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TRANSLATIONAL ECOLOGY

Use-inspired science: making science usable by and useful to decision makers

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Making science usable

A growing body of research in translational science provides a foundation for translational ecologists to consider the practices that show the most promise, as well as the potential pitfalls of those practices. These research approaches (eg user-inspired climate science) require deliberate engagement with end users, and an understanding of the social and cultural contexts in which a research project functions. We examine the climate science translation literature (looking at how research can inform decision making) to identify key issues related to how the social sciences have helped guide researchers engaged in user-inspired research. We focus on understanding the more intangible inputs to research projects, including the social and cultural contexts; stakeholder engagement; the role of social capital; and evaluating the outputs, outcomes, and impacts of translational science projects and initiatives. Research on return-on-investment metrics for translational science is increasingly pointing to the conclusion that intentional, structured processes, such as

those found in translational sciences, boost the likelihood of science being successfully incorporated into environmental decision making and policy.

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In a nutshell:

- Barriers to the use of scientific information in decision making can be overcome by fostering social capital among research collaborators, such as scientists, practitioners, and members of the public
- This is achieved by fostering relationships between these groups through collaborative research opportunities and outreach and engagement activities
- When researchers and stakeholders openly acknowledge differences in professional practices, expectations, and rewards, they establish a foundation for trust and increase the chances of successful collaboration
- The benefits of a well-articulated framework for managing engagement between ecologists, practitioners, and other stakeholders include an increased ability to articulate mutually desired project outcomes and to avoid misunderstandings
- Ecologists can avoid pitfalls and improve the chances of successful scientist–stakeholder collaborative project outcomes by consulting the growing body of successful case studies and examples produced by science translators in ecology, public health, and climate services

As defined earlier in this Special Issue, translational ecology (TE) "is an approach that embodies intentional processes by which ecologists, stakeholders, and decision makers work collaboratively to develop and deliver ecological research that, ideally, results in improved environment-related decision making" (Enquist *et al*. 2017). TE seeks to link ecological knowledge to decision making by integrating science with the social dimensions that underlie today's complex environmental issues. Most notably, TE facilitates this linkage via interactions between decision makers, practitioners, and the public. Distinct from both basic and applied ecology, TE deliberately extends research beyond theory or coincidental applications, and is motivated by a search for outcomes that directly serve the needs of natural resource managers and decision makers. TE is part of a broader movement that aims to update and reinvigorate the social contract between science and society, to make science more useful and usable in the face of rapidly changing and pressing environmental challenges (Lubchenco 1998; National Research Council 1999) and is one of a series of approaches (end-to-end science, boundary work, co-production of science and policy, production of usable or actionable science) that embodies and puts into practice the integration of science and decision-making, through a variety of means. The purpose of this paper is to use our knowledge and awareness of usable climate science research to urge ecologists interested in TE to consider several key elements when designing a TE approach.

The ultimate goal of both the production of usable science and TE generally is for researchers – in conjunction with people who are likely use their findings – to produce scientific information that can help inform solutions to coupled human–environmental problems. Usable science has three main characteristics. First, it is *relevant* to the problem at hand, in that it fits within the decision-making framework in which the information is to be applied, and is produced in a timely manner and at an appropriate scale (Lemos and Morehouse 2005). Second, usable science is *credible*, indicating to likely users that the information was produced according to accepted standards of scientific rigor. Third, usable science must be *legitimate*, meaning that likely users of the information trust that the findings were produced without political persuasion or bias (Cash *et al*. 2003). The absence of one characteristic cannot be offset by an overabundance of one of the others; all three must be balanced in a way that reflects the context of the problem. Both TE and usable science promote science that can inform decisions, and are both particularly focused on collaborating with end users of the science throughout the research process (Panel 1). TE could be used to inform learning-based decision processes, such as adaptive management, a strategy commonly used by federal natural resource and land management agencies to develop, implement, monitor, and adjust management decisions. TE can be applied when a system's controllability and uncertainty are both low, to help in hedging strategies, as well as in systems characterized by a combination of high controllability and low uncertainty, in which adaptive management is warranted (Peterson *et al*. 2003; Williams *et al*. 2009). We believe these translational and user-inspired approaches will help to achieve adaptive-management outcomes.

