP program. The second principal investigator has responsibility for overseeing the activities of research personnel at LSU. There are core office, research, and support staff at OU and LSU that manage the day to day workflow and administrative tasks of SCIPP. The University of Oklahoma provides the lead and associate program managers, climate assessment specialist, two undergraduate assistants, webmaster, and an information technology staffer. LSU has a program manager, service climatologist, and an information technology staffer.

The second type of stakeholders are the people and organizations in the communities impacted by weather and climate extremes. Typical stakeholders collaborating with SCIPP are decision makers and administrative professionals tasked with increasing community resiliency and preparedness like planners and emergency managers. In addition, SCIPP interacts directly with individuals and organizations like schools to share comprehensive and accessible information generated by research activities.

LITERATURE REVIEW

In public policy literature, collaboration via the development of networks of actors is critical for producing collectively-valued outcomes (Provan and Milward 1995). In knowledge intensive organizations (Richards and Duxbury 2015), diverse subject matter experts work collaboratively share resources and expertise to produce knowledge. To foster collaboration, stakeholders should envision themselves as members of a larger network who share resources and jointly produce a collectively-valued outcome (Gano, Crowley, and Guston 2006). In this section, we review knowledge

management literature for guidance on making information resources accessible to the collaborating stakeholders. Then, literature describing ways to make research translation more efficient is presented.

KNOWLEDGE MANAGEMENT

Adopting a knowledge management framework is important, since knowledge has "… the highest value, the most human contribution, the greatest relevance to decisions and actions, and the greatest dependence on a specific situation or context" (Grover and Davenport 2001, p. 6). Knowledge management (KM) helps with systematic integration of an organization's information assets to meet tactical and strategic goals and offers transparency and accessibility of information to the users. Knowledge management activities guide the development of strategies, initiatives, processes, and systems. These activities sustain and enhance the storage, assessment, sharing, refinement, and creation of knowledge.

In KM systems, the knowledge created by one actor may be the feedback necessary for other actors. Linking knowledge resources enables all actors to synchronously perform their respective tasks more efficiently. Shared interests can lead to synergistic interactions that improve individual and network results. The key is the integration of, and access to, shared knowledge. There are some pitfalls to avoid in a KM infrastructure. The creation and continuation of a KM infrastructure can be challenging without dedicated resources and ongoing support (Ratner 2013; Corfield, Paton, and Little 2013), especially in public organizations (Burford 2013).

The KM process features five types of collaborators (see Table 1 below), each with specific roles (Hislop 2013). Assigning these five roles to individuals is necessary for efficiently managing the knowledge of the collaborators. At the organizational level, the human infrastructure of KM introduces a routine for documenting how an activity takes place and how knowledge is created and transferred and by whom (Gherardi 2009). For instance, if new

knowledge is obtained, but cannot easily be found, the value for the actors is limited.

Table 1
Human Infrastructure of Knowledge Management

Knowledge Management Roles	**Role**
Knowledge Leaders	Promotes KM within the organization
Knowledge Managers	Acquires and manages internal/external knowledge
Knowledge Navigators	Knows where knowledge can be located
Knowledge Synthesizers	Records significant knowledge to organizational memory
Content Editors	Codifies and structures content, documents knowledge producers, writers, and editors

At SCIPP, the knowledge leader should ensure that knowledge management practices are promoted within the organization. Knowledge managers, such as research scientists, should acquire climate research findings to be used for future projects, information dissemination, communicating early warnings and preparing mitigation plans. Knowledge navigators should know where this information is found. Knowledge synthesizers should record the acquired knowledge to organizational memory for posterity. The content editor's role in climate science research should be to

structure the systems content and document actors involved in applied research partnerships.

In addition to assigning knowledge management roles, strong information communication technology can increase the efficiency of KM. If knowledge is not captured through information technology practices, it can easily be lost when there is a change in human infrastructure. Alavi and Leidner (2001) find the role of IT to be especially important in support of these processes. “IT can increase knowledge transfer by extending the individual's reach beyond the formal communication lines” (2001, 121). We emphasize the importance of human infrastructure in KM, alongside IT that supports KM. IT also offers the ability for knowledge management collaborators to exist not only within organizations, but between them as well.

