# Improving your impact: how to practice science that influences environmental policy and management

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## Abstract
Scientists devote substantive time and resources to collecting evidence to help solve environmental problems. Managers and policy makers must decide which actions will lead to desired environmental outcomes, based on the best-available evidence. Yet decision-makers frequently do not use much of this evidence. They may be unaware of it, lack access to it, not understand it, or view it as irrelevant. To improve the impact of science on decision making, we outline a set of practical steps: (1) Identify and understand your audience; (2) Clarify the need for evidence; (3) Gather "just enough" evidence; and (4) Share and discuss the evidence. Scientists unable to do each step in this order can still increase the applied impact of their science, especially as part of a larger team. Our hope is that these recommendations will translate into science being used more often when informing environmental and conservation decisions.

**Keywords**: evidence, science communication, stakeholder engagement, applied science, decision making

## Introduction
Decisions about environmental policy and management are often made in short time-frames and with high uncertainty. Environmental managers and policy makers need to quickly decide what to do to achieve their goals (Esch et al. 2018). Applied scientists seek to (and are regularly asked to) provide evidence to inform these decisions. And university scientists are increasingly motivated to conduct research that informs management and policy (Sutherland et al. 2004), although less applied research also has value.

Yet most research does not shape action (Sutherland and Wordley 2017), and is often designed without first talking to decision-makers. In our experience, scientists face a double-edged sword. Often, we are concerned about the slow pace of action and the lack of willingness to use evidence to shape policy and practice. But, just as often, we struggle to deliver evidence fast enough to affect decisions that are imminent. In addition, many scientists conduct research that is disconnected from the decision making of managers and policy makers. The result is that: 1) many scientists—whether in non-profits, government, or universities—produce work that has little-to-no impact on the decision making they are looking to influence; and 2) decisions are often made in the absence of adequate information required to evaluate alternate actions. Solving this requires more than science, including relationship building and communications.

There have been great advances in how to best synthesize and communicate evidence (Walsh et al. 2014, Alahdab et al. 2016). We believe that the key gap remains in what comes before and after evidence synthesis. Academics have analyzed this gap and recommend the need to bridge it (Cook et al. 2013, Enquist et al. 2017, Hallett et al. 2017, Lawson et al. 2017). This literature is insightful but often lacks practical guidelines for scientists that they can use to make their work more relevant and visible to decision-makers (but see Cockburn et al. 2016).

Here, we provide practical recommendations to increase the likelihood that science will lead to impact. Our intended audience is non-profit, government and interested academic scientists of all career stages. This includes both researchers and applied scientists who do not publish their work. We are motivated by our own difficulties in shaping action; difficulties that arise from not following some of the guidance we lay out here. We come from different backgrounds, both academic and applied. Our recommendations are focused on how to frame, conduct, and apply science, but are complementary to well-developed guidelines for evidence synthesis (Dicks et al. 2014, Polasky et al. 2017, Esch et al. 2018, Schwartz et al. 2018).

We group our recommendations into four areas: (1) Identify and understand your audience; (2) Clarify the need for evidence; (3) Gather "just enough" evidence; and (4) Share and discuss the evidence (Figure 1).

## 1. Identify and understand your audience

It is more likely that your research will be used if it answers a specific question for a specific group of decision-makers (your audience, or “end users”).

### 1.1 Why it’s important

Knowledge informs action through people in a variety of roles who will have different objectives and information needs (Table 1). For instance, the actions of land stewards are often influenced by immediate and practical management needs in a specific context. Program or organizational leaders require information on the broader impact or relevance of different strategies. Policy makers are frequently focused on the impact an action will have on desired objectives, as well as the costs, trade-offs and co-benefits. Research and scientific evidence need to influence several of these different kinds of decision-makers to lead to impact. These decision-makers often require different types of evidence – and research products – to address their needs and motivate them to change their planned actions. To that end, impactful science requires that you understand who will use the scientific information you provide and in what context. It also often requires collaborative work and sustained engagement with those decision-makers (Cockburn et al. 2016).

Understanding the audience and how they may use evidence allows you to tailor the type and form of evidence to better meet their needs. For research to be applied, it should answer a question that is relevant to at least one type of decision-maker. An applied research project may emerge in the context of a long-standing relationship between practitioner and scientist. In this case the scientist likely already understands the needs of their partner and is tailoring their science to meet those needs. These relationships are powerful tools for linking science to action, but do not always exist.

