BRIDGING THE GAP BETWEEN RESEARCH AND DECISION-MAKING: EMPIRICAL EVIDENCE FROM A CASE STUDY OF GRAY WOLF (CANIS LUPUS) MANAGEMENT IN THE U.S.

by

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DEDICATION

In memory of my father, Robert W. Brostek, who taught me to be a scholar. And in celebration of my son, Aven, whose curiosity and fascination with the world inspire me every day.

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ABSTRACT

BRIDGING THE GAP BETWEEN RESEARCH AND DECISION-MAKING: EMPIRICAL EVIDENCE FROM A CASE STUDY OF GRAY WOLF (CANIS LUPUS) MANAGEMENT IN THE U.S.

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Does science inform decision-making? This question has been the subject of much attention across a wide range of scientific fields generating hundreds, if not thousands, of publications. In this dissertation, the gap between science and decision-making is examined within the context of conservation biology, including commonly proposed reasons that the gap exists and popular suggestions for bridging the gap, as well as areas where the current literature regarding the gap lacks empirical backing. To address the shortcomings in the "bridging the gap" literature, this dissertation had three goals: 1) to provide additional data about purported barriers and solutions to bridging the gap between research and decision-making; 2) to better understand the role that institutional incentives, which often place an emphasis on academic impacts, may have in the persistence of this gap; and 3) to explore the idea of creating a standardized method to measure the non-academic impacts of scientific activities, as a potential way to incentivize behaviors that bridge the gap. A conservation science implementation case study was conducted and focused on the use of scientific publications to support gray wolf (*Canis lupus*) management decisions in the United States (U.S.). For this case study, reviews were conducted on all wolf literature relevant to this species in the U.S. and bibliometric analyses of U.S. federal regulations governing wolf management were performed. Interviews and surveys with wolf managers and researchers were also conducted in order to better understand the characteristics of research and researchers that are bridging the gap and potentially affecting decision-making. Overall, the results of this case study suggest that 1) science seems to play a role in decision-making; 2) science that is having an impact on decision-making is often the result of collaboration between academic scientists and government employees; 3) scientists based in academia can simultaneously have an impact on decision-making and academic thinking (a "dual-impact"); and 4) analyzing citation data from federal regulations and other similar "decision documents" could provide a new way to measure the impact of scientific research on decision-making. The thesis concludes with brief biographical sketches of scientists who are effectively bridging the gap, and proposes creating a method for measuring the impact of scientific publications on decision-making: a "Management Impact Index."

CHAPTER ONE: INTRODUCTION AND LITERATURE REVIEW

Introduction

"The centers of basic research…are the wellsprings of knowledge and understanding. As long as they are vigorous and healthy and their scientists are free to pursue the truth wherever it may lead, there will be a flow of new scientific knowledge to those who can apply it to practical problems in Government, in industry or elsewhere." (Bush 1945, p. 12).

As suggested by Vannevar Bush (1945) above, knowledge gained from scientific research plays a vital role in our society. Research can inform decision-making and guide policy creation, leading to societal advancements such as new medications, improving safety standards, and advancing technology. However, contrary to Bush's idea, the degree to which scientific research, conducted at universities throughout the U.S., actually does flow to decision-makers in Government is, in many cases, underwhelming. While the flow of information to decision-makers varies across fields of research, there is evidence that the gap between science and implementation exists in many and diverse disciplines such as health services (Dobbins et al. 2007), social sciences (Weiss & Bucuvalas 1980), technology (Beyer 1997), and, particularly, conservation biology (Pullin et al. 2004; Anonymous 2007; Knight et al. 2008).

In this dissertation, the gap between science and implementation is examined within the context of conservation biology, starting with a review and assessment of the "bridging the gap" literature within the field, including reasons that the gap exists, popular suggestions for bridging the gap, and areas where the current literature falls short. A conservation science implementation case study follows, which focuses on the use of scientific publications to support gray wolf (*Canis lupus*) management decisions.

For this case study, reviews were conducted on all of the relevant wolf literature and bibliometric analyses of federal regulations governing wolf management were performed. Interviews and surveys with wolf managers and researchers were also conducted in order to better understand the characteristics of research and researchers that are bridging the gap and having a potential impact on decision-making. The thesis concludes with recommendations for next steps, including creating an alternative method for measuring the impact of scientific publications on decision-making: a "management impact index."

History of "Bridging the Gap"

In the United States, the Post-World War II era ushered in a period characterized by optimism about the role that science could play in decision-making. This optimism led to the establishment of new government scientific institutions in the U.S., such as the Council of Economic Advisors in 1946, the National Science Foundation in 1950, and later, the Office of Science and Technology Policy in 1976 (Desmarais & Hird 2013). However, by the late 1970s, many scientists and policy-makers began to question why so little scientific research was utilized in decision-making. In 1978, the National Research Council (NRC) issued a report entitled "*Knowledge and Policy: The Uncertain Connection,"* which concluded that, despite numerous steps taken to increase the relevance to and use of science for decision-making, "we lack systematic evidence as to whether these steps are having the results their sponsors hope for…" (National Research Council 2012, p. 2). This report focused on the social sciences but highlighted a problem common to many disciplines. Soon after, questions about how science bridges the gap spawned a whole field of research known as "Knowledge Utilization," with its own journal; *Knowledge Creation, Diffusion, Utilization* was started in 1979 and later replaced by *Science Communication* (National Research Council 2012; Desmarais & Hird 2013). In the years since 1979, the field of "knowledge utilization" grew steadily. Despite this growth, a 2012 NRC report, which followed up on the 1978 report, reached the same conclusion as the first—that we still do not have an "adequate understanding of what happens between science and policy" (National Research Council 2012, p. 31).

Bridging the Gap in Conservation Biology

Within the field of conservation biology, the topic of how scientific research informs policy and management decisions (referred to as "decision-making" from here forward, except where specified) is a topic of much interest, and there have been a number of opinion pieces written in the last 15 years. Conservation biology is a multi-disciplinary field that straddles the theoretical and applied, with much of the research focused on the general idea of preserving life on earth. In 2006, John Robinson, then

President of the Society for Conservation Biology, published a paper that discussed the state of the field. He suggested that conservation biology has greatly influenced the practice of conservation but has done little to inform practice outside of the field (Robinson 2006). He stated that conservation science rarely informs national or international policy priorities and initiatives. This idea is supported by the results of studies within conservation biology sub-disciplines such as nature reserve management (Prendergast et al. 1999), endangered species recovery planning (Stinchcombe et al. 2002), and habitat restoration (Seavy & Howell 2010). Overall, the conservation biology "bridging the gap" literature suggests that many important research findings never make their way to policy-makers and government managers and practitioners. Instead, the results and recommendations stay trapped in the world of academic journals, conference proceedings, and ivory tower discussions. If conservation biologists—scientists interested in the preservation and protection of life on earth—are truly going to have a real world impact, the knowledge they acquire needs to find an audience outside of academia and reach those who have the power to implement recommendations that follow from their research.

Why is there a gap between research and decision-making?

The first step to bridging the science decision-making gap is to better understand the nature of the gap and the reasons that it exists. There are several reasons for the gap that are posited in the literature. Based on the current literature review, these reasons are collapsed into seven categories, described below:

1) Lack of Access:

Decision-makers often lack access to scientific publications (Sunderland et al. 2009). While most researchers at academic institutions in developed countries have easy and free access to a wide range of academic journals through their institutional library, this is not true for many decision-makers. For instance, 65% of management plan compilers surveyed by Pullin (2003) indicated that scientific literature is too time consuming to locate and access. In other cases, especially in developing countries, individuals and institutions may not be able to afford subscriptions to relevant scientific journals, and when they can, the literature may not be in the decision-maker's native language (de la Rosa 2000).

2) Lack of Relevance:

Many researchers focus their studies on topics that are of academic interest and highly publishable. Often these topics do not directly align with the knowledge that decision-makers need to do their job. Fazey et al. (2005) conducted a survey of lead authors on 547 conservation papers published in three prominent conservation journals (*Biodiversity & Conservation*, *Biological Conservation,* and *Conservation Biology*) in 2001. They found that, according to the authors, only 20% of published studies had high relevance to policy, and only 37% to management. Relatedly, they also found that, according to the interviewed authors, conservation action related to their published research had only been implemented 33% of the time.

Similarly, Esler et al. (2010) conducted a bibliometric analysis to determine what portion of invasive species literature, published between 1987 and 2009, was "knowing" (theoretical) versus “doing” (management-oriented) research. From the 8,800 papers that were included in the study, 26% mentioned “management,” but only 2% mentioned “policy,” and 3% mentioned “implementation.”

Even when the topics are highly relevant, authors are not taking the extra steps required to make their research more understandable to decision-makers. If decision-makers cannot see the direct relevance of a particular scientific paper, they are not likely to spend the time reading the article and trying to apply it to their own work. The results of studies suggest that this is the case. For instance, when asked why they don’t use scientific literature to help with their decision-making, 25% of the management plan compilers responding to Pullin’s (2003) survey said that it was too technical and difficult to interpret scientific literature in the context of their decision-making.

3) Different Decision-Making Cultures:

The world of science and the world of policy have different cultures, with diverse goals, processes, and languages. While science focuses on producing universally valid knowledge, decision-making focuses on practical actions to address specific issues, often on a specific timeline and in a particular location (Mostert & Raadgever 2008). Scientists are judged by their peers based on metrics such as publication and citation rates and the impact factors of the journal wherein they publish. Decision-makers, on the other hand, are most often accountable to the public and stakeholder groups. Such cultural differences can lead to incongruence between the way that scientists provide information and what decision-makers actually need. For instance, policy-makers are often faced with short time horizons and are seeking immediate “cut and dried” solutions to a problem, but the answers that are given by scientists require long-term planning, incorporate a high degree of uncertainty and caveats, and often require complex implementation (Briggs 2006; Brownson et al. 2006; Hanssen et al. 2009). Often by the time scientific research findings are adequate to support a policy, the issue may no longer be of importance to policy-makers or the public.

Policy-makers are also often interested in data that indicate how the public feels about an issue and why this issue should have priority over others, i.e. public values (Brownson et al. 2006; Likens 2010). Scientific literature rarely goes the extra step to comment on such things, and indeed, may actively disregard public values to focus purely on scientific aspects. Brownson et al. (2006) summarized the cultural differences between the research and policy arenas by comparing the decision-making processes of scientists and policy-makers. There are acute differences in both the concrete steps that decision-makers take as well as in the drivers of their decisions. For instance, scientists systematically test hypotheses through experimental and observational studies to arrive at their results, with their main influence being specialized knowledge. In contrast, policy-makers' knowledge and decisions are tied to the history of related policies and the demands of their stakeholders.

4) Narrow Focus:

Scientific literature also tends to be narrowly focused and does not take into account context (for example, the economic, political, and social) surrounding the issue. Eden (2011) attributes the root of this problem to the fact that we have traditionally used a "loading dock" model of basic research. In this model, which is reminiscent of

Vannevar Bush's (1945) vision of basic research, science determines its own course and will provide a reservoir of knowledge that can be drawn upon. Eden (2011) asserts that this model has not succeeded because resource management requires an approach that is more integrative and inclusive. Policy and management decisions require consideration of multiple disciplines, stakeholders, (sometimes conflicting) objectives, and the political and economic realities (Jacobson & McDuff 1998; Eden 2011; Palmer 2012).

Practitioners and policy-makers must take these real-world complexities into account, while researchers can overlook them. Researchers need to acknowledge these constraints and understand that even if the literature is accessible and relevant to policy-makers and practitioners, the recommendations may be quickly disregarded if they lack political, economic, and social support (Prendergast et al. 1999; Brownson et al. 2006; Arlettaz et al. 2010; Eden 2011; Young & Van Aarde 2011).

5) Lack of Incentives:

Scientists based at academic institutions often do not have adequate incentives to engage in activities that help to bridge the gap between science and decision-making (Briggs 2006; Chan 2008; Chapron & Arlettaz 2008). This is largely the result of an academic institutional structure that does not provide incentives (e.g. credit toward promotions and tenure) to academic researchers to participate in wide public dissemination or implementation of results (Brownson et al. 2006; Arlettaz et al. 2010). Burke and Lauenroth (1997) created a conceptual model of the trade-off that scientists experience when they devote time to policy or other public services. They suggest that ecologists who initially spend a large part of their time on research early in their career are highly productive while those that contribute to policy or other public services do not achieve an equally high level of scientific productivity. Given that scientific productivity is highly valued in academic institutions, many scientists may have little incentive to engage in other activities that take time away from this type of productivity. Although some forward-thinking universities are starting to count public communication of science - and applying science to real world problems - in promotion decisions, most scientists are often dissuaded from doing so in order to concentrate on research that increases the university's academic rankings (e.g. publications in high Impact Factor journals) or brings in funding for the university (Abbot et al. 2010).

6) Lack of Agreement:

Scientific information presented to the public is subject to interpretations that are influenced by personal beliefs and characteristics such as religion, socioeconomic status, race, motivations, and prior knowledge of the way that the world works (Johns 2005; Groffman et al. 2010). Scientific knowledge that is not consistent with other pre-held beliefs and values may be doubted or actively ignored. This is especially true when it comes to "controversial" topics such as climate change (Lorenzoni et al. 2007), evolution (Lawson and Worsnop 1992), and stem cell research (Ho et al. 2008). Further complicating this issue is the fact that the popular media, in an attempt to present a fair and balanced story, tend to highlight controversies while largely ignoring scientific consensus (Mooney 2004; Boykoff 2007; Everland and Cooper 2013). This can further escalate controversies, focusing attention on the non-scientific aspects of the issue and leaving little room for science.

7) Fear of the Appearance of Advocacy:

One of the most important facilitators of moving science into policy is personal contact between scientists and decision-makers (Brownson et al. 2006). Nevertheless, many scientists avoid becoming involved in policy out of fear of being labeled an "advocate," and there is much debate in the conservation biology literature about the appropriateness of advocacy (Kaiser 2000; Scott et al. 2007; Nelson & Vucetich 2009).

At one end of the debate are those that argue that advocacy is part of a scientist's responsibility to society and that failure to advocate can mean that science does not have a "place at the table" during decision-making (Nelson & Vucetich 2009; Parsons 2013). At the other end of the debate are those who feel that it is imperative that scientists avoid any appearance of advocacy. They argue that scientists who advocate for their findings risk becoming indistinguishable from environmental activists or that advocacy can undermine the scientist's, and even the discipline's, credibility (Kaiser 2000; Nelson & Vucetich 2009). The non-advocacy stance may even be encouraged by industries, agencies, or rival scientists who fear that new science may force them to change their practices, increase competition for funding or gain media attention (E.C.M. Parsons, pers. comm.).

The complexities of the arguments on both sides of this debate mean that there are no easy answers for many conservation biologists. Consequently, many refrain from becoming involved in the decision-making process.

Solutions for Bridging the Gap

Bridging the gap between science and decision-making is a complex and multi-faceted problem that will take more than a single silver-bullet solution to resolve. The literature suggests many potential solutions, which have been grouped into eight categories as follows:

1) Implementable Results:

Researchers should consider how research results can be implemented when designing studies, writing up results, and engaging in follow-up activities. Studies suggest that conducting research with an eye toward how the results could be implemented can go a long way toward bridging the gap. For instance, Knight et al. (2008) surveyed the authors of 159 published conservation assessments and found that 70% of the assessments were formulated with the intention of improving research techniques rather than implementing action. Of the conservation assessments whose objectives were to implement action, 94% were actually implemented. In contrast, only 11.7% of the conservation assessments whose primary objective was to advance science through improving research techniques were implemented.

Researchers should write up research results in a way that facilitates use by practitioners and policymakers. For instance, research papers could include a short section that discusses implementation or the implications of the research (Airame 2003; Holmes & Lock 2010).

Finally, researchers should consider being personally involved in the implementation of their recommendations. Arlettaz et al. (2010) found that the involvement of researchers in the actual implementation of their research results led to more successful implementation.