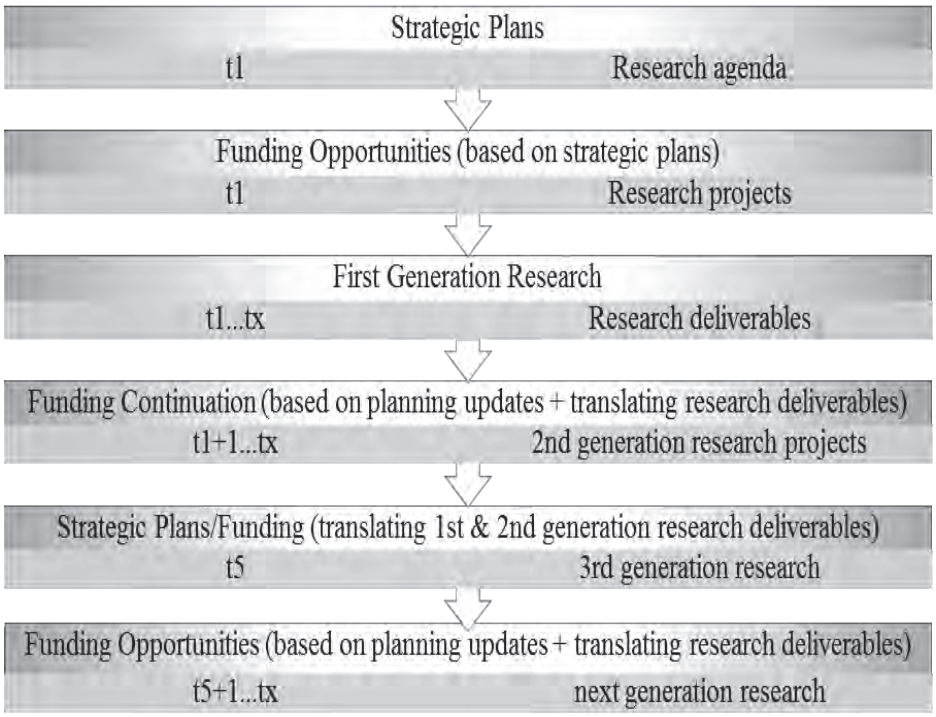
A MODEL FOR EFFICIENT RESEARCH TRANSLATION

Unlike service delivery networks steered by public organizations (Rethemeyer and Hatmaker 2007), the research enterprise does not benefit from the centrality of a single organization to coordinate the activities that produce research deliverables. Yet, research activities need many of the strategic management functions employed in traditional organizations. These functions include strategic planning; budgeting/funding; human and infrastructure assets management; new product/service research and development; and evaluation. There is feedback from one function into the next thus improving strategic management in the next cycle (Franklin 1999).

Using the construct of strategic management function alignment, we propose a research knowledge production cycle with a feedback loop that captures, stores and makes available new scientific and direct practice experience information. This new information can be incorporated into future strategic plans, funding announcements and research projects to translate research more efficiently (see Table 2 below).

In our model, strategic plans are created to set the research agenda. Then, single or multi-year funding is announced at Time 1(t1). Combined, these two documents stimulate research projects that occur over multiple years (t1 . . .tx). The next stage is the communication of research results (collectively called deliverables). The amount of time necessary to plan, award the funding, design and conduct the research, analyze the data and create the research deliverable is variable and can be lengthy. Thus, we use a range estimate of (t1+1 . . .x). Allowing for a range of time means that the cycle is not time-ordered. However, the process can still be conceptualized as a linear cycle; since the funds for each fiscal year go through the entire linear cycle.

Table 2
Research Knowledge Production Cycle



Strategic plans are seldom updated every year and funding opportunities are typically announced before the next strategic plan is available. We denote this as (t1+1 . . .x). Also, as research results get released, research funding opportunities can be fine-tuned to leverage promising practices and to winnow out lines of research that do not hold sufficient promise. We account for this possibility in the third line of Table 2. When the goals in strategic plans are reflected in funding announcements and when research projects produce results that foster goal achievement, then the components of the applied research model are aligned.

The last line of the table reflects the double loop learning that occurs when the strategic plan is periodically updated and informs the next round of funding. Strategic plan updates are informed by external policy priorities and what has/not been funded earlier in the cycles. In addition, strategic plans and funding announcements updates may be based on the knowledge produced in prior generations of research deliverables. When this happens, research translation is occurring.

Alignment and translation activities have increased the impacts of funded research after knowledge management practices were implemented (Mendoza, Bischoff, and Willy 2017). Measured by the volume of publications, these researchers find that a KM strategy adds value to government research and development.

In climate science research, the fulfillment of the five knowledge management roles can support collaboration and make information widely available. Knowledge management processes and roles offer a framework for obtaining and organizing climate knowledge. This knowledge can guide strategic plans updates, funding opportunities and future research projects based on the results generated from current research projects. When combined, the work of multiple KM collaborators can make research knowledge transparent and accessible. Usable information can guide the efforts or researchers, policymakers and practitioners.

Our analysis explores how research translation could become more efficient by aligning the content of strategic plans, funding announcements and research projects. We expect that a human infrastructure network that deliberately assigns the various knowledge management roles will also lead to more efficient translation.