Our guidance is focused on early-stage work with the objective of developing such long-standing relationships and improving the efficacy of shorter ones. Such early-stage projects may come from a motivated scientist without established relationships who is seeking to apply their work to solve concrete problems. Similarly, applied scientists at nonprofit organizations may have a mission-driven strategy focused on influencing specific policies or land use change, without having clearly identified which decision-makers are most important to influence. Scientists should be clear on their motivations and role – whether they are advocating for a particular action, or serving as an honest broker of options to meet an outcome without strong preferences of their own. Sharpening the focus of the research – and ultimately the end products – on specific users will help improve the specificity of the research for the decision at hand and improve the likelihood the research will be used.

As an example, given growing risks of severe forest fires in California there is a push to reintroduce prescribed fire. But there are competing value systems that will influence if and how this should be done. The conservation community already has solid evidence that reintroducing fire as a natural process is necessary for restoring the resilience of western forests (Hessburg et al. 2016). However, there are multiple barriers to increasing use of prescribed fire. Among these are the potential public health impacts of smoke exposure (Brown et al. 2009) and risk of property loss from escaped fires. To influence state agencies responsible for permitting prescribed fire, scientists may need to show how prescribed fire size and timing can minimize air quality and human health concerns (e.g. Prunicki, Kelsey et al. in review). Alternatively, to get support from the Federal Emergency Management Agency (FEMA), you may want to highlight the ability of prescribed fire to reduce damage caused by wildfires.

## 1.2 How to do it

Before gathering evidence, identify and engage the audience who can make things happen on the ground to help solve your problem of interest.

### 1.2.1 Identify the specific, potential audience(s) you want to inform

There may be multiple audiences with different forms of influence and different science needs who could all help you achieve tangible impact (Marshall et al. 2017). Decide whether questions you address through research or evidence gathering are relevant to the decision making of each targeted audience (not always possible), or just the one that is likely to have the most influence on creating change.

### 1.2.2 Work with your target audience(s) to identify and clarify the problem(s) they are trying to solve

Engage the key decision-makers to discuss their perspective on the problem (whether the same as your problem, or a different one). If different, determine whether both can be solved together with the same actions. Discuss possible applications which can sharpen the research concept and lead to tangible collaborations.

### 1.2.3 Engage in the community of practice you are trying to influence

This can include going to practitioner's conferences and joining science advisory committees that are collectively tackling the issue you are interested in. It could also include discussions on social media or online forums, and even individual meetings with key stakeholders. Scientists can play an important role in bringing parties together around an issue and guiding collaborative development of research to solve a problem for specific decision-makers.

### 1.3 What you should know once you've done this step

You will have identified the stakeholders who influence the problem you want to help solve, their needs and objectives, how they see the problem, and whether they perceive a need for evidence. If they were not interested or need evidence outside of your expertise, you can recommend scientists or organizations better suited to meet their needs. Alternatively, you may have identified ways to modify your research proposal to better fit their needs, if you see potential to inform their decision making (either now, or in the future when timing is better).

## 2. Clarify the need for evidence

Evidence often does not lead to action, especially when the wrong evidence is collected. Build on your understanding of your audience and determine what evidence *would* motivate and empower them to do something new or different.

### 2.1 Why it's important

After identifying your intended audience and their objectives, identify what type of evidence is most needed. It is important to understand how the target audience perceives evidence, and whether or not a lack of evidence is a barrier to change (Marshall et al. 2017, Kary et al. 2018). For example, more research on the causes of climate change has had a minimal effect on public beliefs about the underlying cause (Brulle et al. 2012). Further, when conflicting evidence exists, it can lead to camps becoming entrenched behind different paradigms. The role of applied science should be to contribute the most useful knowledge to help the actors reach a decision, although evidence alone rarely catalyzes action.

Decision-makers and scientists may have different ideas of the type of evidence needed (Game et al. 2018). Consider the example of mitigating climate change through soil management that sequesters carbon from the atmosphere into soils (Zomer et al. 2017). To include soil management in formulating national greenhouse gas emission targets for the United Nations Framework Convention on Climate Change (UNFCCC), evidence is needed to identify which practices most effectively build soil carbon. *Why* soil carbon stocks increase is less relevant.