2) Accessible Results:

Many researchers see publication of their research in high-impact journals as a final step in the research process and believe that the published information will "trickle down" to decision-makers (Knight et al. 2008). However, due to the fact that many decision-makers have limited time and access to journals, mere publication is not sufficient to bridge the gap. Scientists need to think more broadly about dissemination. Summarizing results and recommendations on websites, in magazine articles, and in press releases for local newspapers and radio shows are good ways to reach a broader audience.

A 2009 survey conducted by *Nature* found press releases to be the top source of story ideas for science journalists (Brumfiel 2009). Researchers can also create blogs which disseminate their research results and allow for online discussion (Ashlin & Ladle 2006). Like press releases, blogs are quickly becoming an important outlet for scientific information; the *Nature* survey also shows that the percentage of journalists who indicated that they found their story ideas on a scientist's blog rose from 17% in 2004 to 63% in 2009 (Brumfiel 2009).

Social media, such as Twitter, are increasingly a useful avenue for the dissemination of scientific data or ideas (Shiffman 2012; Darling et al. 2013; Parsons et al. 2014). Darling et al. (2013) found that "tweeting" research results facilitated dissemination to a broad audience, including science students, science organizations, government scientists, and journalists.

Orally discussing research results outside of academic conferences is also suggested. Face-to-face interaction with practitioners and policy staff as well as presentations at focused industry workshops can help research reach a wider audience (Groffman et al. 2010; Holmes & Lock 2010).

3) Understand the Context:

For conservation science to be relevant, it cannot be conducted in a vacuum. Outside constraints (including social, economic, and political) influence the way that results will be interpreted and whether they are useful in the real world. While many scientists recognize the importance of contextual information, many do not yet truly integrate this knowledge into their research. True integration would include a thorough understanding and acknowledgement of the political, economic, and social/cultural context surrounding their research.

To accomplish a better understanding of outside context, researchers should broaden their own experience and knowledge. Researchers should become familiar with the context that surrounds their research – economics, public opinion, and industry perspectives, for example (Fleishman et al. 1999; Brownson et al. 2006; Knight et al. 2008; Groffman et al. 2010; Eden 2011). Scientists should be aware of the concerns of decision-makers and stakeholders and look for windows of opportunity in the decision-making process to bring relevant work to light. Furthermore, scientists should be alert to issues and questions that arise in real world controversies and that suggest new directions for research.

Scientists also need to understand how decisions are made (Brownson et al. 2006; Groffman et al. 2010; Strydom et al. 2010). Knowledge and science are not the only factors that come into play when people make decisions — ideology, social identity, trust, habits, stereotypes, and cultural norms all play a role. Scientists need to be aware of these factors and take them into consideration. Putting science into the context of these other factors can help people understand the relationship between different facets of an issue (Airame 2003; Hanssen et al. 2009; Groffman et al. 2010).

4) Advocate:

Sometimes researchers need to ensure that science has a place at the table. In the absence of scientists at the table, decision-makers (policy-makers, in particular) may be more likely to rely on those who are present and demanding to be heard—vested interests or the public, who may not have considered or be able to interpret the data (Brownson et al. 2006). Thus, researchers should be better advocates for their research.

The question that is often asked is how researchers can provide advice to decision-makers without giving the appearance that they are compromising their independence and objectivity (Alpert & Keller 2003; Meffe 2007; Hanssen et al. 2009; Holmes & Lock 2010). Several best practices for advocates have been suggested. Parsons (2013) gives 10 suggestions for researchers wanting to advocate for their findings, including honing communication techniques, sticking closely to the facts, and preparing for attacks. Pielke (2007) suggests that researchers act as "honest brokers of policy alternatives” by openly associating their science with different possible courses of action. This may help to identify choices not previously recognized while allowing researchers to maintain their independence. Additionally, Meyer et al. (2010) suggest seven best practices for advocates. These best practices include accurately characterizing the best available science as well as scientific uncertainty, clearly and thoroughly presenting the argument and avoiding hyperbole. These recommendations are intended to help scientists stay within the realm of “science-based advocacy” rather than “advocacy-driven science.”

5) Create New Incentives:

Institutions need to provide more incentives to researchers who work to bridge the research decision-making gap. In many cases, this requires changing the academic rewards system for promotions and tenure (Briggs 2006; Knight et al. 2008; Esler et al. 2010; Holmes & Lock 2010; Pace et al. 2010). A survey undertaken by *Nature* in 2010 showed that respondents think that their institutions place most emphasis on grants earned, number of publications, publishing in high impact journals, and numbers of citations of published research when making promotion decisions (Abbott et al. 2010). They indicated that much less emphasis was placed on activities such as out-reach to non-scientists, blogging, and public exposure in the press.

Journals should also provide incentives to authors to include information that is relevant to decision-makers. Esler et al. (2010) suggests that one reason that many scientific articles are theoretical and not highly relevant to decision-makers could be that the incentives for “knowing” articles are higher than for “doing” articles. In other words, those publications that are most relevant to decision-makers perform poorly on traditional scales of success (e.g. citation analyses). Esler et al. (2010) conducted a bibliometric analysis of invasive species studies published between 1987 and 2009 and found that research that was geared toward implementation was cited significantly fewer times than theoretical knowledge articles.

If articles that focus on implementation receive fewer citations, there is little incentive for journals (that place great emphasis on their "impact factor") to publish such articles. Academic researchers who want to publish in high impact journals will not submit articles focused on implementation because they know that these have a smaller chance of being published. This sets up a situation in which implementation articles are only published in lower impact journals where they receive less attention and citations and therefore possibly have less influence on decision-making.

6) Better Training:

Institutions need to change the way that scientists are trained. Many students are ill-prepared to engage in science-policy dialogues and to understand the complex social environments in which they might work (Jacobsen & McDuff 1998; Clark 2001; Mooney 2003). To provide students with an appreciation for the complexity of and implementation challenges in policy and management, courses should introduce interdisciplinary perspectives by fusing traditional areas of education such as the humanities, social sciences, and natural sciences and should also strive to teach students how conservation operates in the real world (Jacobsen & McDuff 1998; Knight et al. 2008). Furthermore, institutions need to go beyond teaching facts and analytical skills to include training in applied areas such as competent communication, including writing concisely, writing for the public, and creating and delivering relevant presentations (Brownson et al. 2006). Parsons (2012) suggests that conservationists need to be a “jack of all trades” as well as a “master of all too,” possessing skills such as diplomacy, creativity, patience, organizational skills, and the ability to react rapidly to changing circumstances (p. 369).

7) Develop Relationships with Decision-Makers:

The most useful research is often that which is responsive to decision-making needs. Instead of simply adding an incremental advancement to a theoretical issue, scientists who want to bridge the gap should talk with decision-makers before they begin their research to better understand the types of questions they are trying to address and the timeline for decision-making. Basing research around real-world problems rather than academic questions would lead to an increase in implementable research (Flashpoler et al. 2000; Holmes & Lock 2010; Eden 2011; Karrer et al. 2011).

Some scientists may even want to work with decision-makers to co-produce knowledge. This allows the users of the science (practitioners) to be included in the scientific process and can result in more successful implementation of results (Gallo et al. 2009; Rannap et al. 2009; Arlettaz et al. 2010). This practice can be particularly effective when scientists work to involve leaders of public opinion in the research and implementation process (Fischer 1995; Groffman et al. 2010). Co-production of knowledge requires a shift in thinking – from viewing knowledge as a “thing” that can be transferred from scientists to decision-makers to viewing it as a process of relating and sharing information with the goal of solving complex problems (Roux et al. 2006). The process of relating and sharing information can be helped by a person or an organization (often referred to as a boundary organization) who acts as a facilitator to aid communication between the researchers and non-scientist stakeholders (Guston 2001; Hanssen et al. 2009; Eden 2011).

When seeking to inform policy, in particular, researchers should focus on developing relationships with hired advisory staff of elected officials. Staffers are the gatekeepers and opinion-formers of many decision-makers. Staffers often prefer more details (in contrast to decision-makers who want short reports), so the scientist may find that this is an opportunity to more fully explain their research and its relevance to issues that are germane to the elected official (Brownson et al. 2006).

8) Engage stakeholders:

Researchers should work to build relationships and trust with stakeholders in conservation issues (Brownson et al. 2006; Knight et al. 2008; Holmes & Lock 2010; Soomai et al. 2011). Mostert and Raadgever (2008) describe two categories of stakeholders – “influential stakeholders” and “affected stakeholders.” Influential stakeholders are those that are major players in the policy process and who can promote or block change. Affected stakeholders are those who will be impacted by any changes. It is important to consider who both of these groups are and engage with them as much as possible. Engaging stakeholders early in the research process can help to resolve conflicts and can create communities of practice or knowledge networks (Eden 2011). Engaging stakeholders can also make the research process more transparent, building trust in the process and the researcher (Cook et al. 2013).

Oversights in the Conservation Biology "Bridging the Gap" Literature

Collectively, the literature reviewed above provides a solid beginning to understanding the reasons behind the existing research-decision-making gap and potential ways to bridge the gap. However, the collected work generally overlooks two major barriers to successfully bridging the gap. First, it is composed mostly of opinion pieces with little empirical evidence about which activities actually work best to bridge the gap and have an impact on decision-making. Second, the literature does not adequately address the fact that many academic researchers lack the institutional support to engage in activities that bridge the gap.

Lack of Data

The majority of the "bridging the gap" literature in the field of conservation biology is authored by academic scientists with a focus on what they think works to bridge the gap. Although many papers are based on real world experiences, getting empirical data that might be analyzable can be difficult, as conservation issues are often complex, "wicked" problems with unique characteristics or no "right" answers. The literature that does contain empirical evidence most often provides data from an academic researcher's perspective — for example, studies of researchers' goals when creating conservation assessments (Knight et al. 2008) and author perceptions of the use of management recommendations (Flashpoler et al. 2000; Omerod et al. 2002; Fazey et al. 2005).

Literature providing evidence of what works from a decision-maker's point of view is more rare — exceptions being: studies examining information-gathering methods used by decision-makers (Pullin 2003; Pullin et al. 2004; Seavy & Howell 2010) an examination of the communication practices of scientists and marine fisheries' decision-makers in the European Union (Holmes & Locke 2010), and a study of research needs and results as well as manager perceptions of barriers to and opportunities for use of science in decision-making (Young and Van Aarde 2011). The other notable exception is that there are a few studies that provide a retrospective analysis of what worked in a particular case study — for instance, collaboration between scientists and managers aided the development of a science-based forest management plan in Argentina (Gallo et al. 2009), and self-implementation of researchers' results and recommendations led to the rapid recovery of an endangered hoopoe (*Upupa epops)* population in the Swiss Alps (Arlettaz et al. 2010). One additional case study examined the activities that helped to transfer new science into water management decision-making (Eden 2011). Overall, the few studies that provide empirical data about practices that bridge the gap are valuable and show that there is a need for additional data to complement the large body of thought-pieces.

Lack of Appropriate Incentives

When reviewing the body of "bridging the gap" literature in the field of conservation biology, it is easy to find a long list of things that an academic researcher can do that will help make their research more relevant, accessible, and useful to decision-makers. However, the literature fails to adequately provide solutions to another problem — the fact that while many conservation biologists who are based in academia may have a personal motivation and desire to engage in activities that bridge the gap, there is little institutional support and incentive to do so. This is related to the fact that many academic institutions value research impacts that are not always consistent with bridging the gap.

Different types of Impacts:

Research can have a wide variety of impacts. These impacts can be divided into two broad categories: academic impacts and external impacts (London School of Economics and Political Science 2013). Academic impacts are influences within academia such as publications and citations in peer-reviewed journals and grant dollars received. External impacts are influences outside of higher education such as business, government, or the general public. Activities that bridge the gap are those that have external impacts — influencing policy creation, management plan development, or public opinion, for instance.

While there is variance in the degree to which individual institutions or departments encourage their faculty to have different types of impacts, there is a general perception that most academic departments have an incentive structure that is based on the “academic impacts” of their faculty. In other words, faculty are rewarded more for having academic impacts than external impacts (Abbott et al. 2010; Vale 2012; Brand 2013). This idea is supported by the results of a 2010 poll conducted by *Nature*, as mentioned previously, which showed that 75% of researchers surveyed believed that metrics such as number of publications, citation counts, and journal impact factors were used to make hiring decisions in their department (Abbott et al. 2010). Over 75% also thought these metrics were used for promotion decisions, and over 68% believed they were used during performance reviews and to make tenure decisions..

Activities that bridge the gap and that could have an external impact on management and/or policy decision-making were seen as having less priority. For instance, only 29% of respondents to the *Nature* survey felt that their institution placed enough emphasis on collaborative work outside of their department, and only 24% felt there was much emphasis placed on outreach to non-scientists (Abbott et al. 2010).

The perception that departments place most emphasis on academic impacts may influence how researchers prioritize their activities. When asked to indicate their top five priorities as researchers, the most frequent responses in the *Nature* survey were: 1) publication in high-impact journals, 2) research grants awarded, 3) training and mentoring students and post-docs, 4) number of citations on published research, and 5) number of publications (Abbott et al. 2010). Each of these high-priority activities could be described as activities that contribute to one's "academic impact." Given that a) many researchers believe that their career success is tied to their "academic impact" and b) each researcher has a finite amount of time, it is difficult for many to justify engaging in behaviors that are seen as being of lower value or priority.

So, while the "bridging the gap" literature contains many fine papers that implore conservation biologists to "bridge the gap," it is not realistic to expect academic researchers to change their priorities if there is little institutional support, and hence, little incentive to do so.

Despite the results of Abbott et al. (2010), there is recognition in some communities that external impacts are valuable and should be incorporated into assessments of research (O'Meara 2005; Pfirman et al. 2010; American Society for Cell Biology 2012). However, external impacts are far from having importance that is on par with academic impacts. One possible reason that academic institutions place greater emphasis on academic impacts than external impacts could be that there is currently no standard way to measure the impact of activities that bridge the gap (Pace et al. 2010). In contrast, metrics such as citation rates, journal impact factors, and grant dollars earned provide a standardized way to measure the academic impact of research and researchers. If there were a robust way to measure the impact of scientific research outside of academia, perhaps the activities that contribute to this impact would become more highly valued.

Summary

This dissertation addresses these oversights in the current "bridging the gap" literature — lack of data, appropriate incentives, and measures of external impacts. In the subsequent chapters, a case study is described that was conducted to better understand how we might address these challenges. First, data are provided on some of the characteristics of research and researchers that successfully bridge the gap and have a high impact on policy and management decisions (referred to as "management impact" or

“HMI” from here forward). Secondly, research that bridges the gap is shown to be similar or different from research that has high academic impacts (HAI). Thirdly, some initial steps are laid out that could be used to create a new way to measure the management impact of science. This alternative to the traditional Impact Factor — the Management Impact Index — would provide a measure of the impact of scientific research on policy and management decisions. Finally, the results are discussed in light of the creation of new incentives for researchers.

CHAPTER TWO: CASE STUDY INTRODUCTION

This dissertation focuses on understanding the impact that scientific research has on academic thinking as well as on policy and management decision-making related to one particular conservation issue: gray wolf (*Canis lupus*) management in the United States. This topic was chosen as a case study because there is a large set of scientific publications as well as published records of federal policy and management decisions available for analysis. Also, wolf management has been a highly controversial topic in the U.S. and has received much attention in academic circles, politics and the media. Given the attention to this topic by multiple stakeholders and potential input from a variety of sources, it serves as an ideal test case for examining the role of scientific information plays in decision-making. In this chapter, the history of wolves in two regions of the U.S. (the Northern Rocky Mountain and the Western Great Lakes regions), some of the policies that have influenced this history, and the issues surrounding management and policy decision-making are described.