Lessons learned about producing usable science have emerged from numerous programs established and managed by several US federal agencies, including the National Oceanic and Atmospheric Administration's (NOAA's) Regional Integrated Sciences and Assessments (RISA) and Sea Grant programs, the Department of Interior's Climate Science Centers and Landscape Conservation Cooperatives (LCCs), and the US Department of Agriculture's Cooperative Extension System (CES) and Regional Climate Hubs. Some of these agencies and organizations have been involved in developing usable science for more than a century (eg CES) and for decades (eg RISA and Sea Grant programs), whereas others have been formed only recently. These programs focus on improving our understanding of the rigorous processes and approaches needed to produce usable science so as to better inform climate-related decision making, and the insights gained from these programs are enormously beneficial to the TE community. There is a robust body of literature concerning translational practices in other scientific and medical fields (Cash *et al.* 2006; Ferguson *et al.* 2014; Jacobs 2005), as well as large and diverse communities and networks of researchers, stakeholders, agencies, and organizations engaged in similar approaches throughout the US that ecologists can tap into. The collective knowledge derived from direct experience in climate science research and involvement with this community provides a powerful foundation for TE practitioners to learn from and build on.

Our experience with translational approaches in the field of climate science comes from working with researchers and stakeholders to produce usable science, and from our own research into these processes (McNie 2012; Parris *et al*. 2016; Wall *et al*. 2017). Here, we focus on three aspects of user-driven science that are important for producing usable science: (1) how decisions made well before the actual research process can impact research outcomes (research context); (2) the role of engagement before and during the research project; and (3) designing project outputs and tracking impacts. Although other aspects could have been chosen in addition to these three, an exhaustive treatment is not possible here; thus, given that other papers in this Special Issue present in-depth discussions of boundary spanning (Safford *et al*. 2017), institutional constraints (Hallett *et al*. 2017), and extensive case studies of TE practice (Lawson *et al*. 2017), we devote our attention solely to these three topics.

Research context – inputs to and external influences on the research process

Although it is easy to focus only on the research project, there are many choices made by both researchers and potential end users whose decisions will influence the usability of the science (Figure 1). First, understanding context begins with recognizing inputs to the project which can include both tangible resources such as funding, end user's contributions (both financial and time), as well as more intangible resources such as the capacity of the research team to engage with end users and effect of pre-existing relationships between researchers and end users on the research process. External influences include the organizational context in which the research results may be used. This context includes potential political, financial, or perceptual barriers to that use, the level of scientific or management uncertainty, or the effects of a catalyzing event that exacerbated or created an issue that the research was intended to address. For example, in a climate-related project undertaken in the Great Basin region of the western US that involved collaboration with resource managers to develop scenarios of future management conditions, several participants noted that although they were required to consider climate change in resource planning, little guidance was provided on how to do so; as a result, trying to facilitate this understanding became part of the project (Wall *et al*. 2015). An awareness of such factors helps shape how research should be undertaken, and aids in recognizing potential gaps between available resources and what might be needed. For example, if the likely end users do not have the staff expertise to fully translate technical research results and the capacity to implement management recommendations from the research is identified at the beginning of the project, then outputs can be designed to reflect the current end-user capacity with options for future management actions if more resources become available.

Why engage with end users?

Although there are many approaches to user-driven research, they tend to involve end users in ways that range from highly collaborative (co-produced research) to more intermittent yet ongoing (consultative) (McNie *et al.* 2016; Meadow *et al.* 2015). Across these approaches, the flow of information and knowledge can be characterized as multidirectional, so that all perspectives and knowledge are valued and are incorporated into the research process. The role of end users in the research process depends on the type of research being done (Figure 2). For research that is meant to answer more fundamental scientific questions, involving end users is often unnecessary because it may not even be possible to identify who the end users are until decades later. Research that is intended to inform more immediate decisions, however, requires more end-user participation. In engagement-intensive approaches, end users can help design research questions, collect and analyze data, and develop research outputs. This kind of approach is ideal for informing complex decisions that are rooted in high levels of scientific or management uncertainty and that require new tools to support those decisions. Such tools often involve building stakeholder capacity to engage in research as well helping them to use the research results. For example, FireScape Mendocino (Lawson *et al*. 2017), a collaborative land-management initiative, is facilitated by The Nature Conservancy's Fire Learning Network (FLN). The FLN, a knowledge-exchange network, builds the capacity for partners to understand and use research results to inform landscape restoration practices. These approaches tend to be characterized by an iterative learning and engagement process between researchers and stakeholders. Through iterative interactions, participants share insights from practice and research and develop trust, and hence become a de facto community of practice.