RESEARCH DESIGN

In a nationwide analysis, Franklin, et al. (2017) found weak alignment between strategic plans, funding and research deliverables in drought research. Unfortunately, this empirical analysis was limited to a quantitative review of research deliverables found using academic search engines and publicly available literature. This quantitative analysis did not consider the efficiency of the human infrastructure supporting climate science research. To address this gap, this research focuses on a single organization and expands beyond drought research to all weather and climate extremes.

We used qualitative case analysis methodology (Yin 2014) to analyze the efficiency of the human infrastructure in research translation. The unit of analysis was SCIPP, an organization creating climate science knowledge. We identified the personnel who fulfill the five knowledge management roles through unstructured discussions with SCIPP staff. Research alignment and translation was measured through content analysis of the strategic plans, funding opportunities, research deliverables. The documents analyzed and protocol are described next.

Five strategic plans followed the 2003 CCSP (the plan mandating that the federal Department of Commerce implements national weather and climate policy). The goals in the 2009, 2010, 2014, 2015, and 2016 strategic plans created by units within the Department of Commerce tasked with carrying out the CCSP were analyzed. A 2008 funding announcement created SCIPP. A 2013 funding announcement reauthorized SCIPP. These were used to analyze the alignment of funding with strategic plan goals.

We analyzed SCIPP's annual reports between 2009 and 2017 to: 1) document the research results achieved in each year, 2) identify future research projects and 3) establish the stakeholders with whom SCIPP researchers collaborate. We triangulated our preliminary findings with evidence from documents available on the SCIPP website. If the SCIPP documents reported research activities and stakeholder collaborations that mirrored what was in the strategic plans and funding announcements, then there was alignment. If there was evidence that the engaged research findings in one cycle influenced the language of strategic plans and/or funding announcements in the next cycle, that suggested research translation.

All source documents were analyzed to identify words representing themes and changing emphases (King, Keohane, and Verba 1994). We read the strategic plans, funding announcements and research deliverables to inductively identify words representing goals, processes and outputs/outcomes that were used synonymously (Corbin and Strauss 2015). Our analysis started with the 2003 CCSP strategic plan goals. Iterative key word searches found language in the later plans, funding announcements and the 300+ SCIPP research deliverables suggesting that themes changed over time. Where there was an evolution in a theme, we documented when and in what kind of document the revised theme emerged and when it was picked up in later documents to show that research translation was occurring.

There are internal and external threats to the validity of our research design. The main threat to internal validity is the subjectivity associated with qualitative analysis, as well as a high reliance on analysis of documents created for a different purpose. To mitigate this threat, we triangulated qualitative evidence with descriptive statistics of the coding to assure that our sense of the importance of a theme or word was consistent. Making conclusions about knowledge management practices and research translation with a single case is not generalizable. There are a multitude of agencies, organizations and individuals contributing to this endeavor that may have different results. However, this research protocol can be replicated in other settings or policy areas to test the degree of generalizability and improve external validity.

RESEARCH FINDINGS

The first test of SCIPP's research alignment and translational efficiency examines the personnel who serve the five roles in knowledge management. Even though SCIPP is a single organization, research collaborators come from academic and non-academic organizations and administrative staff work at two organizational locations. This arrangement creates some duplication of roles. For example, there are two principal investigators who have responsibility for leadership and responsibility for producing results from funding. Administrative leadership comes from the University of Oklahoma (OU) principal investigator with help from the program manager. However, in discussions with SCIPP personnel, we found that the role of *knowledge leader* does not seem to be clearly defined nor fulfilled by one person. Instead, the de facto leader is the principal investigator at OU.

OU's principal investigator sets the tone and overall direction and navigates knowledge to connect the people in and collaborators with SCIPP, fulfilling the role of *knowledge manager*. He has responsibility for acquiring and maintaining both internal and external knowledge. There are other researchers at SCIPP who contribute to this function. For example, the investigator responsible for each individual research project holds primary responsibility for acquiring external knowledge and maintaining and communicating internal knowledge.

The role of *knowledge synthesizer* is played by the associate program manager and the climate assessment specialist at OU. Both positions work directly with stakeholders, although the associate program manager focuses more on academic research. The climate assessment specialist synthesizes knowledge more on the practitioner side.

The program managers are primarily responsible for the role of *knowledge navigator*. Inquiries about where to find information go

first to the program managers who give contact information for the right person. This can be whoever they are in closest contact with or just who is around to ask. The program managers also prepare newsletters and facilitate general sharing of knowledge via written and oral communications to stakeholders. Research deliverables include academic publications and formal reports, websites, social media, and inter-office communications. Many have a format to make information immediately usable.