Wolves in the United States

<u>*Early History of Wolves in the Northern Rocky Mountain Region (NRM)*</u>

Fisher (1995) states that prior to the 1870s, it is estimated that there were up to 35,000 gray wolves in the Northern Rocky Mountain region (Idaho, Montana, and Wyoming) along with a large ungulate population (Figure 1 illustrates the historic range of wolves in this region). The large number of wolves in the area was partially due to human activities during this time. In the 1870s, bison (*Bison bison*) were heavily hunted for their hides and tongues, which were considered a delicacy (Fischer 1995). After removal of the hide or just the tongue, bison carcasses were discarded and provided ample food for wolves. As a result, wolf populations grew **(**Fischer 1995). This was an unsustainable situation, and in the 1880s and 90s, excessive hunting practices by humans led to a dramatic decline in bison populations in the area (Fischer 1995). When bison became scarce, hunters began to exploit other game species such as elk (*Cervus elaphus*), deer (*Odocoileus hemionus),* moose (*Alces americanus*), antelope (*Antilocapra Americana),* and big horn sheep (*Ovis Canadensis),* and consequently, populations of these species also began to decline (Fischer 1995). This had two main impacts. First, it reduced the natural prey base of the wolves. Second, it put wolves and hunters in direct competition for these species and motivated hunters to begin practicing predator control strategies to eliminate their competition. During this time, the number of livestock grazing on lands in this area was also increasing. As wolves began to lose their natural prey base, they began to prey on the now abundant livestock. This resulted in wolves being despised by the majority of both stockman and hunters (Fischer 1995).

Figure 1. Current and historic range of the gray wolf in western North America. Source: Sightline Institute (http://www.sightline.org/research/graphics/wildlife-wolf-cs06m/)

European wolves had long suffered from a negative reputation, and this was transported to the United States through stories such as "Little Red Riding Hood" and the "Three Little Pigs" (Schlickeisen 2001). Conflicts between wolves and ranchers and hunters in the West added to this negative image as wolves began to be seen as an impediment to progress and civilization and cast as symbols of evil and destruction.

Individual groups, such as Montana Stockgrowers Association, began to pay bounties for every wolf that was killed, and local campaigns of wolf eradication began (Fischer 1995). This culminated in 1914 when the U.S. Congress appropriated special funds to the U.S. Biological Survey (now the U.S. Fish and Wildlife Service) for "destroying wolves, prairie dogs, and other animals injurious to agriculture and animal husbandry" (Fischer 1995, p. 21). This essentially made wolf eradication government policy. After an intense eradication campaign that included poisoning, shooting, and trapping wolves as well as setting wolf dens on fire, wolves were eliminated from Montana, Idaho, and Wyoming by the 1930s (Bangs et al. 2009).

Early History of Wolves in the Western Great Lakes Region (WGL)

Wolves likely colonized the Western Great Lakes region (Michigan, Wisconsin, and Minnesota) when glaciers retreated over 10,000 years ago. At the time of European settlement in the area in the early 1800s, the region may have contained 10,000 - 18,000 wolves (Wydeven et al. 2009). As European settlers began to move into this area, and harvest the northern forests, the government began to issue wolf bounties which encouraged the killing of wolves. Bounties were established in Michigan in 1838, Wisconsin in 1839, and Minnesota in 1849. These bounties, coupled with drastic reductions in wild ungulate populations - due to year-round human hunting - led to swift declines in wolf populations. By the late 1950s and early 1960s, the Minnesota wolf population fell to approximately 350-700 individuals (Wydeven et al. 2009). Wolves were extirpated from Wisconsin, and only a few remained scattered throughout Michigan by this time, mostly within Isle Royale National Park in Lake Superior (Thiel and Ream 1995; Wydeven et al. 2009).

Image of the Wolf in the United States, 1940-1970

As wolf populations swiftly declined throughout the U.S., a movement to change the image of wolves was also underway (Fischer 1995; Mech 1995; Jones 2002). Centerpieces of this movement were events such as the call for the restoration of wolves to North America by Aldo Leopold in 1944, and by popular publications such as the book "Never Cry Wolf" by Farley Mowat in 1963 which provided a first person narrative on his research on the nature of the arctic wolf (Fischer 1995; Jones 2002). There was also an increasing focus on the nature of wolves on television shows such as "Mutual of Omaha's Wild Kingdom" and in print media such as National Geographic magazine. These publications and television shows brought the story of the wolf to a wide audience across the United States and helped to change the image of the wolf from an evil villain to that of a persecuted icon – a victim of *our* destructive society (Fischer 1995).

In the western United States there was a growing public concern about the loss of pristine wilderness areas. The wolf represented wilderness and the "wild west" to many people, and they associated the loss of the wolf with the loss of an iconic way of life (McNamee 1997; Schlickeisen 2001). Many began to see the wolf as a missing link in an otherwise intact ecosystem in parts of the western U.S. People began to recognize that the loss of this top predator could have negative impacts on entire systems in this region, as the populations of deer and elk grew, and excessive browsing led to the degradation of aspen, cottonwoods, willows, and beaver-created wetlands (Soule et al. 2005; Ripple and Beschta 2003).

Legal Protections

The shift in public attitudes in the 1960s and 1970s was accompanied by a series of political events that helped to change the status of wolves. First, in 1963, a Special Advisory Board on Wildlife Management, chaired by A. Starker Leopold, stated that National Parks should be kept in the condition that prevailed when the area was first visited by white man (Leopold 1963). In the Northern Rocky Mountain (NRM) region, this meant that wolves should be present in Yellowstone National Park. Then, in 1972, President Nixon ordered a ban on the poisoning of predators on federal lands (Executive Order 11643). While not directly related to the movement to return wolves to their historic ranges, this was an important precursor, as this ban meant that, for the first time in nearly a century, national parks such as Yellowstone were free of predator poisons. This made it more likely that wolf populations could survive in such places.

In Wisconsin, bounties were eliminated, and wolves were designated as protected in 1957. Michigan eliminated its wolf bounty in 1960 and provided full protection in 1965. Minnesota also ended its bounty in 1965. In 1967, the gray wolf in the Western Great Lakes (WGL) region was designated as a federally endangered species on the first endangered species list created by the U.S. Fish and Wildlife Service (Department of the Interior 1967). They were again listed in 1974 under the 1973 Federal Endangered Species Act (ESA), which superseded this previous act (Endangered Species Act 1973).

As a result of these protections, the wolf population in the region grew from 1,500 in 1978 to over 3,500 in 2012 (Figure 2 and Table 1).

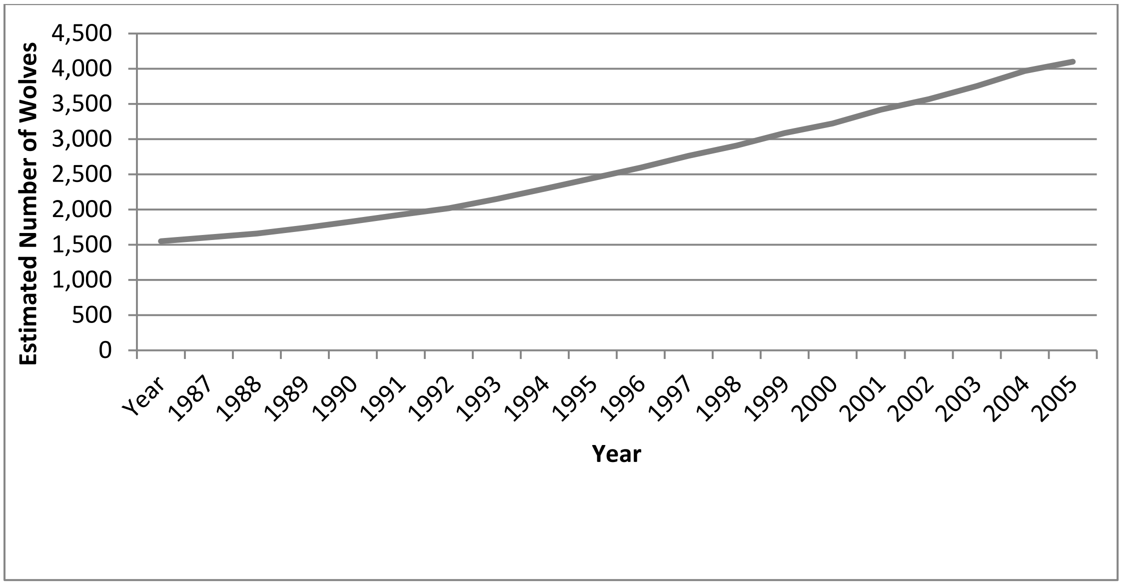

Figure 2. Wolf population estimates in the Western Great Lakes Region, 1987 - 2005.

Table 1. Wolf population estimates in two regions of the U.S.

Northern Rocky Mountain Region December 2012		Western Great Lakes Region Winter 2012-2013	
State	Number of Wolves	State	Number of Wolves
Idaho	683	Michigan	666
Montana	625	Minnesota	2211
Wyoming	277	Wisconsin	809
Total	1585		3686

The 1973 U.S. Endangered Species Act also designated the gray wolf in the Northern Rocky Mountain (NMR) region as an endangered species and mandated the restoration of this species (Endangered Species Act 1973). This gave the U.S. government the choice of: 1) doing nothing to either aid or harm the recovery of wolves and hope that wolves reestablished a presence in this area on their own or 2) artificially reintroducing wolves. In 1975, the U.S. Fish and Wildlife Service established the "Rocky Mountain Wolf Recovery Team" to explore the above options (Fish and Wildlife Service 1987). In 1986, the first naturally dispersing wolves from Canada denned in northwestern Montana (Bangs et al. 2009). As wolves slowly began to migrate back to the region, the Rocky Mountain Wolf Recovery Team also reached the conclusion that science supported the reintroduction of wolves into the NRM region. The first wolves were reintroduced to Yellowstone National Park and central Idaho in 1995 and 1996. This reintroduction greatly accelerated the growth of the wolf population throughout the NRM region (Figure 3). By 2012, over 1,500 wolves were present in the area (Table 1).

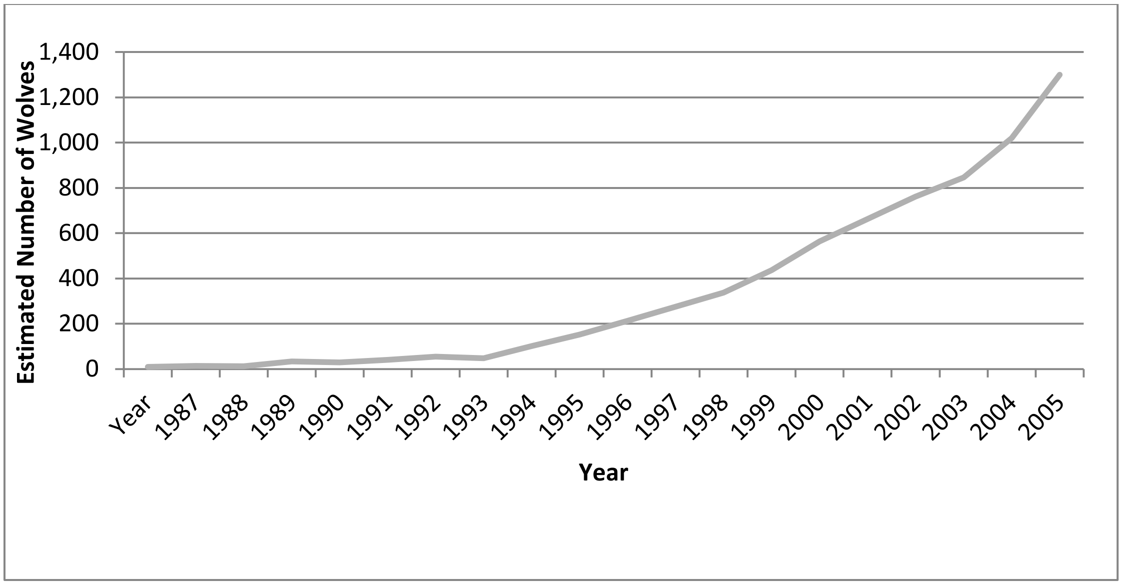

Figure 3. Wolf population estimates in the Northern Rocky Mountain Region, 1987 - 2005

The federal decision in 1974 that wolves should be protected in both of these regions (NRM and WGL) met with a great deal of public, industry, and political opposition, and opposition to wolves in these regions has diminished little with time. The protections afforded by the Endangered Species Act have allowed wolf populations to recover throughout portions of their historic range. For instance, wolf populations have grown in Wisconsin from 44 in 1990 to 1,247 in 2010 and in Michigan from 21 in 1995 to 501 in 2010 (Fish and Wildlife Service 2011c). A similar pattern of population growth in other states within the two regions has led to debate over whether wolves still deserve endangered species protections.

The Fish and Wildlife Service has examined this debate and issued rules on this subject in both regions. In 2007, wolves in the WGL region were removed, or "delisted," from the list of endangered species (Fish and Wildlife Service 2007), and in 2008, the

NRM region's wolves were also delisted (Fish and Wildlife Service 2008). These rulings were subsequently challenged in court, and ESA protections were reinstated in both cases (Humane Society of the United States v. Salazar, 1:09-CV-1092-PLF D.D.C.; Defenders of Wildlife et al v. Salazar et al, Case No. 9:09-cv-00077, Montana District Court).

In 2011, the Fish and Wildlife Service issued new proposed rules for delisting the gray wolf in both regions (Fish and Wildlife Service 2011a, b). In December 2011, the new rule for delisting wolves in the WGL region was enacted (Fish and Wildlife Service 2011c). These rules and the controversy that surrounds them have received much attention in academia, politics, and the media. Consequently, there has been a rapid increase in the number of scientific publications that are relevant to wolf management in the U.S. The attention given to this topic, the large number of relevant scientific publications, and the fact that there have been five proposed and final rules and regulations recently published make wolf management in the U.S. an ideal test case for examining the impact of scientific information on decision-making.

Within the context of this case study, the subsequent chapters of this dissertation address the shortcomings in the current "bridging the gap" literature that were discussed in Chapter 1 — lack of robust measures of external impacts, lack of data about research and researchers that have external impacts (i.e. bridge the gap), and lack of appropriate incentives to encourage researchers to bridge the gap. As a first step to addressing these oversights, how to measure "impact" needed to be addressed. To this end, in Chapter 3, traditional methods for measuring impact are discussed, and an impact measurement for the above case study is developed.

CHAPTER THREE: MEASURING IMPACT

"I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind…" (William Thomson, aka Lord Kelvin, May 3, 1883).

The above quote, which is often applied to business, suggests that we can't understand something until we can measure it. Two other popular forms of this quote, often attributed to management expert Peter Drucker, are: "what gets measured, gets managed" and "that which is measured, improves" (The Drucker Institute, http://www.druckerinstitute.com/). These quotes imply that producing measurements of an activity gives you an understanding of it and, in turn, a way to improve it. If we want to improve the impacts of conservation biology research on decision-making, we need to first find a way to measure these impacts.

Measuring Impact

There are many methods for measuring the impact of scientific research on academic thinking. There are fewer metrics for measuring impacts outside of academia. In Chapter 1, it was proposed that this imbalance, which makes academic impacts easier to quantify and understand, leads many academic institutions to place more emphasis and value on related activities. Consequently, external impacts of scientific research and the activities that promote these impacts are deemed less valuable by many academic researchers. Ultimately, the lack of systematic measures of external impacts could be a crucial barrier to bridging the research and decision-making gap.

In this chapter, some of the methods for measuring academic impacts as well as some proposed methods for measuring external impacts are highlighted. Based on the strengths and weaknesses of the existing metrics, a method is proposed for better understanding one type of external impact — the impact of research and researchers on management and policy decision-making.

Measuring External Impacts

There are no standardized methods for measuring the external impacts of research, though many institutions are attempting to develop suitable methods. For instance, funding agencies throughout the world have an interest in being able to document the external impacts of the research they fund. Countries such as Australia, the U.K., the U.S., the Netherlands, Sweden, Canada, and Japan are each developing methods to better understand these research impacts (Grant et al. 2009; Lane and Bertuzzi 2011). One of the most prominent efforts in the U.S. is the STAR METRICS program.