Although there is intense academic debate about the *why* (Amundson and Biardeau 2018), resolving this debate may not inform action.

### 2.2 How to do it
The following recommendations align with established guidelines for developing theories of change.

#### 2.2.1 Identify if the audience thinks there is an evidence gap (and why)
A perceived evidence gap can come from a lack of evidence, or because available evidence is seen as inadequate. Understanding whether the audience thinks there is an evidence gap and why will help you determine whether to collect new evidence, or whether to re-synthesize or refine communication of existing information.

#### 2.2.2 Identify actions the decision-maker is considering
Usually if a decision-maker is considering taking action, they have a set of potential actions in mind. Understanding actions being considered helps you hone your evidence collection to increase the likelihood of impacting action.

#### 2.2.3 Determine if new evidence will be enough to drive action
In some cases, an audience may want to act but lack the capacity to do so. For example, they may lack financing or staff capacity, in which case even highly relevant new evidence may have no impact. There also may be high organizational resistance to new actions. If these barriers block action more than lack of evidence, explore whether your new research may help them overcome the barriers. For example, whether robust evidence for importance of the desired action would help them raise funds to make it possible.

#### 2.2.4 Translate actions being considered into research questions
The articulated need for evidence is often too broad to be actionable until it is translated into key research questions. For instance, planting winter cover crops on farms is often claimed to improve soil health. If asked to provide evidence evaluating this claim, one question to explore could be how much carbon is built up when applying a specific cover-crop mixture. These questions are often more specific than the overall evidence need, so it is important that generating questions be done collaboratively with the end user to ensure data will be enough to advance action (once collected, synthesized, and communicated).

### 2.3 What you should know once you've done this step
You will know whether new evidence is likely to inform actions taken, and what type of evidence is most needed. You will also have specific research questions developed in partnership with the user that fill at least part of the evidence gap in a way that will help catalyze action.

## 3 Gather "just enough" evidence
Tailor your evidence collection to accommodate the realities of policy and practice (limited time and resources available), while advocating for the rigor needed for action to be credible.

## 3.1 Why it's important

Gathering evidence takes time and money that could be spent on implementation (Salzer and Salafsky 2008). Further, the ability of new evidence to influence decisions often has a limited timeframe (e.g. new legislation or incentive programs are being considered on a certain date). The effort dedicated to gathering or synthesizing evidence should reflect the timeframe for making a decision and the expected value of having new information. The "Value of Information" (VOI) is influenced by factors such as risk associated with making a poor decision, stakeholder comfort with uncertainty, and cost of gathering more information (McDonald-Madden et al. 2010, Polasky et al. 2011, Runge et al. 2011, Canessa et al. 2015, Maxwell et al. 2015, Minelli and Baio 2015, Bennett et al. 2018).

For example, Fisher et al. (2018) evaluated an end user's decision to invest in conservation to improve water quality rather than building a new water pipeline. Comparing models using high-resolution (1-m) spatial data to models using lower resolution data (30-m) they found the finer-scale data would not have changed the decision made to invest in conservation. In this case, higher accuracy did not drive better decisions, but did raise program costs. Beyond accuracy and spatial resolution, "just enough" can relate to many facets of evidence synthesis and creation, including depth and breadth of literature review, complexity of modeling, the extent of new data collection, and the precision of estimated effects. Additional effort for evidence collection should be carefully weighed against the probability of it influencing the decision (Canessa et al. 2015).

Risk tolerance and uncertainty influence how much effort should be invested in evidence gathering. When uncertainty is high, but known or perceived risks of the wrong decision are low, then acting immediately, without new evidence, may be the appropriate strategy. Actions can then be improved through adaptive management. However, if the risk is high or tolerance for risk is low, then the value of new information increases (Howard, 1966). Yet risk and uncertainty come in various guises, which can influence the impact new evidence will have on a decision.

For example, when crafting policies to incentivize reducing greenhouse gas emissions, many forms of uncertainty exist, and their importance varies with context and the kind of decision made (Hawkins and Sutton 2009). When quantitative greenhouse gas reductions are tied to regulatory or funding incentives, improved precision of the impact of management interventions can be high. There is usually high uncertainty in modeled estimates of the impact of different interventions, and high value in research to improve those estimates. But when setting broader climate policy (e.g. to guide global targets and investment), precise estimates are less important than identifying which major drivers of climate change to target (Knutti and Sedláček 2013, Bradford et al. 2016). Policy makers working at different spatial and temporal scales may then vary in how they weigh different types of uncertainty.