With multiple projects being conducted simultaneously in SCIPP, there is not a single person who is the *content editor* for the organization. Instead, the role is better described as a responsibility shared by everyone in SCIPP. Depending on the nature of the content, the researcher leading the project is the one who initially writes the content. If a workshop summary is being produced, the person who led the workshop becomes the content editor. The document is then reviewed by the program manager. Formal reports are produced by many people and the process is organized by the program manager. While other organizations may have a science reporter who would be a content editor, it is unclear if this would be advantageous to SCIPP in terms of efficiency. SCIPP seems to communicate effectively with stakeholders and meet user needs through by sharing the content editor role across the organization.

SCIPP personnel conclude that the organization is functioning in a way that currently meets its needs. Within SCIPP, each of the five KM functions are being performed even though there are informal, and sometimes shared, role assignments. All personnel and researchers increase the value of SCIPP because each shares responsibility for acquiring, maintaining and sharing knowledge in a way that adds value to climate research and practice.

However, there is room for improvement. The lead investigator notes that it is hard to tell how SCIPP's work is used and whether it makes a direct impact. Currently, this information is not systematically collected nor stored and shared. This prohibits consistent evaluation of the impacts of the research findings. SCIPP researchers believe that it would be beneficial to refine impact indicators to better guide

research and increase use. Success in developing and tracking impacts can also enhance the feedback loop and lead to updated strategic plans and funding announcements and foster research translation. Burford (2013) suggests that organizations with a certain mindlessness of KM processes should have a formally assigned knowledge leader to articulate and reinforce a commitment to smart information practices (see Table 3 below). This recommendation seems salient for SCIPP as well.

The second test of the alignment between and translational effects over time analyzed strategic plans, funding announcement and research deliverables between 2003 and 2016. Since the national policy agenda creates the operating environment for climate science research, we used Easton's (1965) black box model segregating political inputs and outputs/outcomes in the external environment from the administrative processes that occur in an organizational black box, in this case SCIPP. We review the three components of the applied research model next.

Table 3
Human Infrastructure Practices at SCIPP

KM Collaborator	**Human Infrastructure at SCIPP**
Knowledge Leader	Principle Investigator
Knowledge Manager	Researchers contribute for their own projects, then Program Manager
Knowledge Navigator	Program Manager
Knowledge Synthesizer	Program Manager for reports and Assistant Manager for websites
Content Editor	Researchers working on specific projects

STRATEGIC PLANS

The first component for research alignment and translational efficiency in climate research are the strategic plans. Starting in 2003, the CCSP set a national agenda to address weather and climate extremes. In later years, units within the Department of Commerce produced six strategic plans establishing national policy and research priorities. Over time, these strategic plans widen the focus from drought and climate variability and change to weather hazards and climate extremes (see Table 4; more detail is in Appendix A).

Table 4

Summary of Strategic Plan Emphases and Changes 2003-2016

Policy Stage	Year of Documents Analyzed 2003 to 2009	2010 to 2014	2015 & 2016
Inputs	Climate variability/ change		Weather hazards and climate extreme
Research Process	Identify stakeholders and needs		Create deliverables for decisions
Stakeholder Process	Create a broad list of stakeholders		Engage in decisions
Outputs/ Outcomes	Provide useful, integrated knowledge		Build capacity to prepare and adapt

Looking at the research process, we find a shift from stakeholders needs to creating deliverables useful for decision-making. The 2003 CCSP articulated goals for stakeholder identification processes. Later plans had goals for engaged co-production in the creation of response and mitigation plans. In terms of outputs, the initial goal was for useful, integrated research responding to stakeholders' needs. Goals in the later strategic plans evolved to transferring knowledge that builds resiliency for communities to prepare and adapt.

The changes over time to the original 2003 CCSP goals are the basis for determining the alignment of funding announcements and research deliverables. They also are used to assess when feedback from the research results and SCIPP's collaborative activities is reflected in future strategic plans and funding announcements, which would suggest research translation.

FUNDING ANNOUNCEMENTS

The second component for research alignment and translational efficiency in climate research are two funding announcements. These should support strategic plan goals by incentivizing research agendas. As shown in Table 5 below, the emphasis changes to the identification of different kinds of weather and climate extremes.

Due to this, the research deliverables are expected to contribute more than forecasts and scenarios. Instead the emphasis is on innovative research that is useful. Part of this shift is supported by an expectation to move from forming partnerships with regional stakeholders to strategically creating user-inspired knowledge for weather planning, mitigation, response and adaptation. Expectations for improving research abilities shift to informing policy decisions and increasing community resilience.