STAR METRICS is a partnership between science agencies and research institutions, led by the National Institutes of Health, the National Science Foundation, and the White House Office of Science and Technology Policy, to document the outcomes of scientific investments. The program is developing measures of the impact of science investments on job creation, scientific knowledge, social outcomes (which include environmental issues), workforce outcomes, and economic growth (National Institutes of Health 2013). This program has received much positive attention and is being emulated in other countries. However, it doesn't directly measure the impact of scientific research on management and decision-making.

More closely related to the goals of bridging the research and decision-making gap is an effort by Sutherland et al. (2011) to develop a method to measure the impact of conservation biology and ecology research on society. According to their method, impact scores are assigned to individual research publications by designated experts and practitioners. Impact scores are derived according to the ability of each publication to answer questions of relevance to end users. This is a novel method that gives a quantitative indication of the potential impact of a publication. However, this method suffers from some problems — mainly that results can be biased by experts' prior knowledge and experience and that the method is time consuming to carry out (Sutherland et al. 2011).

While the efforts by funding agencies provide new ways to understand the external impacts of research, and Sutherland et al.'s research begins to address issues specifically related to bridging the gap, we are still left without an adequate way to measure the impacts of publications on management and decision-making. What we do have, though, is a long history of measuring the impact of scientific research on academic thinking.

Measuring Academic Impacts

One of the most common ways to measure academic impact is through citation counts. Since 1960, when the Institute for Scientific Information (ISI) -- now part of Thomson Reuters -- began publishing the Science Citation Index, citations have been tracked and used as a measure of a scientist's influence (Van Noorden 2010). Additionally, in 1963, Eugene Garfield, founder of ISI, developed the "Impact Factor," which is the most widely known and used metric to measure the influence of a journal. Since the 1960s, the advent of online databases such as Thomson Reuters, Scopus, and Google Scholar have led to the development of ever more sophisticated citation-based metrics at both the level of individual researchers and at the journal level. Below, some of the most popular citation-based metrics at the researcher and journal levels are briefly reviewed.

Researcher Level Metrics

The number of publications produced by an individual scientist is a measure of quantity. How often those publications are cited by others is commonly used as a measure of quality (Vasikaran 2011). The most basic metric used to measure research quality is simply a count of the number of times a researcher or research paper has been cited by others. This is a simple way to quantify the influence of a researcher. However, the simplicity of this method makes it difficult to make comparisons between researchers in different fields, disciplines, or career stages. Variations on this method, developed to address these shortcomings, include only counting citations in top journals or normalizing citations by scientific field (Van Noorden 2010).

Arguably the most popular variation on this method is the h-index. Since being introduced in 2005 by physicist Jorge Hirsch of the University of California in San Diego, this measure has been adopted by many of the major online databases (Van Noorden 2010). The h-index of a scientist is calculated as the highest number of papers that he or she has published that has received at least that number of citations. For instance, a researcher with an h-index of 15 has published 15 papers that have each been cited at least 15 times (Vasikaran 2011). The benefits of the h-index include its simplicity and transparency. However, it is not without critics. One problem with the h-index is that it can never decrease, even if someone stops publishing altogether (Van Noorden 2010).

Variations on the h-index include the g-index, which gives more weight to more highly cited articles, and the contemporary h-index, which gives more weight to recent articles. Web of Science and Google Scholar are just two publication search engines that provide h-indexes, although the latter is of more use for -- often inter-disciplinary -- conservation practitioners, as it picks up citations in journals from multiple fields, not just certain science journals.

Other common criticisms with researcher level metrics are related to the idea that factors other than scientific utility and quality could have an impact on citation counts. For instance, a study of 228 papers published in 53 ecological journals between 1975 and 2001 showed that the number of authors on a paper and the first author's affiliation (both country and university) can have a significant impact on the citation rates of papers (Leimu & Koricheva 2005). Similarly, the h-index can be influenced by gender, country of residence, sub-discipline within ecology and evolutionary biology, and total publication output (Kelly & Jennions 2006). For example, a large productive laboratory, with a team of researchers studying a very narrow subject, could artificially inflate their h-index if the researchers were to cite each other's papers.

Journal Level Metrics

Since 1975, Thomson Reuters has published an annual list of journal Impact Factors: the Journal Citation Report. The Impact Factor of a journal is a measure of the frequency with which an average article in a journal gets cited. The Impact Factor is calculated on a yearly basis and is defined as the mean number of citations that occurred in that year per article published in the journal during the previous two years. The most recent Journal Citation Report includes over 10,000 active journals (Hubbard & McVeigh 2011).

The journal Impact Factor is a highly standardized metric but suffers from issues such as the fact that the Impact Factor of a journal can be influenced by just a handful of highly cited articles (Van Noorden 2010) or that it can be influenced by the size of a particular discipline. For example, within the field of biology, a comparison across disciplines such as ecology and molecular ecology is unfair because of differences in the size (or ages) of the fields (Kokko & Sutherland 1999). Two variations on the Impact Factor are the Eigenfactor and the SCImago Journal Rank (SJR), used by Thomas Reuters and Elsevier, respectively (Van Noorden 2010). These metrics are known as “evaluative informetrics” and give a heavier weight to papers that are themselves more highly cited.

Despite some of the existing criticisms, citation-based metrics at both the researcher and journal levels are a widely accepted and used measure of the influence of research on scientific thinking (i.e. the academic impact of research). One strength of citation-based metrics is that the information is readily available through online databases such as Web of Science, Thomas Reuters, Scopus, and Google Scholar. Citation-based metrics also provide objective measures that are relatively transparent.

Citations as a Measure of External Impact

Given the history and popularity of citation-based metrics, it reasons that we might build on this method to begin to measure the impacts of research outside of academia. Following the tradition of using citations as a measure of academic impact, it is suggested that citations in documents that government bodies issue to support decisions they make (i.e. rules and regulations) can provide some measure of the potential impact of scientific literature on decision-making. In addition to the fact that there is a long history of using citations as a proxy for impact, there is reason to believe that research cited in rules and regulations has had an impact on decision-making. In 1993, U.S. President Clinton issued an Executive Order that stated that federal agencies must base decisions on "the best reasonably obtainable scientific, technical, economic, and other information concerning the need for, and consequences of, the intended regulation" (Executive Order 12866, 1993). Therefore, the research cited in government rules and regulations should be a representation of the research that was: 1) accessible to decision-makers, 2) relevant to a particular policy or management decision, and 3) deemed to be of high quality. Ultimately, research cited in rules and regulations is research that has “bridged the gap."

Using Citation-Based Metrics to Understand Different Types of Impact

Citation-based metrics were used to examine the impact of scientific publications on questions related to wolf management in the United States. Citations of scientific publications in peer-reviewed journals, as well as five federal regulations, were examined to understand the impacts of this research. Specifically, an attempt was made to understand the inputs to policy and management decision-making within the context of the gray wolf case study. Next, data were provided on some of the characteristics of research and researchers that successfully bridge the gap and have a high impact on policy and management decisions (HMI). Then research that bridges the gap was looked at to see if it is similar or different from research that has high academic impacts (HAI). Finally, initial steps were laid out that could be used to create a new way to measure the management impact of science.

This addition to traditional impact measurements — the Management Impact Index — would provide a way to measure the impact of scientific research on policy and management decisions. The development of a management impact index could: 1) change the value that academic institutions place on research and researchers with characteristics that correlate with high management impact, 2) provide incentives to academic researchers to make their work more relevant to decision-makers, and 3) move the field of conservation biology closer to bridging the research and decision-making gap.

CHAPTER FOUR: CHARACTERISTICS OF HIGH IMPACT LITERATURE

On any given topic in conservation biology, there is a body of knowledge represented in the peer-reviewed, published literature. Within this set of literature, publications have varying degrees and types of impacts. For instance, one publication may have an impact on how academic researchers think about an issue. Another may influence the decisions of managers and policy-makers. Other publications have no obvious impact at all and remain uncited, and perhaps unnoticed, by both academics and decision-makers. Assuming that the reasons that one publication has an impact and another does not are not random or arbitrary, one can ask the question: are there characteristics of publications that correlate with a particular type of impact?

Within the context of a case study of wolf management in the U.S., this dissertation examines the characteristics of publications that have high academic or management impacts. As discussed in Chapter 3, publications with a high academic impact (HAI) are those that are most highly cited in the body of academic literature. High management impact (HMI) publications are those that are cited in documents used to support decisions made by managers and policy-makers. This chapter describes the following characteristics of wolf conservation and management literature: a) publication journal, b) journal Impact Factor, c) article topic, d) author affiliations, and e) author collaborations. It then explores whether two subsets of this body of literature — HAI and

HMI publications — display characteristics that differentiate them from the larger body of wolf literature. The results are discussed in relation to the question of whether certain characteristics of publications correlate with different types of impacts, and more specifically, whether there are certain characteristics associated with literature that successfully bridges the gap.

Methods

Part 1. Identification of the Literature

Part 1a. Identification of All Relevant Literature

Before identifying the high impact literature for this case study, it was first necessary to identify the larger universe of literature relevant to wolf management in the U.S. (hereafter referred to as "All Relevant"). While it is not possible to identify every individual publication that could have any relevance to the topic, the following methods were employed in an attempt to be as comprehensive as possible.

To identify the body of literature relevant to wolf management in the U.S., a list of relevant journals was compiled. First, a search of journals that were electronically available on Web of Science was conducted to identify those journals that published articles containing the keyword “wolf.” This list was reviewed, and journals that were not relevant (such as *Astronomy Astrophysics,* which published articles about Wolf-Rayet stars rather than *Canis lupus*) were eliminated. Second, five U.S. federal regulations related to wolf management were reviewed to create a list of journals cited (see Methods Part 1c below). The lists of journals from Web of Science and from federal regulations were combined to form a list of potentially relevant journals. Next, a search for the keyword “wolf” was completed in each of the potentially relevant journals. The resulting list of publications was then reviewed for relevance to wolf management in the U.S., and irrelevant articles (such as those that used the word “wolf” as a metaphor for something other than *Canis lupus*) were eliminated. The remaining publications formed a master list of articles relevant to wolf management in the U.S., published through the year 2011.

Part 1b. Identification of High Academic Impact (HAI) Literature

Articles within the set of All Relevant publications (Part 1a) were each ranked by the number of times they had been cited in other peer-reviewed scientific publications. The number of citations was determined using data in Web of Science as of 15 October 2013. After examination of the distribution of citation frequencies, articles that ranked in the top 10% (in terms of citations) were chosen as the HAI set of literature.

Part 1c. Identification of High Management Impact (HMI) Literature

The sources of information that had a potential impact on wolf management decisions were identified by conducting a bibliometric analysis of five federal regulations related to wolf management in two regions of the U.S. — the Northern Rocky Mountains (NRM) and the Western Great Lakes (WGL). For the following regulations, the list of sources cited was obtained from the U.S. Fish and Wildlife Service:

1) “Designating the Western Great Lakes Population of Gray Wolves as a Distinct Segment; Removing the Western Great Lakes Distinct Population Segment of the Gray

Wolf From the List of Endangered and Threatened Wildlife" (2006 WGL) (Fish and Wildlife Service 2006);

2) "Final Rule to Identify the Northern Rocky Mountain Population of Gray Wolf as a Distinct Population Segment and To Revise the List of Endangered and Threatened Wildlife" (2009 NRM) (Fish and Wildlife Service 2009);

3) "Proposed Rule to Revise the List of Endangered and Threatened Wildlife for the Gray Wolf (*Canis lupus*) in the Eastern United States, Initiation of Status Reviews for the Gray Wolf and for the Eastern Wolf (*Canis lycaon*)" (05-2011 WGL) (Fish and Wildlife Service 2011a);

4) "Removal of the Gray Wolf in Wyoming From the Federal List of Endangered and Threatened Wildlife and Removal of the Wyoming Wolf Population's Status as an Experimental Population" (2011 NRM) (Fish and Wildlife Service 2011b); and

5) "Final Rule Revising the Listing of the Gray Wolf (*Canis lupus*) in the Western Great Lakes" (12-2011 WGL) (Fish and Wildlife Service 2011c).

Each bibliography was examined, and citations were classified into one of 40 categories based on the information source -- e.g. peer-reviewed journal, state report, press release, etc. (see Appendix 1 for a full list). Articles published in peer-reviewed science journals were considered to be HMI publications.

<u>Part 2. Characteristics of Wolf Literature</u>

After the set of All Relevant publications was compiled (Part 1a above), each publication was examined to collect the following data: publication journal, journal Impact Factor, topic, author affiliations, and author collaborations. Summary results were calculated for the set of All Relevant literature and then broken down into the two subsets of high impact publications (HAI and HMI literature). Characteristics of the HAI and HMI data sets were compared with characteristics of the larger population of wolf literature, represented in the All Relevant literature data set, as described below.

Part 2a. Publication Journal

For all articles, the journal of publication was identified. The number of times that a specific journal occurred in each data set (All Relevant, HAI, and HMI literature) was calculated, and journals were rank-ordered by the number of times they were represented in the data. The journals that occurred most frequently (top five) in each data set were compared. Chi-square tests were performed to determine if the frequency that some journals occurred in the HAI and HMI literature was different from their representation in the larger sample of All Relevant literature.

Part 2b. Journal Impact Factor

Journal Impact Factors were obtained from the 2012 Journal Citation Report, published by Thomson Reuters (http://thomsonreuters.com/journal-citation-reports/). The Impact Factors of all journals represented in the data sets were obtained. The mean Impact Factors of the journals in each of the three data sets are described.

Part 2c. Publication Topic

Using Web of Science and online library holdings, the abstract was obtained for each publication in the set of All Relevant literature. Each abstract was reviewed to determine the general topic of the publication. After each publication was assigned a topic, the list of topics, and as necessary, the abstracts were reviewed once more to identify and condense similar topics. The percentage of publications on each topic was calculated for each data set (All Relevant, HAI, and HMI literature).

Part 2d. Author Affiliations

Using Web of Science and searches of online library holdings, every author's affiliation at the time of article publication was determined. Affiliations were classified as either: 1) academic (including university and college affiliations), 2) government (including state, federal, provincial, and regional government affiliations), or 3) other (including non-profit, private organization, and tribal affiliations). If two different affiliations were listed for an author, the affiliation listed first on the publication was recorded as the primary affiliation.

Chi-square tests were performed to determine whether the number of authors with academic and government affiliations in the HAI and HMI data sets were different from their representation in the set of All Relevant literature. Separate tests were performed on data from first author affiliations and all author affiliations (first authors plus all co-authors).

Part 2e. Author Collaborations

Using the data on author affiliations obtained in Part 2d, each article was classified by the composition of the team that authored the article. Teams were classified as including: a) only academic authors, b) only government authors, c) academic and government authors, d) academics as well as those with "other" affiliation, e) government as well as those with "other" affiliation, or f) all authors with "other" affiliations. Chi-square tests were performed to determine whether the composition of the teams in the HAI and HMI data sets differed from the proportion of such teams in the set of All Relevant literature.

Results

Part 1. Identification of the Literature

Part 1a. Identification of All Relevant Literature

A search of Web of Science produced a list of the 100 journals that most frequently published articles containing the keyword "wolf." This list was reviewed, and journals that were not relevant were eliminated, resulting in 48 potentially relevant journals. A review of journals cited in federal regulations related to wolf management yielded an additional 28 relevant journals. The two lists of journals were combined to form a list of 76 potentially relevant journals. A search for the keyword "wolf" was completed in each of these 76 journals. The resulting list of publications was then reviewed for relevance to wolf management in the U.S., and irrelevant articles were eliminated. The remaining list of relevant publications represented 730 articles from 60 journals, published between 1944 and 2011.

Part 1b. Identification of High Academic Impact Literature

The 730 articles compiled in Part 1a were cited a total of 17,973 times. The number of citations per article ranged from zero to 454 (*M* = 24, *SD* = 41, Median = 11, Mode = 0). As illustrated in Figure 4, a small number of articles accounted for a large proportion of the citations. For instance, the top 10% (73) most highly cited articles accounted for nearly half (48%) of all of the citations in the sample. Given that these few articles accounted for this large percentage of all citations, a 10% sample was chosen as the set of "high academic impact" literature. These 73 articles ranged in the number of times cited from 54 to 454 (*M* = 117; *SD* = 70; Median = 90; Mode = 64, 70, 79, 90; each occurring three times in the data, as shown in Figure 5).