## 3.2 How to do it

Gather the amount and type of evidence needed to inform a decision in a timely manner.

### 3.2.1 Understand the type of data your audience needs

Establish whether specific quantitative evidence is needed to ensure an outcome (e.g. X tons of $CO_2e$ reduced by a certain practice at a certain location and timeline) or if qualitative directional evidence will suffice (e.g. intervention X will increase $CO_2e$ captured, or will increase it more than intervention Y). Explore whether site-specific information is needed, or if general information will do. For example, conservation agriculture on average increases soil carbon, but won't for some geographies because of soil type and climate (Govaerts et al. 2009).

### 3.2.2 Tailor the type of evidence to the value of information

Different approaches vary in their strengths and weaknesses, ranging from time-consuming, quantitative meta-analyses usually focused on a narrow body of literature to rapid expert assessments that provide a qualitative projection of outcomes but may be more inclusive of available evidence (Grant and Booth 2009). If the value of new information is low and/or time constraints are high, consider expert assessment or other rapid methods. If the value of information is high and time allows, consider more time-intensive approaches.

### 3.2.3 Evaluate the potential for adaptive management

Adaptive management is a continual learning process. It emphasizes trying different practices, measuring their success, and changing management accordingly (Walters 1986). If adaptive management is viable (especially if the initial value of new information is low), invest more effort in planning for monitoring than on generating extensive evidence up front.

### 3.2.4 Make and execute a work plan that meets the hard deadline for a decision to be made

Identify methods appropriate for the research question and type of data needed. Given resource and other constraints, ensure that data collection or synthesis can be completed in time to influence the decision.

### 3.3 What you should know once you've done this step

You understand the appropriate time, rigor, and approach for collecting and synthesizing "just enough" evidence to best inform an action or policy given the audience's known tolerance for risk.

## 4. Share and discuss the evidence

Most scientific articles are not read by targeted or potential audiences. To achieve the desired impact of their research, scientists should invest time in how the evidence is communicated.

### 4.1 Why it's important

If evidence is not seen and understood by the relevant audience, it will have little to no impact on action. Many excellent peer-reviewed papers are not read beyond researchers. Even applied journals in conservation and ecology are not regularly read by environmental managers and policy makers. Peer-reviewed papers are still tremendously important outlets for reporting science, but are insufficient to ensure adoption of information (van Kerkhoff and Lebel 2006). Even where work is co-developed (and potentially co-implemented) with potential users, the highly technical language of peer-reviewed work can limit full understanding and, thus, potential application. Impact can be improved by communicating results to the broadest suite of relevant audiences in ways that capture attention and meet their needs.

## 4.2 How to do it

Building on the three steps outlined in previous sections, scientists should invest in communicating their findings (Figure 2). This may require an investment in your own professional development as a scientist, such as communications training.

### 4.2.1 Develop a clear, compelling message

You should have a consistent message summarizing your research that will motivate your audience. It should include key results, why they matter, and clear recommendations or options for decision-makers. A good message is short but memorable, avoids denigrating the audience's beliefs, and is positive (Cook and Lewandowski 2011). People want to see solutions that show how they can have positive impact, rather than avoiding what they have been doing wrong (Tversky and Kahneman 1981). There are several trainings (online and in-person) publicly available to help scientists craft and deliver clear messages. Examples include COMPASS' Message Box training and Alan Alda's Center for Communicating Science. There are also written resources like "Don't be such a scientist" (Olson 2009) and "Do I make myself clear?" (Evans 2017).

### 4.2.2 Document relevance and caveats associated with the evidence

Explore your audience's confidence in the underlying science, and flag key concerns or questions. Explain how appropriate the data sources and methods are for addressing the questions being asked (e.g. Silver 2012, Ionides et al. 2017). For example, document the credibility of the data sources and methods, the applicability of the evidence to their particular context, and explain the (in)consistency of results among approaches (Game et al. 2018). If relevant comparative case studies exist, use them to highlight key factors that could impact the results.