There are also consultative or contractual approaches that are less engagement-intensive, which, when used successfully, produce usable science that can support management decisions. For example, personnel with Bureau of Land Management (BLM) districts in Nevada expressed concerns about their ability to effectively monitor climate and weather conditions for management applications because of the scarcity of observation stations in the state. In response, the Nevada State BLM office asked the Western Regional Climate Center (Reno, NV) to identify gaps in the observation network to help determine effective placement of observation stations based on applied management needs (eg habitat, rangeland, wildfire, drought). Although BLM employees were not involved directly in the assessment of climate monitoring for land management applications, they identified and discussed the problem, reviewed preliminary outputs, and offered suggestions on how to refine outputs to better fit the BLM planning processes. The research team made a deliberate effort to engage and collaborate with the BLM at key points during the research process that were identified at the beginning of the project.

As demonstrated by the examples above and in Figure 2, each of these approaches to engaging with stakeholders and end users – whether directly or indirectly – can be extremely effective. Not all questions, researchers, and likely users are amenable to highly collaborative approaches that require consistently sustained and intensive engagement. Furthermore, recognizing the possibility of "stakeholder fatigue", and of end users becoming overwhelmed by other job demands or even by the required level of interaction with other researchers is an important consideration in selecting an engagement approach. For the field of TE, encouraging a diversity of engagement frameworks is critical, as doing so acknowledges that developing TE science is not a "one-size-fits-all" solution.

How to engage with end users

Surprisingly, recent studies suggest that few research projects designed specifically to engage with end users included formalized plans for doing so in the proposal, despite the presence of such plans as useful indicator of successful engagement (Wall *et al*. 2017). Ideally, a plan should address by what means, how frequently, and at what depth of engagement (ie emails versus in-person meetings) the researchers, likely users of the information, and other stakeholders expect to communicate. Other considerations include: how differences in expectations regarding involvement will be resolved; who will be responsible for initiating communication; the level of interest among researchers in how the results and outputs from the project will be used; what the expectations are for engagement beyond the end of the project; and what barriers may hinder successful use of the results by stakeholders.

To function effectively, researchers who develop outputs such as decision support tools and technical models often need to be integrated into existing technical, bureaucratic, and operational systems already employed by end users and their organizations. For instance, articulating a research plan that directly addresses stakeholder engagement and integration of the research with existing policy contexts helped University of Hawaii (UH) researchers achieve positive outcomes for a project based on a translational science approach. In that case, the researchers turned to logic modeling (Taylor-Powell and Henert 2008), a technique frequently used for program planning by non-profit organizations and by the CES, to articulate aspects of stakeholder involvement, interactions with researchers, research outputs, and ultimate outcomes of collaboration. One aspect of the project involved a more consultative mode of engagement that originated with a researcher's white paper analysis of law and policy frameworks. Mapping stakeholder involvement and interactions, as well as desired project outcomes through the logic model, enabled the UH research team to infuse insights from the white paper into the policy process (Ferguson *et al.* 2016a). A key aspect of this work was the researchers' ability to develop social capital with stakeholders, and to build and maintain productive relationships through the use of "soft skills", such as listening to and communicating (Panel 2).