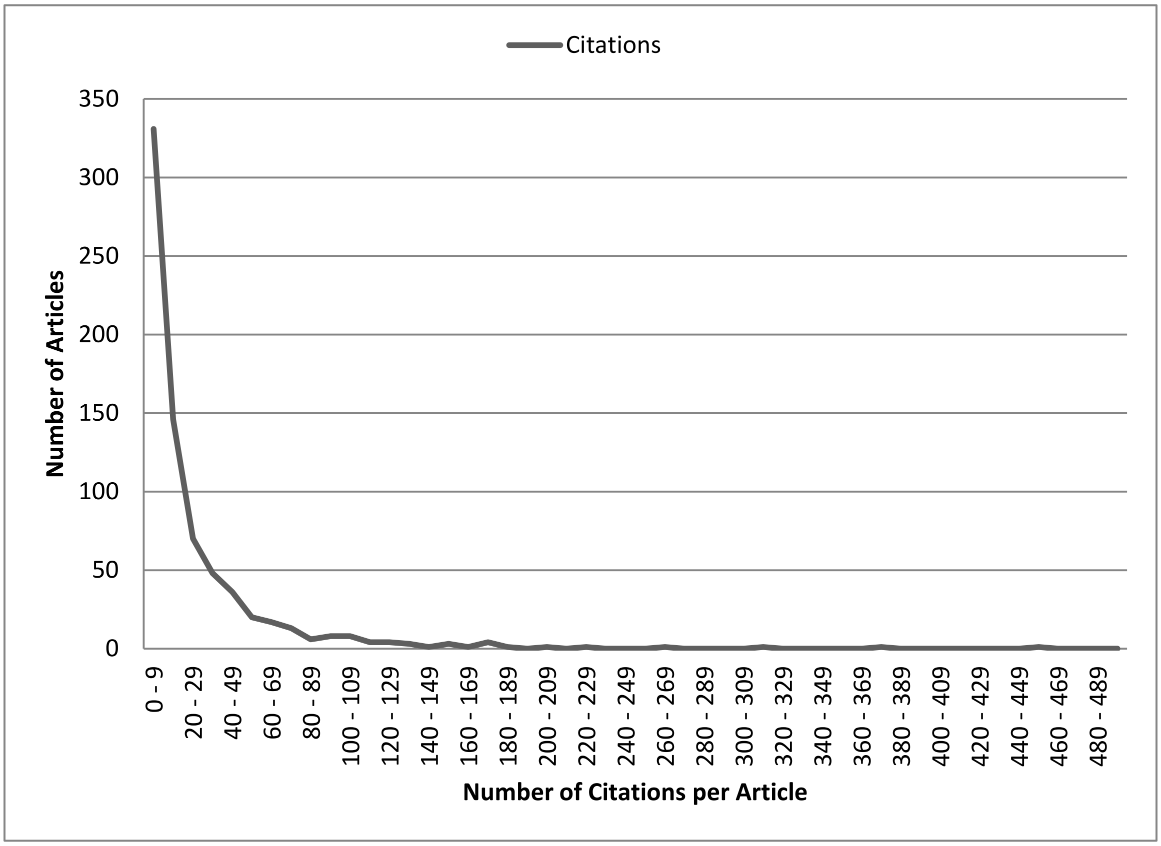

Figure 4. Number of citations per article in the set of All Relevant wolf literature.
The 730 articles were cited a total of 17,973 times, and the number of citations per paper ranged from zero to 454 (M = 24, SD = 41, Median = 11, Mode = 0).

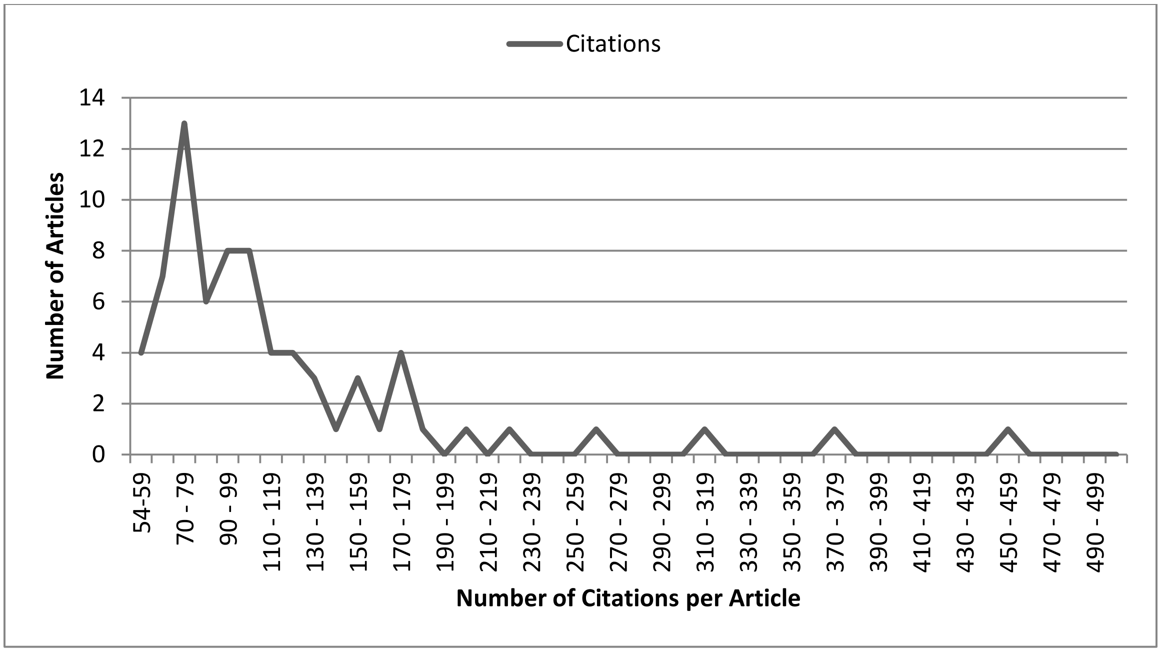

Figure 5. Number of citations per article in the set of High Academic literature.
The 73 articles were cited a total of 8,564 times, and the number of citations per paper ranged from 54 to 454 (*M* = 117; SD = 70; Median = 90; Mode = 64, 70, 79, 90, each occurring three times in the data).

Part 1c. Identification of High Management Impact Literature

Across the five federal regulations relevant to wolf management, there were a total of 1,005 sources of information cited in the bibliographies. The number of citations per regulation ranged from 126 to 243. After removal of duplicate citations (i.e. sources that were cited in more than one regulation), there were 552 unique sources cited. Across the five regulations, the most frequently cited sources of information were peer-reviewed journal articles (35%), state-issued reports (13%), edited scientific volumes (11%), federal government-issued reports (5%), and personal communications (5%). Other sources of information cited include dissertations and theses, press releases, and conference proceedings (see Appendix 1 for more details).

Of the 1,005 citations in the five regulations, 348 were articles from peer-reviewed published journals. After removal of duplicate citations (i.e. articles that were cited in more than one regulation), there were 174 unique published articles cited. These 174 published articles comprise the HMI set of publications.

Regional Differences in HMI articles: Three of the regulations that were examined for this analysis were related to wolf management in the Western Great Lakes region, and two were related to wolf management in the Northern Rocky Mountain region. An examination of journal articles cited in the five regulations revealed that only 12% of articles were cited in regulations from both regions. This indicates that there may be some regional differences in the use of scientific publications. Therefore, the characteristics of the publications cited in each region were compared using methods described in Parts 2a through 2e above.

The examination of the basic characteristics of peer-reviewed literature cited in the five regulations revealed some differences between the literature used to support decision-making in the two regions (full data from this analysis is available in Chapter 2 and Appendix 1). Differences were found in the journals cited and topics of research. However, these variations seem to be the result of inherent differences due to the history of wolf management and the current issues faced in each region (more details in Appendix 1). Because these differences are also represented in the broader data set of All Relevant literature, the HMI publications from both regions were combined for analyses in Part 2, and data from all five regulations were considered as one complete set of HMI data.

Part 2. Characteristics of Wolf Literature

Part 2a. Publication Journal

The set of All Relevant articles (n=730) came from 60 different journals. The HAI articles (n = 73) came from 27 different journals, and HMI articles (n = 174) came from 52 different journals. A review of the occurrence of these journals in each of the three data sets showed that there is a great amount of overlap. Out of the 60 journals, 23 occurred in all three data sets, and an additional 16 journals occurred in two data sets. Table 2 lists the five most frequently occurring journals in each of the three data sets (data in bold). The most highly cited journal in the set of All Relevant literature was *Canadian Field Naturalist*, which was the source of 12% (n = 84) of all of the articles relevant to wolf management. The most highly cited journal in the HAI data set was *Conservation Biology*, which was the source of 21% (n = 15) of the HAI articles. The most highly cited journal in the HMI data set was the *Journal of Wildlife Management*, which was the source of 10% (n = 18) of the articles. Two journals, *Journal of Wildlife Management* and the *Wildlife Society Bulletin*, were among the top five journals in all three data sets. Two other journals, *Canadian Journal of Zoology* and *Conservation Biology*, were among the top five journals in one or more but not all data set(s).

Table 2. Most frequently cited journals in each data set.

Journal	All Relevant Literature*	High Academic Impact Literature*	High Management Impact Literature*
Canadian Field Naturalist	**12% (n = 84)**	0% (n = 0)	3% (n = 6)
Canadian Journal of Zoology	**10% (n = 72)**	**10% (n = 7)**	4% (n = 7)
Conservation Biology	5% (n = 38)	**21% (n = 15)**	**9% (n = 15)**
Ecology	2% (n = 17)	**8% (n = 6)**	0% (n = 1)
Journal of Mammalogy	**5% (n = 40)**	1% (n = 1)	4% (n = 7)
Journal of Wildlife Disease	5% (n = 38)	0% (n = 0)	**5% (n = 9)**
Journal of Wildlife Management	**9% (n = 66)**	**7% (n = 5)**	**10% (n = 18)**
Molecular Ecology	2% (n = 16)	5% (n = 4)	**5% (n = 8)**
Wildlife Society Bulletin	**9% (n = 56)**	**7% (n = 5)**	**10% (n = 17)**

* The five most frequently cited journals in each data set are noted in bold.

There are three journals (*Conservation Biology*, *Ecology*, *and Molecular Ecology*) that account for a relatively low proportion of articles in the sample of All Relevant literature but a large proportion of articles in one or both of the High Impact data sets. Chi-square tests were performed to determine whether or not there was a difference between the frequency of the occurrence of these journals in one or more of the High Impact data sets compared to All Relevant literature.

Conservation Biology was one of the most frequently occurring journals in the HAI and HMI data set, accounting for 21% (n = 15) and 9% (n = 15) of the articles, respectively. In contrast, this journal was the source of only 5% (n = 38) of the articles in the set of All Relevant literature. Chi-square tests were conducted to determine if the differences between the frequency of the occurrence of the journal *Conservation Biology* in each of the High Impact data sets and the sample of All Relevant literature were significant. *Conservation Biology* occurred significantly more often in both the HAI data set (X^2 (1, N = 73) = 32.01, $p < 0.0001$) and the HMI data set (X^2 (1, N = 174) = 4.22, $p < 0.05$).

Ecology was the source of 8% (n = 6) of the articles in the HAI data set but only 2% (n = 17) in the sample of All Relevant literature. A chi-square test showed that this difference was significant (X^2 (1, N = 73) = 8.23, $p < 0.005$), indicating the journal *Ecology* occurred more often in the HAI data set than would be expected, given the sample of All Relevant literature.

Molecular Ecology was the source of 5% (n = 8) of the articles in the HMI data set but only 2% (n = 16) in the sample of All Relevant literature. A chi-square test showed that this difference was significant (X^2 (1, N = 174) = 4.09, $p < 0.05$), indicating the journal *Molecular Ecology* occurred more often in the HMI data set than would be expected, given the sample of All Relevant literature.

Part 2b. Journal Impact Factor

Impact Factors were obtained for 58 of the 60 journals in the All Relevant literature data set. As might be expected, given the overlap in journals between data sets (described above), the mean Impact Factors of the journals in the All Relevant, HAI, and HMI literature data sets were similar (4.274, 4.53, and 4.36, respectively). However, the mean Impact Factors of the five most frequently occurring journals in the HAI and HMI data sets (2.72 and 2.9, respectively) were higher than the mean Impact Factor of the five most frequently occurring journals in the set of All Relevant literature (1.29; see Table 3). This suggests that there may be a potential relationship between high impact publications (both HAI and HMI) and the Impact Factor of journals.

Table 3. Impact Factors of the five most frequently occurring journals in each data set.

Top 5 Journals in All Relevant Literature	Impact Factor	Top 5 Journals in HAI Literature	Impact Factor	Top 5 Journals in HMI Literature	Impact Factor
Canadian Field Naturalist	0.04	Conservation Biology	4.355	Journal of Wildlife Management	1.64
Canadian Journal of Zoology	1.5	Canadian Journal of Zoology	1.5	Wildlife Society Bulletin	0.95
Journal of Wildlife Management	1.64	Ecology	5.175	Conservation Biology	4.355
Wildlife Society Bulletin	0.95	Journal of Wildlife Management	1.64	Journal of Wildlife Disease	1.271
Journal of Mammalogy	2.308	Wildlife Society Bulletin	0.95	Molecular Ecology	6.275
	M = 1.29		*M* = 2.72		*M* = 2.9

Part 2c. Topic

An abstract was obtained for 700 of the 730 publications in the All Relevant literature data set, 72 of the 73 HAI publications, and 171 of the 174 HMI publications. Abstracts were not available for the remaining publications, and therefore, these articles were excluded from this analysis. After a review of each available abstract, every publication was classified into one of ten topic areas: disease, wolf dispersal patterns, wolf genetics, habitat, wolf-human conflict and human attitudes toward wolves, impact on prey species, wolf management techniques, natural history and biology of wolves, policies relevant to wolf management, and trophic cascades.

As shown in Table 4 and noted in bold, the three most common topics in the set of All Relevant literature were natural history and biology of wolves (27% of publications), wolf management techniques (20%), and impact of wolves on prey species (13%). The three most common topics of HAI publications were the impact of wolves on prey species (21% of publications), habitat (18%), and genetics (15%). The most common topics of HMI publications were genetics (19%), human issues (16%), and the natural history and biology of wolves (12%).

Table 4. Percentage of article topics in each of the data sets.

Topic	Percent of All Relevant Publications* (N = 700)	Percent of HAI Publications* (N = 72)	Percent of HMI Publications* (N = 171)
Disease	7% (n = 46)	1% (n = 1)	11% (n = 19)
Dispersal	3% (n = 22)	3% (n = 2)	7% (n = 12)
Genetics	10% (n = 70)	**15% (n = 11)**	**19% (n = 32)**
Habitat	5% (n = 34)	**18% (n = 13)**	11% (n = 18)
Human/Social Issues	7% (n = 47)	10% (n = 7)	**16% (n = 27)**
Impact on Prey	**13% (n = 94)**	**21% (n = 15)**	4% (n = 6)
Management	**20% (n = 142)**	13% (n = 9)	12% (n = 20)
Natural History	**27% (n = 191)**	4% (n = 3)	**12% (n = 21)**
Policies	2% (n = 12)	1% (n = 1)	5% (n = 8)
Trophic Cascades	6% (n = 42)	14% (n = 10)	5% (n = 8)

* The three most frequently occurring topics in each data set are noted in bold.

Part 2d. Author Affiliation

For each article within the two data sets, information was gathered about the affiliation of each author at the time that the article was published. Out of 730 articles in the set of All Relevant literature, complete data (information about all authors on each publication) was available for 661 articles. Partial information (information about some of the authors) was available for an additional 25 articles (for a total of 686 articles). Complete information was available for 72 of the 73 HAI articles and for 165 of the 174 HMI articles (information was not available for the remaining articles). Across All Relevant articles, affiliation information was collected for 2,295 authors (Table 5). Several authors wrote multiple articles in the data set, and there were 1,063 unique authors in the data set. There were 285 total authors (206 unique authors) in the HAI data set and 650 total authors (355 unique authors) in the HMI data set. The mean number of authors per article was similar across the data sets.