### 4.2.3 Create a communications plan as part of the research design

Science communications are often planned around the release of a paper. Beginning planning for communications much earlier allows for: 1) selecting a product format(s) and outlet your audience will read (e.g. blogs, video, news, webinars, etc.); 2) identifying the most effective venues (e.g. electronic, by mail, or in-person) to share the communications product(s); and 3) creation of additional tools to facilitate uptake of the evidence (e.g. a web page to visualize your results). Communications plans are ideally developed with communications experts and members of the target audience, and updated as research is completed. Communication products should be shared repeatedly over time to increase the likelihood of them being received by the intended audience(s).

### 4.2.4 Meet with your audience(s) face-to-face

Face-to-face interaction between scientists and users is one of the most important ways to increase use of evidence (Seavy and Howell 2010). This can include meetings, field visits, workshops, conferences, and high-quality videoconferencing. Not all face-to-face interactions are equal; the quality of interaction depends, in part, on how well you communicate, which is why communications training is so valuable. These personal interactions are part of a long process of building relationships with decision-makers that is essential to see your work make an impact in the world.

#### 4.2.5 Improve your writing

You need to produce good written products, through improving your writing skills and/or enlisting help from experts. “Good” products provide information that is efficiently understood and used by the intended audience. This is a challenge for even experienced writers. Always seek feedback on your writing from multiple people outside of your technical area, including from a potential user, communications expert, or friend. This can help you find jargon and knowledge assumptions that impede full understanding. Even peer-reviewed journal articles should have a compelling narrative with engaging language, while also being technical and precise (Schimel 2012).

#### 4.2.6 Remove barriers to access

Lack of access to protected articles is a barrier for a decision-makers, so commit to making research papers and products publicly available. If open access is not an option, posting the accepted version on a personal website is typically permitted. Follow copyright laws and journal guidelines; sharing via institutional web pages, or repositories like ResearchGate, is increasingly not allowed. Before acceptance, you can post a copy of your submission in a pre-print archive, which allows you to share your product with your audience earlier.

#### 4.2.7 Publish accessible summaries of your work

Write and share non-technical summaries of your results on social media, for a blog, or other online outlets (e.g. for The Conversation, a research news site dedicated to sharing scientific research in a journalistic style; The Conversation US Inc. 2019). Ensure your summaries are accessible and engaging. Ideally use a variety of approaches, as different people learn better through diagrams, by reading, or by listening. Communicate key technical terms and concepts with a good narrative — use engaging language without obscuring nuance (Dubé and Lapane 2014) and connect to tangible examples (Dahlstrom 2014). For example, a story about a farmer who planted cover crops may be more memorable than citing the mean reduction in soil erosion under cover crops. Then, promote your own work through social media with an engaging tweet (or a coordinated series of tweets) that link to the summaries and the paper.

#### 4.2.8 Share all data and code, not just statistically significant findings

Following best practices in data availability means your work is more available to both academics and non-target decision-makers. A bias towards significant findings in peer-reviewed literature can mask what does not work. We recommend making all results available and visible, even if they are not the center-point of your communications strategy (Sutherland et al. 2004). Key findings should be summarized in an evidence library (e.g. Conservation Evidence; ConservationEvidence.com, 2019). Data should be archived in a repository (e.g. Knowledge Network for Biocomplexity or others depending on norms for a given field) that generates digital object identifiers (DOIs) and cites these in publications. We recommend sharing code on GitHub.

### 4.3 What you should know once you've done this step

You have a communications plan developed with your research team, and ideally with your intended audience. After you have results, you have met with users and discussed your work. You published your work in a technical journal, and/or you have non-technical products. Your target audience can accurately describe the core findings of the work and how that evidence is important to their potential actions. Finally, you shared all data and code (within legal and ethical limits) on a stable repository, ideally with a DOI for data.

## Conclusion

Scientists need to work deliberately on shaping their science to have impact. This applies both to applied scientists whose job requires influencing decision-makers, and to academic researchers interested in having their work be applied. The practical steps outlined here are critical elements to having a tangible influence on decision making. Ideally scientists can follow them from start to finish when involved in a project from the beginning, working with colleagues with complementary expertise. See Figure 2 for a potential decision tree for this process. However, when asked to engage on a project where decisions have already been made (e.g. defining an audience and the need for evidence) there is still value in reviewing all steps to understand what has been learned and how to ensure the work going forward will have impact. How you engage will likely be influenced by the context, as well as the resources available to both you and the decision-makers. For example, many decision-makers are embedded within organizations that have effective communications, so your role could be limited to ensuring the veracity of evidence presented. However, even in this context, the scientist should remain involved in development of communications materials to ensure important details from the evidence are not lost.