One challenge often faced by scientists who work closely with end users is how to most effectively manage the relationship, or boundary, between the distinct worlds of science and society. Successful "boundary management" can ensure the production of information that is useful, salient, legitimate and credible, and that responds to users' needs, while simultaneously avoiding politicization of science or the "scientization" of politics (Guston 1999, 2001; Sarewitz 2004; McNie *et al.* 2016). Boundary management requires effective communication between scientists and stakeholders, translation of information into forms that are understandable by end users, and scientist–stakeholder mediation, all of which may require substantial time and resource commitments from researchers who are often already stretched thin by multiple obligations and responsibilities. Stakeholders and researchers may need to shape research agendas together, or negotiate amongst themselves to reach consensuses about project outputs. This process is common to most adaptive management processes, where parties must come to agreements about how to implement strategies and influence decisions. It is important to recognize that while accountability in research depends on peer review, accountability in other fields might depend on political safety or support of oversight bodies, such as agency panels or a board of directors (White *et al*. 2008). Boundary work can be carried out by individuals on the research team or boundary organizations, whose function is explicitly aimed at boundary work (for example, LCCs often function boundary organizations, creating a bridge between researchers and research results and the end users of the results, such as resource or water managers), and assumes even greater importance as political stakes increase or as marginalized populations play a larger role in user-driven and collaborative science (McNie *et al*. 2016). For example, Mott Lacroix and Megdal (2016) examined social learning and infusion of science in water-management decision making in Arizona. As a separate project, they explored management of the boundaries between university scientists and stakeholders who were participating in a process to introduce new science into water governance at state, watershed, and municipal scales, and recommended the establishment of a diverse steering committee that included representatives of various stakeholders and interest groups. The steering committee guides and changes the process according to stakeholder concerns, freeing the science team to serve as boundary managers, neutral conveners of the process, and topic experts.

Designing research project outputs, outcomes, and tracking impacts

A crucial set of challenges in producing usable science are developing outputs, identifying outcomes, and tracking the impacts of the research. To be able to successfully identify outcomes and track impacts requires designing metrics at the start of a project. Distinguishing between outputs, outcomes, and impacts is helpful for ensuring that the research meets the overall goal of directly serving the needs of natural resource managers and decision makers; in addition, successful metrics for outcomes and impacts can be used to meet return-on-investment criteria, increasingly part of the business end of grants and contracts. In this context, *outputs* are the products from a research project, and may include reports, papers, tools, datasets, workshops, new relationships and expanded networks, training, and other tangibles (Figure 1). *Outcomes* stem from the use of outputs and often refer to an event or a condition of direct importance to the stakeholder, such as improved prediction capability or the identification and reduction of uncertainties (National Research Council 2005). *Impacts* refer to the benefits to the stakeholders, or to society generally, of the research or collaborative process; for example, reduced vulnerability to climate change or recovery of an endangered species would be impacts of usable science.

It is important to consider how to improve outputs for potential use by stakeholders. This includes asking questions such as: what format should be used to communicate and share the output(s)?; are resources available to produce more than one type of output to meet multiple needs (eg articles for publication in peer-reviewed journals, a jargon-free report for use by stakeholders)?; what purpose(s) will/could the outputs serve?

For example, scientists from the Western Water Assessment RISA responded to a request from water managers in Colorado, who were motivated by extreme drought in 2002, to provide scientific insights on historical drought events in the region through the analysis of tree rings (Woodhouse and Lukas 2006). During the course of many interactions with these managers and others from additional Intermountain West states, the scientists learned that the data, research results, information, and methods were most effectively presented via multiple formats, including a web-based data portal accompanied by explanatory text, and hands-on workshops. These communication approaches served to (a) orient water-agency technical professionals to the field research and statistical methods used in dendrohydrology and (b) allow for discussion of the methods at a deep enough level to ensure sufficient credibility for these proxy data to inform water management (Rice *et al*. 2009).

It is helpful to describe the expected or desired outcomes of a project – how the research will be used – during initial project development, to ensure that both researchers and end users have complementary project goals. Broadly, outcomes can be categorized in several ways to help researchers and end users conceptualize how research outputs might be used, and how these outcomes can lead to desired impacts. Use can be *conceptual*, in which the stakeholders perceive themselves or their organization as better informed, share the results with others, or form a new opinion about the issue. For example, the Resilient Coastlines project of Greater San Diego (www.resilientcoastlines.org) brings together multiple climate science, planning, and research collaboratives to fill information gaps that serve as barriers to action on coastal resilience; by combining research with innovative and consistent communication, the alliance expands public engagement in coastal planning. Information use can also be *instrumental*, in which results are used to contribute directly into a management plan, policy, or other management/operational decision or action (see Panel 3). A third use is *justification*, in which the research is used to justify an earlier decision (eg Ray and Webb 2016) or a request for resources to enhance capabilities, such as mitigating risks associated with drought or fire, eg proactive fuel treatments in wildfire prone areas. At the end of a project, questions to evaluate outcomes may include: are the research findings perceived as credible by both researchers and stakeholders?; was the stakeholder's input into the project evident?; will the results meet stakeholder needs? If so, how will the stakeholder use the results?