Table 5. Number of authors in each data set.

	All Relevant Literature (n = 661)	High Academic Impact Literature (n = 72)	High Management Impact Literature (n = 165)
Total Number of Authors	2,295	285	650
M # authors per paper	3	4	4
Total number of unique authors (duplicates removed)	1,063	206	355

First Authors: Table 6 shows the percentage of first authors with each affiliation (academic, government, and other) for each data set. The majority of first authors in each data set had an academic affiliation. The percentage of first authors with an academic affiliation was highest in the HAI literature (78%). The number of first authors of HAI publications with academic affiliations was significantly greater than expected, given the number of academic first authors in the sample of All Relevant literature (X^2 (1, N = 72) = 6.02, $p < 0.05$). In contrast, the number of first authors of HAI publications with government affiliations was significantly less than would be expected (X^2 (1, N = 72) = 4.43, $p < 0.05$).

Chi-square tests of the authorship of HMI publications revealed that the number of first authors with government affiliations was greater than would be expected, given the number of government authors in the sample of All Relevant literature (X^2 (1, N = 165) = 5.99, $p < 0.05$). The number of first authors of HMI articles with academic affiliations was not significantly different than would be expected.

Table 6. Affiliations of the first authors of articles in each data set.

First Author Affiliation	All Relevant Literature (n = 686)	High Academic Impact Literature (n = 72)	High Management Impact Literature (n = 166)
Academic	64% (n = 440)	78%* (n = 56)	59% (n = 97)
Government	28% (n = 189)	17%* (n = 12)	36%* (n = 59)
Other	8% (n = 57)	6% (n = 4)	6% (n = 9)

* : $p < 0.05$

All Authors: Table 7 shows a summary of the affiliations of all of the authors associated with the publications in each data set. Similar to the analysis of first author affiliations, the majority of the authors in each data set had an academic affiliation. Chi-square tests were performed to determine whether the relationship between author affiliation (academic or government) and high impact publications (HAI or HMI) were significant. All tests were significant. The number of authors of HAI publications with academic affiliations was greater than expected, given the number of academic authors in the sample of All Relevant literature (X^2 (1, N = 283) = 9.02, p < 0.005). The number of authors of HAI publications with government affiliations was less than expected (X^2 (1, N = 283) = 8.67, p < 0.005).

Chi-square tests of the authorship of HMI publications revealed that the number of authors with government affiliations was greater than would be expected, given the number of government authors in the sample of All Relevant literature (X^2 (1, N = 646) = 17.25, p < 0.0001). The number of authors of HMI articles with academic affiliations was less than expected (X^2 (1, N = 646) = 12.81, p < 0.0005).

Table 7. Affiliations of all authors of articles in each data set.

	All Relevant Literature	High Academic Impact Literature	High Management Impact Literature
Number of Articles	686	72	165
Total Number of Authors	2,213	283	646
Academic	57% (n = 1,266)	66%[a] (n = 187)	50%[b] (n = 325)
Government	32% (n = 696)	23%[a] (n = 66)	39%[b] (n = 252)
Other	11% (n = 251)	11% (n = 30)	11% (n = 69)

[a] : $p < 0.005$
[b] : $p < 0.0005$

Part 2e. Author Collaborations

Using the data on author affiliations obtained in Part 2d, articles were classified by the composition of the team that authored the article. Teams were classified as including: a) only academic authors, b) only government authors, c) academic and government authors, d) academics as well as those with "other" affiliation, e) government as well as those with "other" affiliation, or f) all authors with "other" affiliations. The percentages of papers in each data set that were authored by teams of each type were calculated (Table 8). Additionally, for each data set, the percentage of teams that included at least one academic author as well as the percentage of teams that included at least one government author was calculated (Parts g and h in Table 8).

Table 8. Types of author collaborations on papers in each of the data sets.

	All Relevant Literature	High Academic Impact Literature	High Management Impact Literature
Number of Articles	661	72	165
Teams Includes:			
a) Academic Only	38% (n = 250)	40% (n = 29)	29%* (n = 48)
b) Government Only	17% (n = 111)	10% (n = 7)	22% (n = 36)
c) Both Academics and Government Employees	32% (n = 221)	33% (n = 24)	37% (n = 61)
d) Academic and those with "Other" Affiliation	8% (n = 53)	17% (n = 12)	10% (n = 16)
e) Government employee and those with "Other" Affiliation	1% (n = 9)	0% (n = 0)	2% (n = 4)
f) "Other" Only	4% (n = 27)	0% (n = 0)	0% (n = 0)
g) At least one academic author (teams types a + c + d above)	78% (n = 514)	90%* (n = 65)	76% (n = 125)
h) At least one government employee (teams types b + c + e above)	50% (n = 331)	43% (n = 31)	61%* (n = 101)

* : $p < 0.05$

Chi-square tests were performed to determine whether the composition of the teams in the HAI and HMI data sets were different from teams in the set of All Relevant literature. Results of the chi-square tests revealed that while teams that consisted of only academic authors (represented in Part a of Table 8) were not significantly more or significantly less likely to have authored HAI articles, they were significantly less likely to have authored HMI articles (X^2 (1, N = 165) = 5.06, $p < 0.05$) than would be expected, given the frequency of such teams in the All Relevant literature data set. Teams that only included government authors (represented in Part b of Table 8) were not significantly more or significantly less likely to have authored high impact articles (HAI or HMI) than would be expected. Teams that included both academics and government employees (represented in Part c of Table 8) were also not significantly more or significantly less likely to have authored high impact articles (HAI or HMI) than would be expected, given the frequency of such teams in the All Relevant literature data set.

Teams that included at least one academic author (represented in Part g of Table 8) were significantly more likely to have authored HAI articles than would be expected, given the frequency of such teams in the sample of All Relevant literature (X^2 (1, N = 72) = 5.12, $p < 0.05$). Similarly, teams that included at least one government employee (represented in Part h of Table 8) were significantly more likely to author HMI publications than would be expected, given the frequency of these teams in the sample of All Relevant literature (X^2 (1, N = 166) = 7.81, $p < 0.01$).

Discussion

The analyses discussed in this chapter had two purposes: 1) to understand the characteristics of research that bridges the gap (HMI literature in this case study) and 2) to assess if the literature that has a potential impact on decision-making (HMI literature) is the same that has a high impact in the academic world (HAI literature).

Characteristics of HMI Literature

In order to differentiate characteristics of HMI literature from the general characteristics of wolf literature, HMI publications were examined within the context of the broader body of relevant literature. Results suggest that there are particular journals that publish much of the literature that is bridging the gap. For instance, of the 60 journals that published relevant wolf literature in this case study, five journals published almost 40% of the HMI literature. This suggests that articles published in these journals may be more accessible and relevant to the work conducted by decision-makers. However, the fact that the HMI publications came from 52 different journals indicates that decision-makers are not restricting their information searches to only a few journals. Rather, they are considering information from a variety of scientific publications. This seems to contradict the idea that decision-makers have limited access to scientific journals, which is often cited as a barrier to bridging the gap (Pullin 2003; Sunderland et al. 2009). Interviews and surveys with decision-makers were conducted to further explore this issue and are described in Chapter 5.

The majority (59%) of research that bridged the gap was written by a first author with an academic affiliation. This arguably suggests that decision-makers depend upon academically-led research to support decision-making. However, gap-bridging research was more likely to be authored by a first author with a government affiliation than would be expected, given the prevalence of such authors in the wider body of wolf literature. Government employees were first authors on 36% of HMI publications compared to 28% of the publications in the full body of relevant literature. This suggests that government researchers may be conducting and publishing the research they need to do their job rather than just depending on academics to conduct this research or searching the literature for information already published on these topics. Possible reasons that decision-makers might conduct their own research include a lack of relevant research being conducted by academics (as suggested by Pullin 2003; Fazey et al. 2005; Esler et al. 2010) and the need for information sooner than academics can provide it (as suggested by Brownson et al. 2006). Interviews and surveys with decision-makers, described in Chapter 5, further explore these ideas.

The results of analyses of the composition of the teams authoring the HMI literature suggest that articles authored only by academics are less likely to bridge the gap and have an impact on decision-making. In contrast, teams that include at least one government employee were significantly more likely to bridge the gap. This data supports a suggestion frequently made in the bridging-the-gap literature: researchers that want to bridge the gap should collaborate with government practitioners and decision-makers (Brownson et al. 2006; Gallo et al. 2009; Rannap et al. 2009, Arlettaz et al., 2010).

Comparison of HAI and HMI literature

Within the context of wolf management, three journals published much of the high impact research. *Conservation Biology*, *Journal of Wildlife Management*, and the *Wildlife Society Bulletin* were each among the most frequently occurring journals in both the HAI and HMI data sets. Collectively, these three journals published roughly a third of all the high impact scientific articles — 35% of HAI articles and 29% of HMI articles. This data suggests that these journals are publishing research that is of high relevance to both academic researchers as well as decision-makers. This may be consistent with the goals of each of these journals. For instance, while the *Wildlife Society Bulletin* and the *Journal of Wildlife Management* do not have particularly high Impact Factors (0.95 and 1.64, respectively), both journals strive to publish high quality scientific articles of relevance to a broad range of wildlife professionals (http://www.wildlifejournals.org/view/index.html). *Conservation Biology*, which has a relatively high Impact Factor, for a conservation-oriented journal, of 4.355, is published with the goal of promoting "the highest standards of quality and ethics in conservation research and encourages communication of results to facilitate their application to management, policy, and education" (http://www.conbio.org/publications/conservation-biology). To this end, a new section of *Conservation Biology* called "Conservation in Practice" was launched in 1998. This new section was designed to publish articles that apply principles of conservation biology to the "real world" (Meffe 1998). In contrast, *Ecology*, which was the third most frequently occurring journal in the HAI literature and has a relatively high Impact Factor (5.175), publishes "articles that report on the basic elements of ecological research" (http://esapubs.org/esapubs/journals/ecology.htm). Perhaps, consequently, *Ecology* published only one of the articles in the HMI data set.

These results suggest two things. First, articles that are published in journals that explicitly focus, in whole or part, on bridging the gap may be successfully publishing gap-bridging articles. Second, journals already having a high academic impact (such as *Conservation Biology)* can continue to do so while also publishing articles that are relevant to decision-makers.

While direct statistical comparison was not done between the two sets of high impact literature, the data suggests that first author affiliation may affect the type of impact of an article. Seventy-eight percent of HAI articles had a first author with an academic affiliation, while only 59% of HMI articles had an academic first author. Similarly, only 17% of HAI articles have a government first author, while 36% of HMI articles had a first author with a government affiliation. Additionally, 90% of HAI literature included an academic author on the team, while only 76% of HMI literature included an academic author. While these results suggest that author affiliations can influence impact type, they also suggest that research conducted by (and in many cases, led by) researchers with academic affiliations help in bridging the gap. Over three-quarters of the research articles that bridged the gap in this case study included an academic researcher on the team, and 59% of the papers that bridged the gap had a first author with an academic affiliation.

Is it possible to have a "Dual Impact?"

As discussed in Chapter 1, academic researchers may want to bridge the gap, but institutional pressures and incentives encourage them to have high academic impacts rather than management impacts. This begs the question: is it possible to simultaneously have both types of impacts (a "dual impact")? In this case study, 30 out of the 730 relevant articles had both high academic and management impacts. While this number may seem low in proportion to the body of All Relevant literature, it is, in fact, 41% of the HAI articles. Due to the small number of dual impact articles in this case study, statistical analyses were not performed on the characteristics of the articles. However, a summary of some of the relevant characteristics are described in Table 9.

Table 9. Characteristics of "Dual Impact" literature.

Number of Articles	30
Number of Journals in Data set	14
Top Five Journals	Journal of Wildlife Management (n = 7) Wildlife Society Bulletin (n = 3) Conservation Biology (n = 2) Bioscience (n = 2) Ecological Applications (n = 2)
Top Three Topics	Habitat (n = 8) Genetics (n = 6) Management Issues (n = 4) Social Issues (n = 4)
Number of Unique Lead Authors	24
Total Number of Authors	138
Total number of unique authors (duplicates removed)	112
M number authors per paper	4.6
First Author Affiliations	
Academic	67%
Government	30%
Other	3%
Author Collaborations	
Academic Only	17%
Government Only	24%
Both Academics and Government Employees	45%
Academic and those with “Other” Affiliation	14%
Government employee and those with “Other” Affiliation	0%
“Other” Only	0%

The characteristics of the dual impact articles reflect (and in some cases, amplify) trends seen in the larger sets of high impact literature discussed above. For example, the most frequently occurring journals are those that place an emphasis on publishing high quality research that is also relevant to decision-makers. Also, similar to the larger sets of high impact literature, the majority (67%) of articles had a lead author with an academic affiliation, and 30% had a lead author with a government affiliation. Finally, 45% of Dual Impact articles were the result of teams that included both academic and government researchers.

Despite the small number of Dual Impact articles in this case study, these 30 papers suggest that it *is* possible for articles and researchers to both bridge the gap and have a high academic impact. Further, the summary of the characteristics of these articles suggests that the ability to have this dual impact may not be by chance. Follow-up studies should explore the characteristics of a larger sample of dual impact literature in greater detail to better understand whether there are characteristics that are consistent with dual impacts.

Overall, the results of the bibliometric analyses described in this chapter suggest that publications that have high impacts (academic or management impacts) are not a random subset of the literature available on a topic. The next chapter in this dissertation describes the results of interviews and surveys of academics and decision-makers, which were conducted to further understand the characteristics of research and researchers that are bridging the gap and having an impact on decision-making.

CHAPTER 5: INTERVIEWS AND SURVEYS WITH ACADEMICS AND DECISION-MAKERS

Following the collection and analysis of bibliometric data (Chapter 4), interviews and surveys of academic researchers and decision-makers were conducted. Interviews and surveys of academics focused on research dissemination and outreach activities, their interactions with decision-makers, and barriers to and incentives for engaging in activities that help to bridge the research and decision-making gap. Interviews and surveys of decision-makers focused on better understanding how they use scientific information, barriers to their use of science research, and how they collaborate with academic researchers.

Methods

Interviews

Between April and June 2013, a total of 16 interviews were conducted with a sample of a) academic researchers who have published articles relevant to wolf conservation and b) managers and policy-makers (collectively referred to as decision-makers) who have a job that is relevant to wolf management in the Western Great Lakes (WGL) or Northern Rocky Mountain (NRM) regions. All recruitment materials, interview procedures, and interview questions were approved by George Mason's Institutional Review Board.

Potential interviewees were chosen according to a set of pre-determined criteria. Decision-makers met the following criteria: 1) currently or previously employed by a U.S. state or federal agency or a legislative body that is involved with the creation of wolf management plans or regulations in the WGL or NRM regions and 2) had some role in the creation of wolf management plans or regulations related to wolf management. Academic researchers met the following criteria: 1) published research relevant to wolf management in the WGL or NRM regions within the last 10 years and 2) hold a faculty position at a U.S. university or college.

Emails were sent in February 2013 to 60 potential participants who met these criteria (43 decision-makers and 17 academics) to ask for their participation in an interview. Recruitment emails were sent to a greater number of decision-makers than academics for two reasons. First, an attempt was made to interview personnel from the most relevant state agency in six states (Montana, Idaho, Wyoming, Michigan, Minnesota, and Wisconsin) as well as relevant federal agencies (U.S. Fish and Wildlife Service, National Park Service, and U.S. Department of Agriculture). Second, while academic researchers generally have a website that describes their research and publication record, there is often limited information about state and federal government personnel that is publicly available on the internet. This made it difficult to determine who the most relevant contacts were from each state and federal agency. Therefore, emails were sent to a large number of potential decision-makers, many of whom sent a response indicating that they were not the most appropriate representative from their agency.