Focusing your involvement in areas that best fit your expertise and those that the decision-makers lack, will help you efficiently inform the decision process. Engaging in this process should lead to a stronger relationship between scientist and user. In many organizations, scientists often serve multiple roles as applied scientists and facilitators of partnerships with management agencies or individual managers. We believe that strong applied science relies on forming trusting relationships between scientists and their partners. Following this guidance should help those relationships develop. Ideally much of our guidance will eventually feel normal and become part of your established process of engagement with decision-makers.

We deeply appreciate that people spend a great deal of time developing and synthesizing much-needed science to help address problems in conservation and the environment. Our hope is that the recommendations we make will translate to that science being used more to inform decisions about the issues you care about.

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## Authorship contributions

All authors contributed to this work equally.

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## Tables

Table 1. Typology of potential users of scientific information. Scientists often use catch all words like practitioner and policy maker to refer to a diverse set of potential users with different objectives. Understanding these diverse objectives is important for targeting science to have impact.

| Type of user | Description | Nature of objective | Most useful knowledge |
|---|---|---|---|
| Land steward | Land/property managers (e.g. reserve manager) | Needs to know the best management practices to achieve their desired objectives for a specific geographic place. | Practical, context-specific, and precise |
| Project/Program Manager | Leader of a team focused on a specific issue, community, or region | In addition to understanding what the best management practices are, they need to understand contributing factors to success or failure. This includes how these factors interact with each other to influence the outcomes for the target issues. | Practical and context-specific, as well as broader awareness of enabling conditions |
| Department or Agency Leader, Executive Director, Policy Maker | Leader of a government agency or large department, or an executive leader for non-profit organization | Needs to know multiple benefits, trade-offs, and costs (time, effort, and money) among varying actions and priorities at a broader scale (e.g. across contexts) to balance outcomes and to communicate effectively about issues. | Practical-Conceptual |
| Philanthropist or Influencer | A major donor or public figure who can dedicate resources, catalyze | Wants to know the latest and most impactful science and | Conceptual |

| | | | |
|---|---|---|---|
| | support, and/or influence public opinion | practice to promote promising work. | |

## Figures

Figure 1. The steps this paper recommended to increase the likelihood that research will have an impact on decision making. This may not be a linear process, but generally will begin at the top and move down. Consider monitoring the influence of the work to improve in the future.