Tracking the impacts (ie, the effect or consequences of the outcomes) of usable research can extend well beyond the timeline of most projects, but identifying outcomes that were successful at the end of the project can support identifying these future impacts. The conceptual use of research by end users at the end of a project may lead to an instrumental use at a later date, during management plan updates, revisions, or as resources become available, leading to further impacts. For example, initial outcomes for the PocketCard project discussed in Panel 3 were largely conceptual, as the end users discussed the findings and possible management actions with the research team after the project ended. Instrumental use of the research findings occurred several years later during an update to the National Fire Danger Rating System, when several recommendations were incorporated. Future evaluation can assess the impacts of these changes on wildland firefighter safety.

Conclusion

Translational ecology differs substantively from both applied and basic research (Enquist *et al*. 2017). As McNie *et al*. (2016) noted, the basic versus applied science paradigm revolves around knowledge generation but fails to address the “multiple and complex roles that stakeholders may play in influencing knowledge generation and use”, leaving a gap in our understanding of how science can support decision making and the barriers to science being used in decision making and policy development. In this way, TE seeks to fundamentally alter the applied/basic science paradigm by explicitly engaging stakeholders in the generation and utilization of knowledge, thereby creating an alternative paradigm for ecologists to address the multilayered and complex ecological problems faced by decision and policy makers.

Key aspects of this alternative paradigm, as viewed here through usable climate science research and experience include (1) the need to proactively consider and respond to the research context early in a research proposal and project; (2) an emphasis on the need for intentional planning and engagement with stakeholders and for intentional boundary management between researchers and end users; and (3) the need to co-design project outputs, identify desired outputs, and consider tracking possible impacts from the research. Our fundamental goal in this paper is to communicate to the reader that translational research, such as TE or usable climate research, requires intention on the part of the researcher, the funding agency, and intended users of the research outputs. Entering into collaborative research without formal plans for engagement and managing the science–society boundary increases the chances of making mistakes and of missing opportunities to improve linkages between science and decision making, and reduces the likelihood of producing usable science. Based on multiple decades of research into the mechanics of scientist–stakeholder relationships within the realm of decision making in various fields, we believe that thoughtful and explicit incorporation of these concepts and practices will lead to improved communication and collaboration, thereby increasing the likelihood of success in the adoption of ecological science into environmental decision making and policy formulation.

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Figure 1. *Components of use-inspired or translational research include context-related components, such as resources for the project, processes that utilize communication and collaboration, and the results of the research, which include outputs (such as data sets or reports), outcomes (the science is perceived as usable, and other desired changes, such as*

increased collaboration between researchers and end users), and impacts related to how the research knowledge is used in decisions.

Figure 2. *Graphic representation of three categories of research – basic, applied, and user-inspired – in relation to the roles of end users in the research process, and the types of decisions being made. For research results and other knowledge generated or co-developed to support decisions (ie management actions, policy decisions, or programmatic development), there is often a need for greater involvement with potential end users throughout the research process. Note: this graphic is meant to provide the reader with a visual aid to compare the degree of engagement with end users across a continuum of research approaches and does not represent an exact determination of the amount of research performed in each of these areas.*

Panel 1. Key factors in producing usable science

Drought in the late 1990s and early 2000s, (Figure 3) in conjunction with negotiations of new dam operation licenses, spurred a request for development of a drought assessment tool for the states of North Carolina and South Carolina (a catalyzing event). Researchers collaborated with state decision makers to develop a tool that was sufficiently flexible to accommodate the diverse requirements of regional decision makers, including natural resource managers, state drought task forces, and stakeholders wanting to provide input regarding the Federal Energy Regulatory Commission's (FERC) application process for new dam licenses (Carbone *et al*. 2008). Success in this endeavor required these translational researchers to understand and negotiate diverse decision-making contexts, respond to information demands from state agencies responsible for disaster relief declarations (requiring weekly timescale assessments at local spatial scales), and operate within the constraints of information requirements for FERC dam relicensing (requiring drought measures for a variety of US Geological Survey hydrologic units).