Table 5
Summary of Funding Announcements Emphases and Changes: 2008-2014

Policy Stage	Year of Documents Analyzed 2008	2014
Inputs	Create south central, midwest RISAs	Identify weather & climate extremes
Research Process	Generate forecasts & scenarios	Conduct innovative research, provide tools
Stakeholder Process	Assess needs, form partnerships	Provide user-inspired research
Outputs/ Outcomes	Improve applied research abilities	Inform policy and assist communities

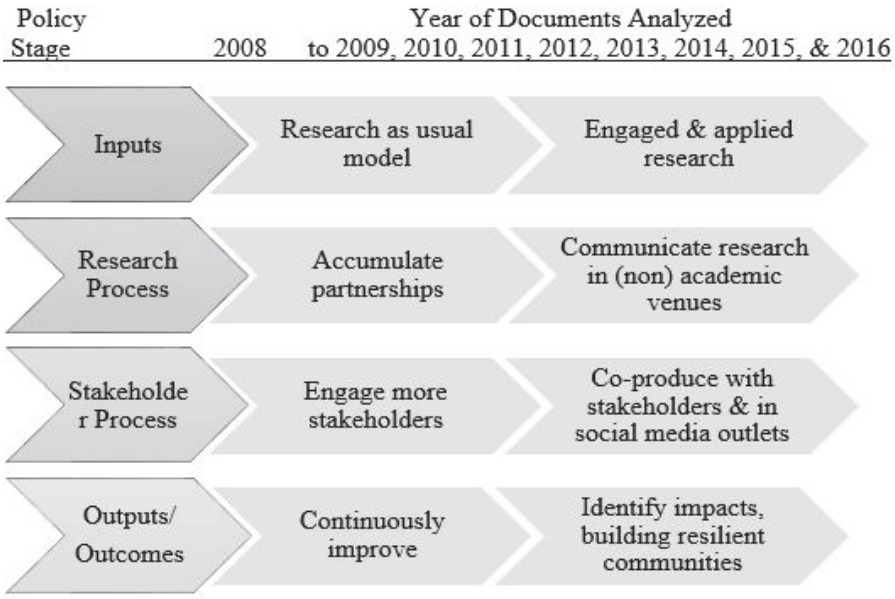
RESEARCH DELIVERABLES

The third component for research alignment and translational efficiency in climate research are the research deliverables. Our analysis of 300+ research deliverables found that a business as usual model was clear at the start of SCIPP. This morphed into an engaged and applied research model (see Table 6 below). This is not surprising since climate research was already occurring at the University of Oklahoma and at Louisiana State University. This research process initially supported the accumulation of partnerships. As it matured, SCIPP shifted its emphasis to communicating results

in academic and non-academic venues. In fact, the delivery via social media and SCIPP followers have grown suggesting co-production relationships with more and more stakeholders. Turning to the outputs/outcomes, the research deliverables show continuous improvement in the way research offers useable information. The new venues for communicating results are better able to inform policy decisions and strengthen community resilience. SCIPP has named impacts, but staff acknowledge refinement is needed.

Table 6

Summary of SCIPP Research Deliverable Emphases and Changes: 2008-2016



Using findings from analysis of the strategic plans, funding announcements and research deliverables, we can draw conclusions

about SCIPP's research alignment and translation. In Table 7, we conclude that there is alignment between the external and internal operating environment for SCIPP. This is seen in changes over time in what topics to study, what kind of research is usable and the benefits of partnerships with engaged stakeholders.

For example, the initial strategic plan called for meeting stakeholder needs for information and creating deliverables that met these needs. The funding announcement noted that it would be necessary to assess stakeholder needs and generate forecasts and scenarios. SCIPP's 2009 Annual Report had sections titled: "Current Areas of Focus – Climate, Community Engagement and Drought" and "Research, Stakeholder Collaboration and Tool Development". For all three documents, common themes are stakeholder engagement and offering climate information that would be useful to stakeholders.

Table 7

Alignment and Feedback Between Plans, Funding and Research Deliverables

Inputs: Different types of environmental conditions and weather events

Strategic Plans	Climate variability and change, RISA focus on hazards and extreme events reflects a widening definition
Funding	RISA focus for SCIPP & upper Midwest US expanded to hazards & event
Research Deliverables	Emulating a "business as usual" research model early; then an engaged and applied research model
Research Findings:	**Alignment & translation - research and partnerships lead to a wider definition of hazards and extreme events**

Processes: Produce Research

Strategic Plans	Broad definition to co-production of specific types of deliverables
Funding	Changing emphasis to innovation and types of deliverables
Research Deliverables	Accumulating partnerships producing expanded research communicated in academic and non-academic venues
Research Findings:	**Alignment - increase in applied research - needs assessments, planning, evaluation**

Processes: Engage Stakeholders

(decision/policy makers, public, across sectors, local, regional, global, community, NIDIS)