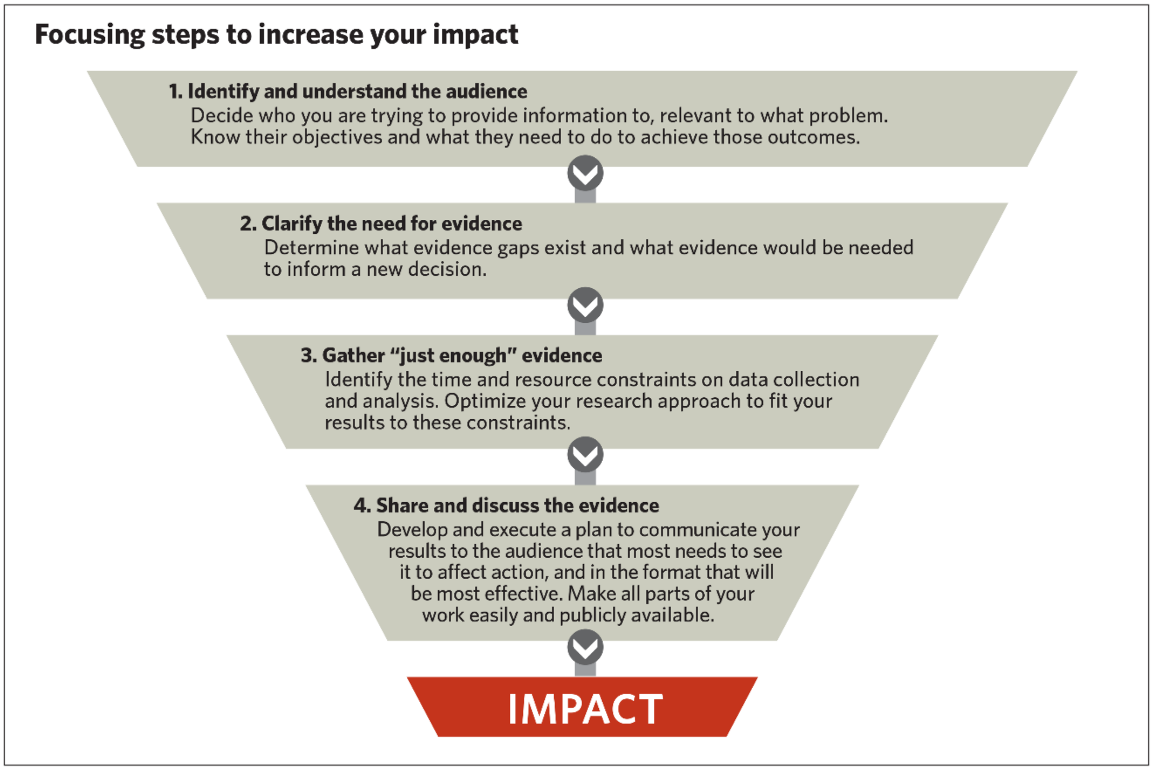
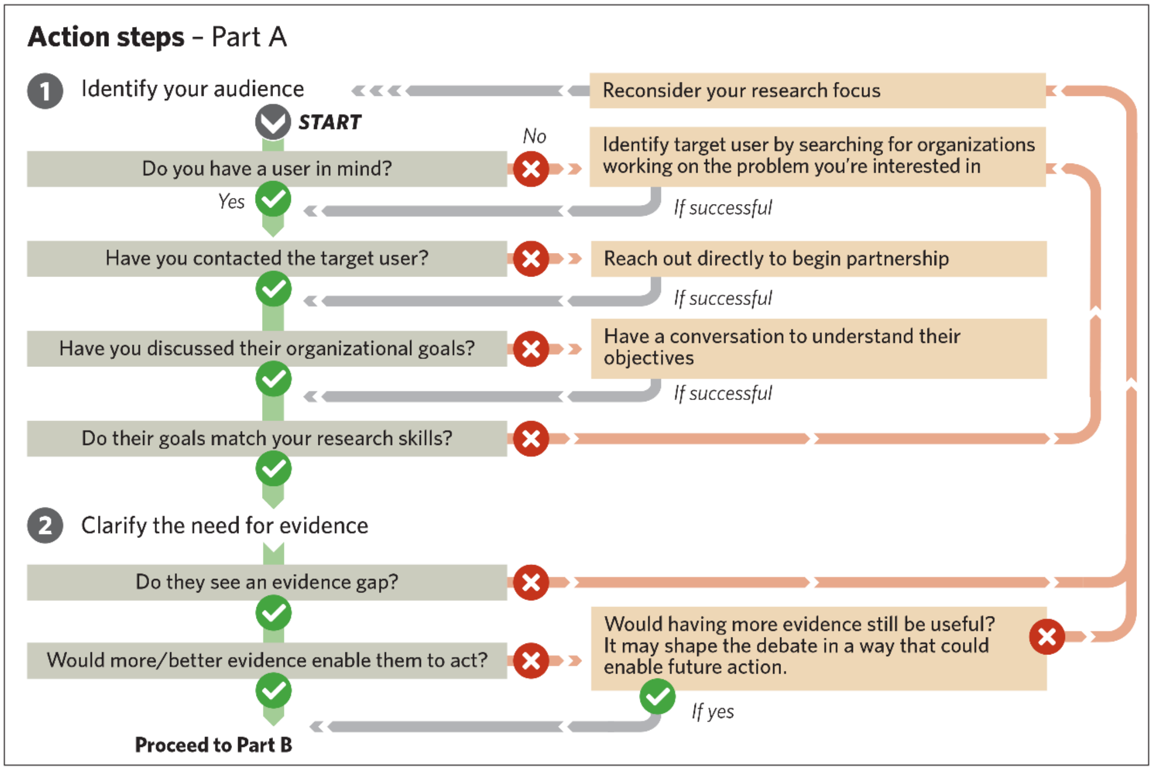
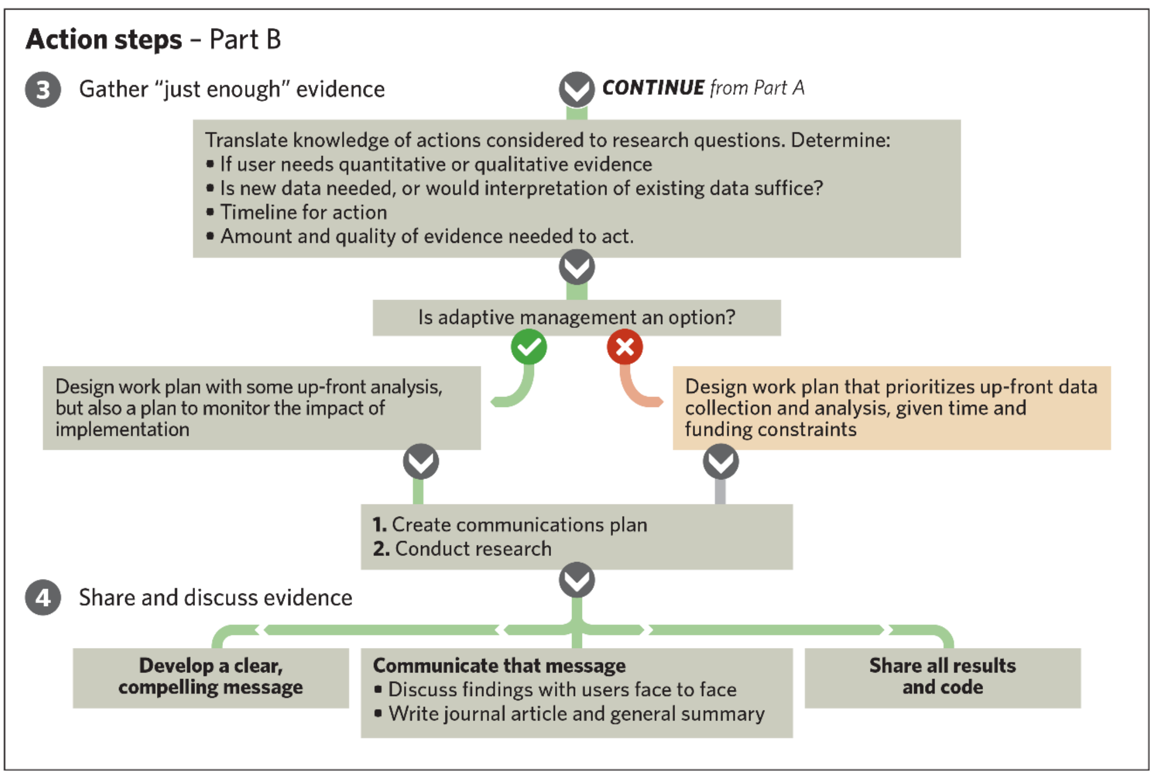