Caption:

Figure 3. *North Carolina's Fontana Lake during drought conditions.*

Credit:

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Panel 2. Social capital and "soft skills" in translational research

An important but often overlooked component of the translational research process, social capital is needed to build and maintain productive relationships – based on mutual trust and respect – when creating, transferring, and utilizing usable science for decision support (Levin and Cross 2004; McNie *et al*. 2016; Simpson *et al*. 2016). Like any form of capital, social capital can be generated, spent, and lost, and so great care must be taken to manage it according to the situation. Social capital describes the relationships and "goodwill that others have toward us" (Adler and Kwon 2002) and affects how information is exchanged, how people or organizations exert influence and power, and informs perceptions of solidarity and allegiance. Research indicates that strong, trustworthy relationships increase the likelihood that people will listen to and act upon new information (Levin and Cross 2004; Lemos *et al*. 2012). Social capital plays a critical role in knowledge generation and sharing when there are extensive cultural, economic, or educational differences between knowledge producers (eg scientists) and knowledge users (eg individuals, organizations, tribes). When scientists interact with more marginalized populations, they often need to develop and deploy greater social capital (Figures 4 and 5). Creating social capital usually requires the use of "soft skills", such as listening, communicating, mediating, negotiating, and sharing (McNie 2007).

Working with Native American communities

Ferguson *et al*. (2016b) described a 5-year process of collaboration with the Hopi Department of Natural Resources (HDNR) to develop a local drought information system for a Native American tribe that is both isolated from major population centers and located in a region that suffers from a dearth of standard scientific data. To co-develop an effective drought plan based on local sources of information, the research team included a citizen of the Hopi Tribe, whose insider perspective and extensive social capital, developed through previous work with HDNR, facilitated improved integration and contextualization of drought information. The scientists first invested considerable effort into understanding drought from the perspectives of individuals across the spectrum of Hopi society and the institutional context into which HDNR drought advisories fit, then proceeded to cultivate relationships with the HDNR and Hopi villages, whose governance of drought ultimately dictates the effectiveness of drought preparedness and response actions, as a means of increasing engagement. The research team's commitment to a long-term, iterative process of engagement and partnership fostered social capital with key agency officials and pilot communities (Figure 5); this, in turn, engendered sufficient trust to implement a drought system that goes beyond provision of information, to facilitate dialogue about drought among managers and citizens.

Working closely with the Bishop Paiute Tribe Food Sovereignty Program, researchers at the Desert Research Institute (DRI) are using "micro-narratives" to understand how food sovereignty, climate change, and resource-management decisions are impacting tribal communities along the eastern front of the Sierra Nevada range in California. Federal resource managers in the area wanted to understand how resource-management actions affected these communities, including impacts on traditional hunting and gathering activities, whereas personnel with the Food Sovereignty program sought to understand how community members could be better engaged in traditional food consumption and crop production to foster tribal culture and healthy eating habits. Key to this project was the hiring of research assistants from the community, as well as working closely with existing tribal programs to support programmatic goals and outcomes while simultaneously developing a research design that met all of these needs. Using community members formally in the research project allowed for a greater level of participation and involvement and provided resources to the Food Sovereignty Program, allowing both to leverage resources and social capital in support of project and program goals.

Caption:

Figure 4. *Overlooking the Hopi and Navajo Nation Reservations in Arizona.*

Credit:

Amadeustx/Shutterstock.com

Caption:

Figure 5. *Postcard created and mailed to all enrolled tribal members for project outreach.*

Credit:

Kunder Design Studio/DRI

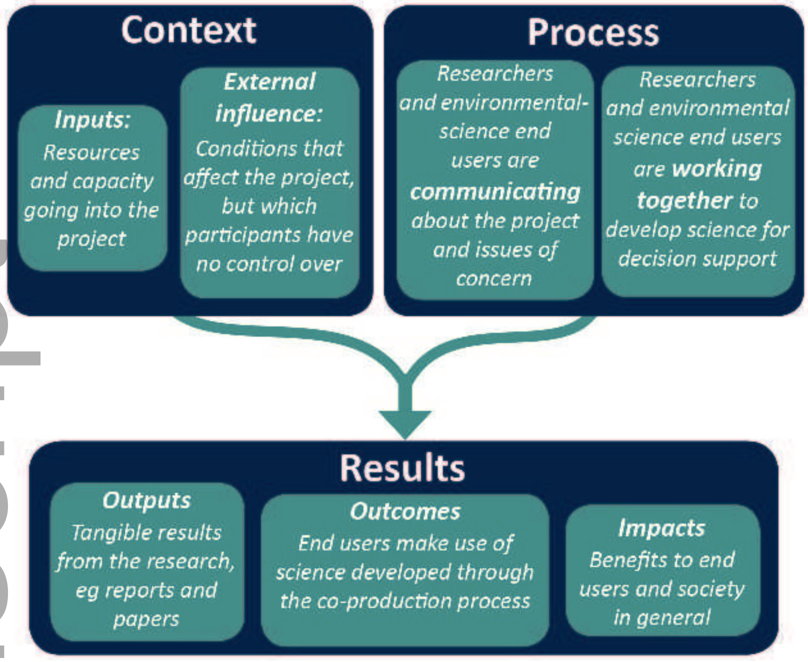
Panel 3. An instrumental use of research results: direct impacts to policy and management

Fire Danger PocketCards, which are carried by every wildland firefighter, provide a means for interpreting and communicating key fire danger index values set by the National Fire Danger Rating System. Developed in response to a fatal incident in which firefighters working in unfamiliar territory were caught off-guard by unexpected fire behavior, Fire Danger Pocket Cards serve as a "low-tech" tool for improving firefighter safety (Figure 6). Working with the National Wildfire Coordinating Group's Fire Danger and Fire Behavior Subcommittees, researchers from DRI co-developed a project to address concerns that the PocketCards were being underutilized by wildland firefighters. A key initial finding was that younger firefighters were less likely to use the cards if the "fire to remember" example included in the PocketCard occurred too long in the past (ie before they were born), as they simply did not think the fire was relevant to them. This and other findings led to a series of recommendations to the National Wildfire Coordinating Group Fire Danger Subcommittee that resulted in changes to the National Fire Danger Rating System, as well as to the design and content of the PocketCards.

Caption:

Figure 6. *Wildland fire fighters use prescribed fire to manage rangeland vegetation.*

Credit: A Orlemann/Shutterstock.com



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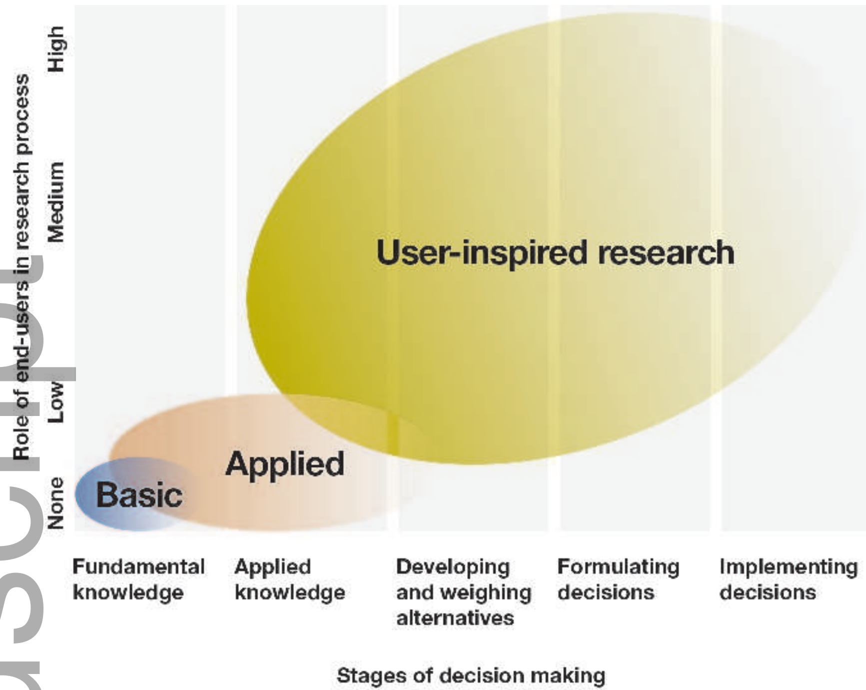

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