Strategic Plans	From broad stakeholder list, global emphasis falls away, regional/community specific emphasis increases
Funding	From assess to meet needs and assist regional stakeholders in all phases of climate change response
Research Deliverables	Engaging more stakeholders with research deliverables reflect co-production & create social media followers
Research Findings:	**Alignment & translation - stakeholder engagement adds applied research, communications to social media followers**

Outputs/Outcomes: Climate Information and Decision Making

Strategic Plans	Integrated research responding to needs then transferring knowledge & building resiliency for communities to prepare and adapt
Funding	Continue producing scientific research and use this to inform policy decisions and community preparation and mitigation efforts
Research Deliverables	Continuous improvement to create and attempt to measure broader climate science impacts and resilient communities
Research Findings:	**Alignment - Knowledge diffusion to partners & engaged stakeholders, integrated climate science with societal adaptation**

We found mixed results in terms of the translation of research results into future strategic plans and funding announcements. We analyzed this by finding new themes in SCIPP's Annual Reports from one year to the next. Then, we compared these to strategic plans and/or funding announcements in later years.

Here is an example of areas where we found evidence supporting research translation.

Year: New Titles in SCIPP Annual Reports

2009: Research projects and stakeholder collaborations
2010: Accomplishments
2010: Communicating science to decision makers
2011: Exemplifying regional climate services
2011: Team projects - deliverables, stakeholder collaborators, connecting science to practices
2013: Project database
2014: Measuring success

2014 Funding Announcement (evidence)

Conduct innovative research, provide tools (collaborations to develop projects, databases)
Provide user-inspired research (stakeholder collaborators, connecting science to practices)
Inform policy and assist communities (communicating science, providing regional services)

Year: New Titles in SCIPP Annual Reports

2015: Increasing resiliency & preparedness for weather and climate extremes
2015: Key outreach activities
2015: Narrative examples
2015: Measuring overall impact
2015: NIDIS - Weather and prediction tool databases

2015/2016 Strategic Plans (evidence)

Weather hazards and climate extremes (weather and climate extremes)
Deliverables for decisions (weather and prediction tools and databases)
Engage in decisions (measuring overall impact)
Build capacity to prepare and adapt (increase resiliency and preparedness)

There were areas where there was no evidence of translation, especially in the outputs; much of the documents continue prior themes. This finding supports SCIPP's perspective that the measurement of impacts can be improved and that knowledge management could more systematically capture and compare impacts over time. Limited translational efficiency is not surprising since our analysis was limited to the results from SCIPP. Strategic plans and

funding announcements are at the national level and other actors also influence translation

DISCUSSION

SCIPP uses an applied research model to integrate empirical and experiential climate science evidence for community planning, mitigation, response and adaptation efforts. The 2003 Climate Change Science Program reflected a national desire for useable climate science and broader societal impacts from climate research deliverables. Ten Regional Integrated Science Assessment organizations, including SCIPP, were created to expand stakeholder co-production to increase regional resiliency and preparedness. We find that SCIPP's inputs, research and stakeholder processes, and outputs/outcomes are aligned. However, the translation of research results could be more efficient in the areas of processes and outcomes.

Adopting knowledge management practices in SCIPP could improve research translation. The small number of SCIPP administrative personnel makes it difficult to assign all five knowledge management roles. Instead, roles are selectively assigned and there is a heavily reliance on individual researchers to contribute to the KM system. We find that SCIPP's human infrastructure had deficiencies such as the absence of formal responsibility assignments for all the roles, but especially for the knowledge leader role

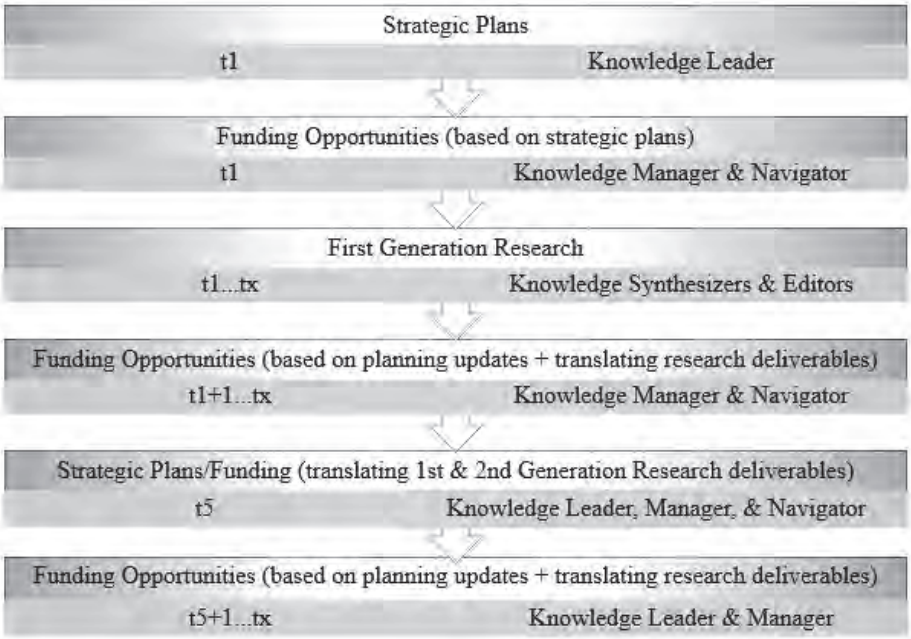
SCIPP personnel are not unaware of this challenge and suggest that uniform metrics developed in collaboration with stakeholders could help institutionalize knowledge. The potential value of this idea that was recognized in the 2009 strategic plan which called for infrastructure for knowledge transfer and stipulated collaboration by organizations having responsibility for delivering climate information. Organizations like SCIPP were tasked with developing institutional pathways, policy requirements, and innovative technical