In-person interviews were conducted with five academics and 11 decision-makers. Each interview was audio recorded and later transcribed. Eight interviews took place in April 2013 at the Midwest Wolf Stewards Meeting in Silver City, MI. The other eight interviews took place in May 2013 at locations throughout the Northern Rocky Mountain region. The interviews lasted an average of 46 minutes, but some were considerably longer than others, with all the interviews ranging from 18 to 108 minutes.

Interviews were semi-structured, and questions focused on three themes for both academics and decision-makers. The interviews with academics focused on 1) their research dissemination and outreach activities, 2) their interactions with federal and state decision-makers, and 3) institutional incentives to engage in different types of research-related activities. Interviews with decision-makers focused on 1) their role in wolf management decisions, 2) their access to and use of scientific literature, and 3) their interactions with academic researchers. Information obtained from the interviews was coded and grouped according to these themes.

Surveys

Two survey questionnaires (one for academics and one for decision-makers) were designed to a) follow-up on and collect more detailed information than was obtained in the interviews and b) reach out to additional participants who did not participate in the interviews. Questions on both surveys reflected the three themes established in the interviews (as described above).

To ensure questions were unambiguous to survey participants, both surveys were piloted with colleagues who were not potential participants in the study. The recruitment materials and survey questions were approved by George Mason University's Institutional Review Board for human subjects research, and the survey instrument was uploaded to the online survey tool at www.surveymonkey.com.

In February 2014, recruitment letters with a link to the appropriate survey (academic or decision-maker) were sent by email to 42 potential participants (20 academic and 22 decision-makers). Potential participants were chosen according to the same criteria used for interview participants (as described above). Two follow-up requests were sent to all potential participants. Surveys were completed by six academics and 12 decision-makers.

Both survey instruments can be found in Appendix 2. References in this dissertation to specific questions in the survey are accompanied by the question number (Q#).

Description of Academic Surveys

Theme 1: Research Dissemination and Outreach Activities

Respondents were asked a series of five questions (Q2-7) that focused on how they disseminated their research results and whether they engaged in outreach activities. For this section of the survey, participants were instructed to think only about their research that was relevant to wolf management (rather than other research they might conduct that was not relevant to this topic).

Respondents were asked to rate how frequently they had used the following outlets for dissemination of their research results: peer-reviewed journals, edited volumes, presentations at professional scientific meetings, presentations at state or federal government meetings, and outreach to the public (Q2). They were also permitted to add additional categories of dissemination. Responses to the five choices were scored on a five-point Likert scale, and results were calculated as weighted averages (M_w).

Next, respondents were asked to list: a) the journals that they felt were most appropriate for publication of their research results (Q3), b) the conferences they had most frequently attended (Q4), c) any federal or state government meetings they had attended (Q5), and d) the types of outreach activities they usually conducted (Q6). Finally, respondents were asked to rate how frequently the intended audience of their research was each of the following: the public, policy-makers, scientists in state or federal government, and scientists in academia (Q7). Responses to each of the choices in Q7 were scored on a five-point Likert scale, and results were calculated as weighted averages.

Theme 2: Interactions with Federal and State Decision-makers

Respondents were asked a series of 10 questions (Q8–17) about their interactions with decision-makers at state and federal agencies and their participation in the creation of wolf management plans and regulations.

Respondents were asked to rate how relevant their research was to state and federal decision-makers (Q8). A follow-up question (Q9) asked respondents to rate how frequently they felt their research was utilized by state and federal decision-makers. Next, respondents were asked to rate how relevant their research was to policy-makers (Q10) as well as how frequently they felt their research was utilized by policy-makers (Q11). Responses to all four questions were scored on a five-point Likert scale.

Respondents were asked to rate, on a five-point Likert scale, how frequently they had worked directly with state or federal decision-makers (Q12). A follow-up question (Q13) asked those respondents who indicated that they had worked directly with decision-makers to describe those collaborations.

Questions 14 & 15 asked respondents if they had ever participated in the process of creating wolf management plans, and if so, to describe the role they had played in the process. Similarly, questions 16 & 17 asked respondents if they had ever participated in the process of writing regulations related to wolf management, and if so, to describe the process.

Theme 3: Institutional Incentives

Respondents were asked a series of six questions (Q18–23) that focused on the types of research-related activities and measures of impact that were valued and incentivized at their institution and how these values and incentives affected their own behaviors. They were asked to consider all of their academic activities (not just those related to wolf-relevant research) when they answered questions in this section. Questions in this section were adapted from Abbott et al. (2010).

Respondents who indicated that they had participated in the process of creating wolf management plans (Q14) or wolf regulations (Q16) were asked if they felt that their institution valued those activities (Q18 & 19). Next, respondents were asked to rate, on a four-point rating scale, the amount of emphasis they thought their academic institution placed on 17 different scientific activities, such as publications in high impact journals, grant dollars awarded from federal and state sources, collaboration with government scientists, and talks at professional meetings (Q20). A follow-up question (Q 21) specifically asked respondents if their department provided any incentives to collaborate with government scientists.

Respondents were asked to think about the range of possible measures of scientific contributions (based on the list of activities provided in Q20) and indicate their own top five priorities (Q22). Finally, respondents were asked if they thought that the way their institution evaluated their work affected their behaviors (Q23).

Description of Decision-maker Surveys

Theme 1: Role in Wolf Management Decisions

Respondents were asked a series of six questions (Q1–6) to determine the role that they had played in the creation of wolf management plans and regulations. Questions 1 and 2 asked respondents if they had ever participated in the process of creating wolf management plans, and if so, to describe the role they played in the process. Those respondents who indicated that they had participated in the process were then asked to choose, from a list of nine potential sources, all the sources of information they had used when creating wolf management plans (Q3).

Questions 4 and 5 asked respondents if they had ever participated in the process of creating regulations related to wolf management, and if so, to describe the role they had played in the process. Those respondents who indicated that they had participated in the process were then asked to choose, from a list of nine potential sources, all the sources of information they had used when creating regulations (Q6).

Theme 2: Access to and use of Scientific Literature

Respondents were asked a series of six questions (Q7–12) about their access to and use of scientific literature. These questions were adapted from Pullin (2003).

Question 7 asked respondents to indicate, on a five-point Likert scale, how often they had used published scientific papers to support their decision-making. Results were calculated as weighted averages of the responses. A follow-up question (Q8) asked respondents who had infrequently used scientific papers to support decision-making to indicate the reasons that they did not use such papers more frequently. Respondents were provided with a list of seven potential reasons and asked to choose all that applied to them. They were also allowed to list additional reasons. An additional follow-up question (Q9) asked those respondents who had frequently used scientific papers to support decision-making to indicate how they generally located and accessed publications. Respondents were provided with a list of seven potential methods and asked to select all that applied. Respondents were also allowed to list additional methods.

Respondents were provided with a list of 11 journals that published articles relevant to wolf management (based on data discussed in Chapter 4) and were asked to rate the relevance of each journal to their own work, on a four-point rating scale (Q10). Respondents were also given the option of choosing “I don’t know” for each journal. Results were calculated as a weighted average of responses. A follow-up question (Q11) asked respondents to list any additional journals that were relevant to their work.

Question 12 asked respondents to rate how easily they were able to access each of the journals that were listed in Q10. For each journal, respondents chose from the following options: 1) I have great difficulty accessing this journal; 2) It takes a little extra work, but I am still able to access this journal; 3) I have easy access to this journal; and 4) I don't know.

Theme 3: Interactions with Academic Researchers

Respondents were asked a series of three questions (Q13–16) about their experiences working with academic researchers. Respondents were asked to indicate, on a five-point Likert scale, how often they had collaborated with researchers who were based at academic institutions (Q13). Respondents who indicated that they had sometimes or frequently collaborated with academic researchers were asked to briefly describe those collaborations (Q14).

All respondents were provided with a list of six potential benefits of collaborating with academic researchers and asked to select those that they saw as the greatest benefits (Q15). They were also allowed to list other benefits not included in the list provided.

All respondents were then provided with a list of six potential barriers to collaborating with academic researchers and asked to select those that they saw as the greatest barriers (Q16). They were also allowed to list other barriers not included in the list provided.

Results

The following sections provide the results of both the surveys and interviews with each group of participants (academics and decision-maker). Results are provided by theme within each participant group, with survey results discussed first and followed by relevant quotes from the interviews. Due to the low number of participants in each group, results were not statistically analyzed.

Interviews and Surveys with Academic Researchers

Theme 1: Research Dissemination and Outreach Activities

Surveys

Survey respondents were given a list of possible outlets for research dissemination and asked to rate how frequently they used each outlet. Publication of research results in peer-reviewed journals was the most frequent outlet used by the respondents (M_w = 4.83; see Figure 6). Presentations at professional scientific meetings was also a frequent outlet for dissemination (M_w = 4.0). Less frequently used outlets for dissemination were presentations at government meetings (M_w = 3.33), outreach to the public (M_w = 3.17), and edited volumes (M_w = 2.33). Results are shown in Figure 6.

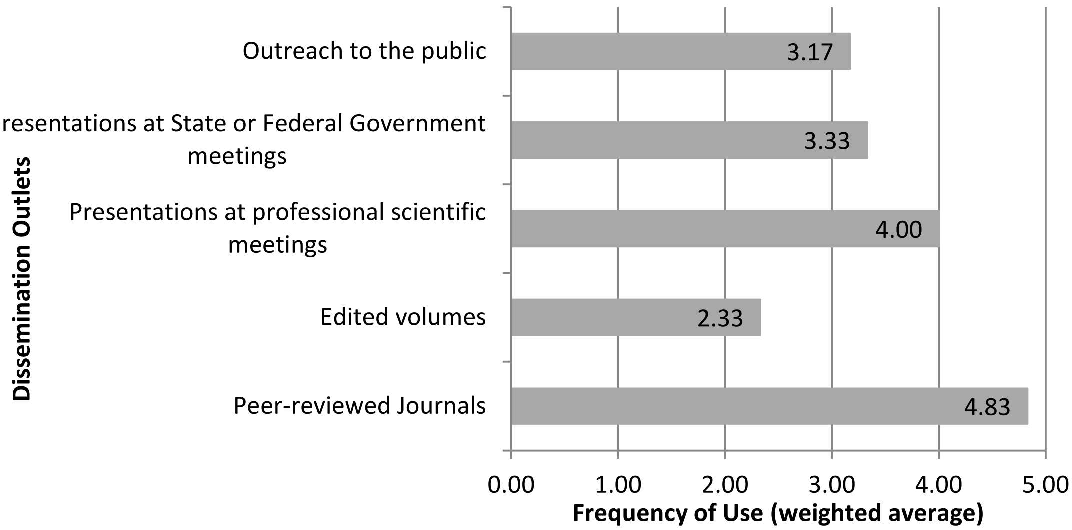

Figure 6. Responses to the question: "What are the main outlets for dissemination of your research findings?"
1 = never; 2 = rarely; 3 = sometimes; 4 = frequently; 5 = very frequently. Results are reported as weighted averages of the responses. N = 6.

When asked to list journals that were most appropriate for the publication of their research, the six respondents provided a total of 35 responses and listed 20 unique journals (after duplicates were removed). Two journals, *Journal of Wildlife Management* and *Wildlife Society Bulletin*, were listed by four of the six respondents (Table 10). *Biological Conservation*, *Ecological Applications,* and *Ecology* were listed by three of the respondents. Table 10 summarizes all responses to this question.

Table 10. Journals most appropriate to respondent's research.

Listed by Four Respondents:	Journal of Wildlife Management Wildlife Society Bulletin
Listed by Three Respondents:	Biological Conservation Ecological Applications Ecology
Listed by Two Respondents:	Conservation Biology Human Dimensions of Wildlife Journal of Applied Ecology Science
Listed by One Respondent:	Behavior Bioscience Canadian Journal of Zoology Conservation Letters Forest Ecology and Management Nature Journal of Animal Ecology Journal of Mammalogy Proceedings of the Royal Society B Society and Natural Resources Wildlife Biology

Respondents were asked to list the professional scientific meetings they had attended most frequently. The six respondents provided a total of 10 responses and mentioned six unique meetings. The meeting of the Wildlife Society was listed by four of the six respondents. The Midwest Fish and Wildlife Conference was listed by two respondents. Other meetings that were listed (each mentioned one time) were the Ecological Society of America, International Association for Society and Natural Resources, Society for Conservation Biology's Congress for Conservation Biology, and the Midwest Wolf Stewards Meeting.

Respondents were asked to describe the types of federal or state government meetings that they had presented at, if any. Four of the respondents indicated that they had presented at a state or federal government meeting. The types of meetings listed included single-state resource management agency meetings (e.g. Department of Natural Resources or state Fish and Wildlife Agencies), multi-state resource management agency meetings, National Park Service meetings, and legislative committee meetings.

Respondents were asked to list the types of outreach activities, relevant to their wolf research, they had conducted. Two of the respondents indicated that they had given both presentations at universities as well as participated in media interviews. Other outreach activities listed by respondents (each mentioned one time) were press releases, talks at NGOs, talks to other stakeholder or public groups, and use of a webpage for outreach. One respondent said that they had not conducted any outreach and "prefer to keep a low profile."

Participants were asked to rate how frequently the intended audience for their research was the public, policy-makers, scientists in state or federal government, or scientists in academia. As shown in Figure 7, the most frequently intended audience was scientists at federal and state government agencies ($M_w = 4.83$). This was followed by policy-makers ($M_w = 4.50$), academic scientists ($M_w = 4.17$), and the public last of all ($M_w = 3.50$).

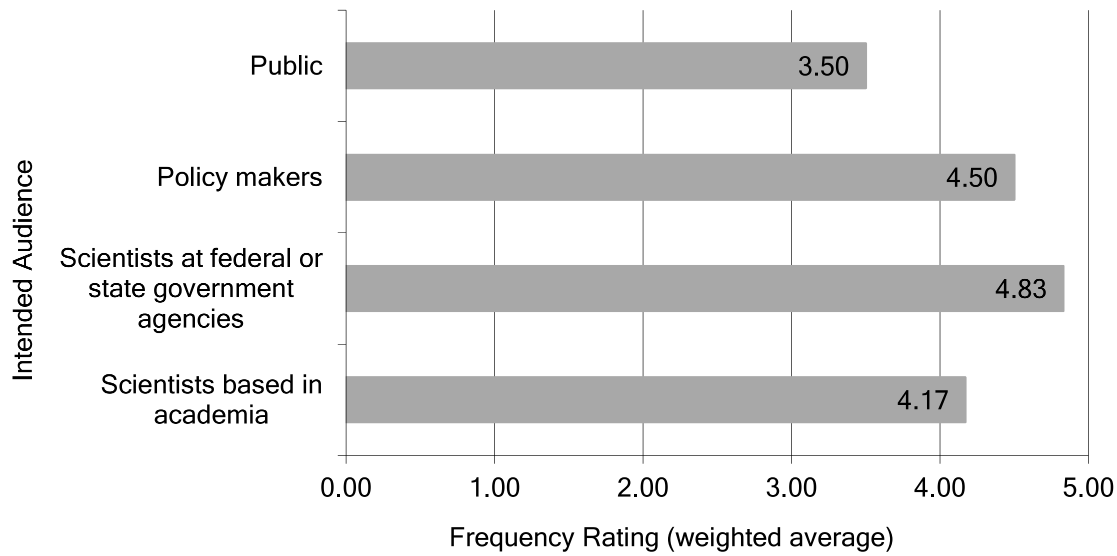

Figure 7. Responses of academics to the question: "Who is the intended audience for your research?"
1 = never; 2 = rarely; 3 = sometimes; 4 = frequently; 5 = very frequently." Results are reported as weighted averages of the responses. N = 6.

Interviews

Interviewees were asked to describe their research dissemination and outreach activities. Academic A described the nature of his outreach activities: "*I'm a worker bee behind the scenes, but I do present a lot of my stuff to managers, to agencies and professional meetings, and things like that. But I don't go to the public really*."