Figure 2. A potential decision tree for following the guidelines in this paper (begin with Part A and proceed to Part B).


Action steps – Part A
1 Identify your audience
START
Reconsider your research focus
No
Do you have a user in mind?
Identify target user by searching for organizations working on the problem you're interested in
Yes
If successful
Have you contacted the target user?
Reach out directly to begin partnership
If successful
Have you discussed their organizational goals?
Have a conversation to understand their objectives
If successful
Do their goals match your research skills?
2 Clarify the need for evidence
Do they see an evidence gap?
Would more/better evidence enable them to act?
Would having more evidence still be useful? It may shape the debate in a way that could enable future action.
If yes
Proceed to Part B


Action steps – Part B
3 Gather "just enough" evidence
CONTINUE from Part A
Translate knowledge of actions considered to research questions. Determine:
▪ If user needs quantitative or qualitative evidence
▪ Is new data needed, or would interpretation of existing data suffice?
▪ Timeline for action
▪ Amount and quality of evidence needed to act.
Is adaptive management an option?
Design work plan with some up-front analysis, but also a plan to monitor the impact of implementation
Design work plan that prioritizes up-front data collection and analysis, given time and funding constraints
1. Create communications plan
2. Conduct research
4 Share and discuss evidence
Develop a clear, compelling message
Communicate that message
▪ Discuss findings with users face to face
▪ Write journal article and general summary
Share all results and code