processes to transfer maturing climate research to others (2009 RISA Vision, p. 6).

To achieve this goal for infrastructure development, we see in Table 8 that knowledge management roles can be assigned based on the stages in the research knowledge production cycle.

Table 8

Knowledge Management in the Research Knowledge Production Cycle



The creators of strategic plans in NOAA units are the knowledge leaders. Program managers overseeing federal funding are the knowledge managers. Those accountable for the acquisition and management of internal and external knowledge nationally and at regional organizations like SCIPP are knowledge managers and

knowledge navigators. Individual researchers at SCIPP equate to knowledge synthesizers by contributing significant knowledge to organizational memory. They are assisted by regional and federal policy managers who are content editors who are answerable for codifying and structuring content, and deal with capturing and documenting knowledge researchers, writers, and editors.

A robust model of KM in climate research would feature a more cohesive structure which requires knowledge leaders, managers and navigators to align strategic plans, funding opportunities and research projects. As suggested by the research knowledge production cycle, after multiple generations of research, people in these three KM roles could efficiently translate research to inform plans, funding, and future projects. When successful, decision making would be improved and resiliency and preparedness would be increased.

CONCLUSION

The knowledge management (KM) literature stresses the need for managing knowledge produced, stored and shared by an organization. Our analysis suggests that, in the climate research realm, KM could be more effectively managed if SCIPP deliberately articulately and assigned KM roles. Capturing, organizing and making SCIPP data transparent and accessible, would document breakthroughs and innovations, informing the choice of future research projects. Combined, this would enhance the probability of research translation and create useable knowledge informing policy decisions and increasing preparedness and resilience.

Our analysis found alignment between strategic plans, funding announcements, research and stakeholder collaboration processes and the communication of usable research results. However, there is potential to enhance the utilization of research results to increase translational efficiency and contribute to a policy accretion process

(Weiss 2002), provided the human infrastructure necessary for knowledge transfer is bolstered.

Examining the relationship between human infrastructure and research translation efficiency through the lens of knowledge management suggests how to structure practical applications of KM to increase the visibility and use of research results. Through double loop learning research deliverables can inform future strategic plans and next generation funding. A successful knowledge management process can support engaged research by multiple stakeholders. Combined this could efficiently translate research and improve policy and practice.

Although these findings suggest the potential for application to various policy domains, studies with more climate science organizations are needed to see if the findings are generalizable. Or, our findings could be tested in a different substantive policy area. There is the potential for SCIPP's applied research model to be used in other publicly funded programs. For example, best practices from collaborative research could generate usable evidence for improving educational outcomes to practitioners charged with implementation.

Mann concludes that "…[t]he tremendous strides that have been made in the treatment of cardiovascular disease have been the result of sustained and coordinated translational efforts by academic and industry partners" (2017, 103). Our analysis applies theory from one area of science to another to explore how it could contribute to more focused research, quicker implementation of best practices and increased visibility and use of research findings. KM practices can also open communication and collaboration pathways. If successful, climate research networks can more efficiently translate research findings, communities can be more resilient and prepared for weather and climate extremes; each leading to broad societal impacts.

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APPENDIX A

Strategic Plan Emphases and Changes: 2003-2016

	Inputs: the different types of environmental conditions and weather events
2003 CCSP	Climate and non-climatic factors,
2009 RISA	Natural hazards, environmental disturbances, sea-level rise
2010 NOAA	Water resources, coasts, climate ecosystems, marine changes
2015 CPO	Drought, flood, fire, extreme heat, water supply changes, snow pack, sea level rise, severe storms, melting ice, permafrost
2016 RISA	Climate hazards and extreme events
Finding:	**Climate variability and change, RISA focus on hazards and extreme events reflects a widening definition**

	Processes: Produce Research
2003 CCSP	Meet stakeholders needs for climate knowledge including non-climatic factors
2009 RISA	Assess regional climate, improve literacy and adaptation, inform policy
2010 NOAA	Address societal challenges in climate impacts
2014 OAR	Conduct and translate meaningful and actionable research
2015 CPO	Monitor & forecast, educate & raise awareness, communicate (outreach)
2016 RISA	Create useful regional climate research and information to meet DM needs
Finding:	**Broad definition to co-production of specific types of deliverables**
	Processes: Engage Stakeholders
2003 CCSP	Respond to needs of decision/policy makers & public across a broad range of sectors at local, regional & global scales
2009 RISA	Support collaborative decisions through knowledge management, dialogue, promote expanding suite of capabilities
2014 OAR	Work with stakeholders on the ground to know needs
2015 CPO	Communicate & provide outreach activities for education & public awareness
2016 RISA	Engage hand in hand with stakeholders and decision makers
Finding:	**From broad stakeholder list, less global emphasis, more community emphasis**
	Outputs/Outcomes: Climate Information and Decision Making
2003 CCSP	Produce integrated knowledge that is useful, responsive to needs
2009 RISA	Conduct experimental research and create decision products

2010 NOAA	Transfer knowledge and expand use of suite of capabilities
2014 OAR	Work with communities & stakeholders to meet needs and translate to action
2015 CPO	Embed research information into preparedness and adaptation activities
2016 RISA	Advance knowledge to build capacity for preparation and adaptation
Finding:	**Integrated research responding to needs then transferring knowledge & building resiliency for communities to prepare and adapt**

APPENDIX B

Funding Announcements Emphasis and Changes: 2008-2016

Inputs: the different types of environmental conditions and weather events

2008 RISA	Drought is a serious concern
2014 RISA	SCIPP Region, floods, coastal, climate impacts, marine and Great Lakes ecosystem
Finding:	**Create SCIPP & upper Midwest US expand to weather and climate extremes**

Processes: Produce Research

2008 RISA	Generate integrated research into global environment changes & drought, provide forecasts & scenarios, work with NIDIS
2014 RISA	Conduct innovative, interdisciplinary research with drought monitoring and prediction products and scenarios
Finding:	**Changing emphasis to innovation and types of deliverables**

	Processes: Engage Stakeholders
2008 RISA	Assess needs & adaptive capacity, form partnerships, develop regional stakeholders
2014 RISA	Provide user-inspired, regionally relevant research, assist management & facilitate planning processes
Finding:	**From assess to meet needs and assist regional stakeholders in resiliency and preparedness**

	Outputs/Outcomes: Climate Information and Decision Making
2008 RISA	Improve ability to observe, understand, predict & respond to climate changes
2014 RISA	Inform resource management and public policy, prepare for floods in urban coastal communities, mitigate climate impacts
Finding:	**Continue producing scientific research and use this to inform policy decisions and community preparation and mitigation efforts**

APPENDIX C

SCIPP Research Deliverables Emphases and Changes: 2008-2016

	Inputs: the different types of environmental conditions and weather events
Annual Reports	Research changes in climate & drought to hurricane, storm surge, tornados, floods, heat, fire, ice, sea-rise, water resources, severe storms, extreme events
Publications	Research projects expected to produce academic, non-academic deliverables
Website	To be developed as communication and outreach

Finding:	**Emulating a "research as usual" research model early; then an engaged and applied research model**
	Processes: Produce Research
Annual Reports	Conducting research with partners & continuous expansion of government and non-government partners
Publications	Reporting findings in books, chapters, journals & non-academic reports to workshops, meetings, professional presentations to data bases & user tools
Website	Posting researchers' publications, annual & technical reports, workshop agendas & summaries, webinars, newsletters & social media
Finding:	**Accumulating partnerships producing expanded research communicated in academic and non-academic venues**
	Processes: Engage Stakeholders
Annual Reports	Identifying and developing stakeholders & partners becomes collaborations, communications with narratives, and joint activities
Publications	Empirical research evolves to report events & adaptation activities with new stakeholders (OK's Tribes, Emergency Managers/Planners, communities)
Website	Communicating information about SCIPP becomes invitations to join webinars, workshops, field photo events; listen to podcasts & subscribe to social media
Finding:	**Engaging more stakeholders with research deliverables reflect co-production & create social media followers**

Outputs/Outcomes: Climate Information and Decision Making

Annual Reports	Shifts traditional publications to reports; databases; planning, evaluation & mitigation activities; building expertise; partner projects & measuring impacts
Publications	Describes weather/events changes to predictive scenarios, international comparisons, technical & lay language reports/recommendations
Website	Updates to front page more frequently for activities and research deliverables, better links so user finds more items on website
Finding:	**Continuous improvement to create and attempt to measure broader climate science impacts and resilient communities**