Academic D talked about why he thinks it is important for academics to reach out to decision-makers:

> *If there's two papers by equally credible scientists that a manager or policy-maker is reading, and one's written by somebody that they've heard make sense to them, that they have built some rapport and trusting, or at least respecting their work, and another is a top-notch NSF-funded scientist in the nation on that topic, they're going to take the one where they've seen that person, they've talked to them, they've heard them in their meetings, they've seen communications that*

make sense to them, and that they know those people care about helping inform managers versus the person that happens to be the biggest wig in the nation or the world on those particular topics. In fact, those folks I think would be the least likely to be effective in influencing managers in general.

Similarly, Academic D stated:

I think how you make your science have impacts is you have to go talk to managers. And you have to talk to them in a meaningful way. Very few of the academics I know go to the standard meetings and conventions of managers. And oftentimes when they do and give a presentation, it's totally esoteric or so buried in stats and technical stuff that the audience is not listening, or they just simply don't trust your conclusions because so many gyrations have been performed on the data that they're not familiar enough with, and as they should not be, to know if they can trust anything that comes out the other end.

Academic B also talked about the importance of outreach to decision-makers but indicated that outreach to the public is also critical:

One thing that a lot of people on the outside and a lot of people in academia think is that it's the science that drives this stuff [decision-making]. Not so much. I try to look at it as informing the decision-making process, and to inform the decision-making process, you've got to get information out to scientists who can say, "Yep, this is real, peer-reviewed; we buy these results" to the managers, who can use that in management plans or to decide which way to go. But probably most importantly to the public, because they're the ones who tell the managers ultimately what to do and tell the politicians. They hire them, they fire them, vote them out, and then things change. So all of those audiences need to be informed, and that's a huge job.

Finally, Academic C described his commitment to outreach and some of the benefits he has derived from his efforts:

I've just always had deep commitment to outreach for its own sake. I believe it's my duty to communicate to scientists, to more than just other scientists, and I enjoy sharing in those ways. In that enjoyment, I spend a great deal of time trying to understand how to better connect with members of the general public just because you can't talk to a classroom of undergraduates or scholars in the same way you would talk to the general public. It takes different messaging, and you *need to understand narrative and all sorts of stuff. So I worked on that for its own sake. Well, in doing that, I think I'm better at understanding other people's perspectives on management issues, and for wolves that's a big deal, understanding folks who like wolves and why folks who don't like wolves.*

Theme 2: Interactions with Federal and State Decision-makers

Surveys

One hundred percent of survey respondents (n = 6) indicated that they felt their research was very relevant to federal and state wolf managers and practitioners. However, only three of the respondents (50%) felt that their research was very frequently (n = 1) or frequently (n = 2) used by federal or state wolf managers and practitioners, and three respondents felt that their research was sometimes (n = 2) or rarely (n = 1) used by such stakeholders.

Similarly, all respondents felt that their research was very relevant (n = 2) or relevant (n = 4) to policy-makers, but only one respondent felt that their research was frequently used. Three respondents felt that their research was sometimes used. The other two respondents felt that their research was rarely (n = 1) or never (n = 1) used by policy-makers.

Respondents were asked how frequently they had worked directly with federal or state wolf managers and practitioners. Four of the respondents indicated that they had very frequently (n = 3) or frequently (n = 1) worked with government wolf managers or practitioners. The other two respondents indicated that they had rarely (n = 1) or never (n = 1) engaged in these collaborations.

The four respondents who indicated that they had frequently worked with federal or state wolf managers and practitioners were asked to describe that work (Q13). Respondents indicated that they had provided formal and informal consultation on specific projects or collaborated on research.

Respondents were asked if they had ever participated in the process of creating wolf management plans. Two respondents indicated that they had participated in this process. These respondents were asked to describe the role that they had played in the process. The respondents indicated that they had contributed by "authoring technical sections and conducting literature reviews" as well as "supporting the plans with research results and reading drafts."

Respondents were asked if they had ever participated in the process of writing regulations relevant to wolf management. All six respondents indicated that they had never been involved in this process.

Interviews

Interviewees were asked to describe their interactions and collaborations with decision-makers. Academic A described how he often bases his research agenda on the needs of managers:

> *Out here, agencies really depend on research, so it's been kind of nice. I'll go to an agency and say, "What are you guys thinking? What kind of questions do you have?", and they'll go, "Oh yeah, this is what we were thinking." It's been a really great opportunity out here.*

He contrasted this with the less effective way he used to interact with decision-makers, saying: *"In my earlier days, I would sit back and try to imagine what would be* *useful to a manager, go out and do the research, and I'd show it to the managers and go, 'Don't you think this is cool?', and they'd be like, 'I don't need that.'"*

Academic C described a different type of interaction with decision-makers: *"I do what – for lack of a better word— might be considered consulting… So, not so much as doing research but just kind of bringing research to them, so they can be aware of it and that sort of thing."*

Academic C then elaborated on some of the challenges of acting as a consultant to decision-makers and how he navigates those challenges:

> *So I don't necessarily agree with why this… DNR thinks there should be a harvest. I think they've got it wrong. But they still come to me to ask me about technical questions about it, and I'm alright answering those questions. Because they know that I don't like their reasons, but I'm also – it's my duty as a citizen to be a proper guardian of the kind of ecological facts of the matter, and I know how they wish to address them.*
>
> *And so I don't have trouble giving advice. This is usually done in an informal situation or a phone call – "Hey, what do you think of this? Would this work? How would you go about it? If we propose this, what concerns would you have?" I would say, "Well, these are my technical concerns." They would say, "Oh, OK." And then I would say "these are my social and normative dimension concerns," and they're like, "well, OK, we're glad to know about those." They're much politer. I'm good friends with them all. So they're like "OK, good. Thanks for the techno cover." But I am so happy to advocate for what I think is right and then the dimensions things, and they're happy to be respectful of me in that and listen when it's appropriate for them to listen, to tell me to be quiet when it's appropriate for them to tell me to be quiet, and so forth.*

Interviewees also talked about why it is often essential to form good relationships with decision-makers. For example, Academic C said:

> *If you're a wildlife biologist, you only have a few, relatively speaking, avenues for funding, and depending on the state where you live, one of the key avenues of funding would be the state. So if you're a jerk to those people, you're not going to get the money that you need to become a successful faculty member.*

Academic B provided a different example of the importance of forming good relationships:

> *A big part of the reason that [researchers need to work with decision-makers] is that when wolves were listed, you had to get permits from the state, from the Fish and Wildlife Service, and from whoever's land you're going to handle animals on. So unless you're working with them, and they feel reasonably comfortable with you, you're probably not going to get the permit.*

Academic C described how there are both benefits and concerns associated with developing relationships with decision-makers:

> *You actually have to kind of cultivate a relationship and those relationships, I think, have strengths and – strengths and weaknesses aren't the right word…But that kind of collaboration can be very good because it can ensure that research really is focused on the question at hand. But then if a person is concerned about independence between the scientific progress and whatever interest the state government might have, then there are always concerns about that. Those concerns play out wildly differently all over the place from being not a concern at all to raising an eyebrow or people wondering a little bit. I mean at the end of the day, everything has passed peer review and that sort of thing. But it's certainly on people's minds when navigating those relationships.*

Interviewees were also asked about the role that they think science plays in decision-making. Responses to this question varied considerably. For instance, Academic C stated:

> *I think that you can be impactful in two ways. One would be in terms of technical information, and the other would be in terms of information that changes people's attitudes. That impact is intangible, I think. I think it's important, but it's a bit intangible. It's important for shaping the tenor of the discourse that leads to the management.*

Academic C elaborated on this idea with an example of how science is influencing discussions related to the impact of wolves on prey populations:

> *This is a place where you have more data than you can ever want or imagine. You have some of the brightest minds working on this topic, evaluating, critiquing this topic with all of that brain power and all of that data. You still can't agree whether wolves have had a strong effect on Yellowstone elk. So again, that would be an example of where I think information… has an important influence on management, but I think it influences more the tenor of the discourse that leads to the management rather than like oh, here's the managed prescription that we can see that's tied to some issue over here.*

Academic A described some of the circumstances that can help or hinder the use of science in the decision-making process:

> *If there's very little uncertainty about something, or very little consequences for being wrong, there's probably not a lot of room for science. But if there is a lot of uncertainty, then I think there are two ways that can be addressed. One is to do research directly targeted at that uncertainty, and that's the research that's easiest to sell to a management agency, because if they don't fund the research, it's probably not going to get done. But if you can go to them, and either working with them or they tell you or you figure out that "Boy, how can you make a decision unless you know this?", then they're pretty open to what you have to say. The other way that you can do it is just kind of be lucky. Either that or visionary. A lot of times, those of us in the wildlife biology world consider ourselves applied scientists. We're doing stuff that we hope will be applied, and sometimes it is, sometimes it isn't, and sometimes it's because we guessed wrong, and we're doing something that is kind of general application, but managers don't need that at the time. Or sometimes we're ahead of our time, where we're able to look down the road and say, "This is coming," and the managers say, "Well, it's not here right now."*

Academic D expressed some different ideas about how he thinks decision-makers choose the science they use to support their decisions:

> *[Managers and policy-makers] are listening to some science, and I don't know what science they're listening to and establishing policy. Like I said, the tendency would be to pick the science that supports your constituency groups or your own opinions about the system, because there's a wide range of science to select from.*

Interviewees also discussed why they think some scientists have more impact than others. Academic C observed:

> *One of the great limitations that I see is that we're organized into our discipline so strongly, and while the management is always interdisciplinary, and so even among academics, you can have a wildlife ecologist and a wildlife sociologist and a wildlife policy person. Those three people don't speak the same language, and so they actually can't collaborate as long as they can't understand each other, and you're not going to understand each other by meeting for a weekend. That's huge. Why are some scientists more influential than others in management? I would be wondering about their tolerance and capacity to work outside the discipline. I'm pretty sure that's a big part of it, because there are the folks [who] would never leave the departmental office or the folks that aren't interested in that. There's nothing wrong with that, but that's why they don't leave because of their offices, because they're not comfortable in those arenas.*

Academic D elaborated on this idea and explained that some academics have not formed positive relationships with decision-makers:

> *I don't think academics oftentimes are well-respected or listened to by management people, because academics don't respect management people and ignore the insights that management biologists might have and just can be arrogant and aloof. It doesn't take a whole lot of interactions with academics to turn folks off that are making decisions, if they think, "These folks aren't at all grounded in reality, and they're just looking to make a splash with some paper that is as dramatic as possible in order to advance their own careers, and not really interested in supporting management."*

Theme 3: Institutional Incentives

Surveys

The two survey respondents who indicated that they had participated in the process of creating wolf management plans (Q15) were asked if they felt that their academic department valued that contribution. One respondent answered “yes,” and the other answered “no.”

All respondents were asked to rate how much emphasis they thought their department placed on various scientific activities. Participants felt that their departments placed most emphasis on publications in high impact journals ($M_w = 4.0$), followed by grants and income from federal sources ($M_w = 3.83$); grants and income from state sources ($M_w = 3.17$); and training and mentoring students, postdocs, and junior faculty ($M_w = 3.17$; see Figure 8). Respondents indicated that “bridging the gap” activities, such as outreach to non-scientists and collaborative work with government scientists, received less emphasis in their departments ($M_w = 1.83$ and $M_w = 2.33$, respectively).

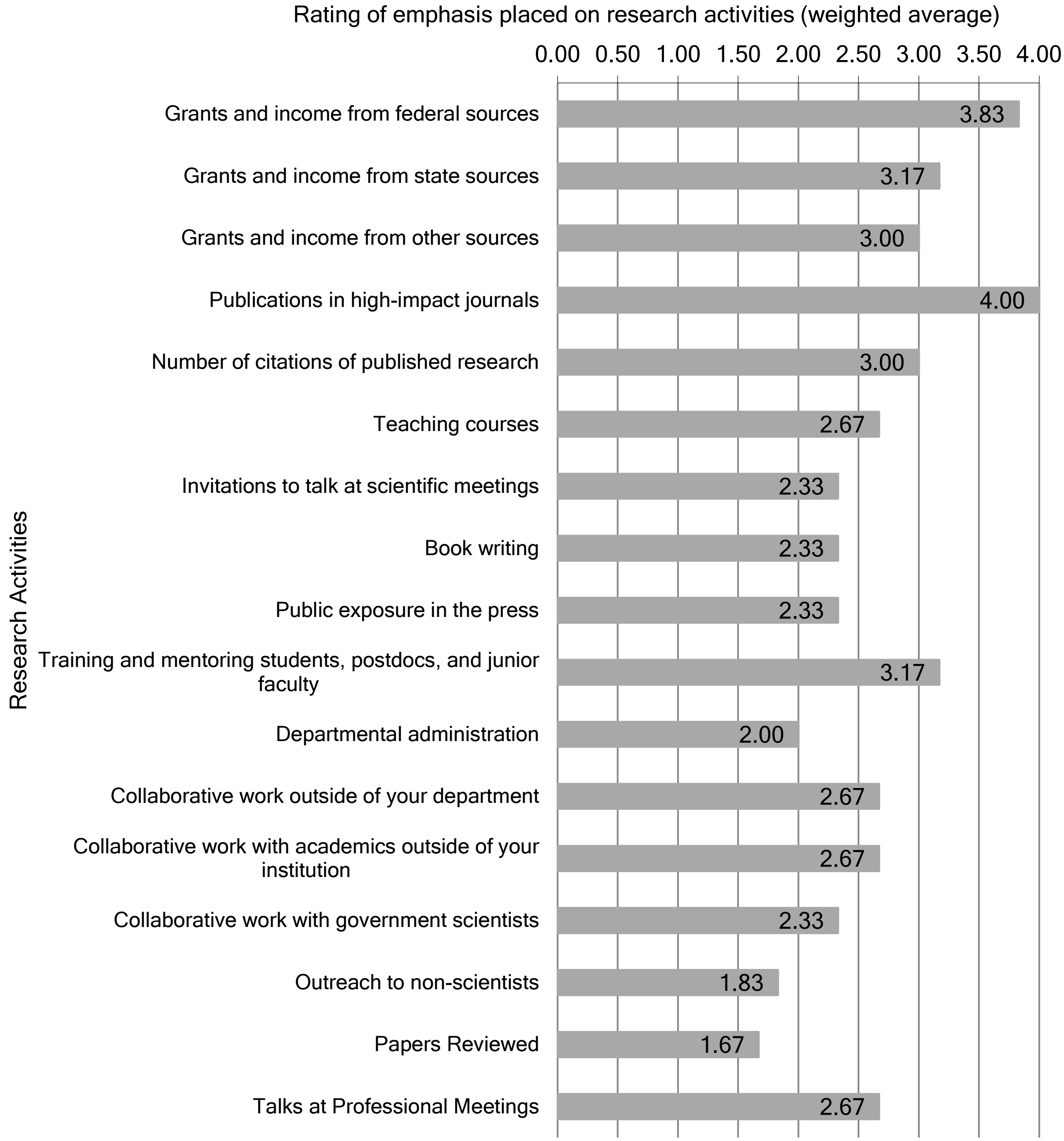

Figure 8. Responses of academics to the question: "How much emphasis do you think your department places on the following scientific activities during performance reviews and decisions on advancement and tenure?"
1 = No Emphasis; 2 = Little Emphasis; 3 = Some Emphasis; 4 = Considerable Emphasis." Results are reported as weighted averages of the responses. N = 6.

When specifically asked if their department provided any incentives to collaborate with government scientists, five of the six respondents answered "no." One respondent indicated that their department did provide incentives for these collaborations. This respondent stated: *"I receive credit in annual and periodic performance evaluations for collaborative work with agencies because it is fundamental to our mission. Occasionally I receive non-competitive funding to promote such collaboration."*

Respondents were asked to think about the range of possible measures of scientific contributions and to rank their top five priorities. The following activities were ranked in the top five by four of the six respondents: 1) publications in high impact journals; 2) number of publications; and 3) training and mentoring students, postdocs, and junior faculty (Figure 9). One additional activity, collaborative work with government scientists, was ranked as a priority by three of the six respondents.

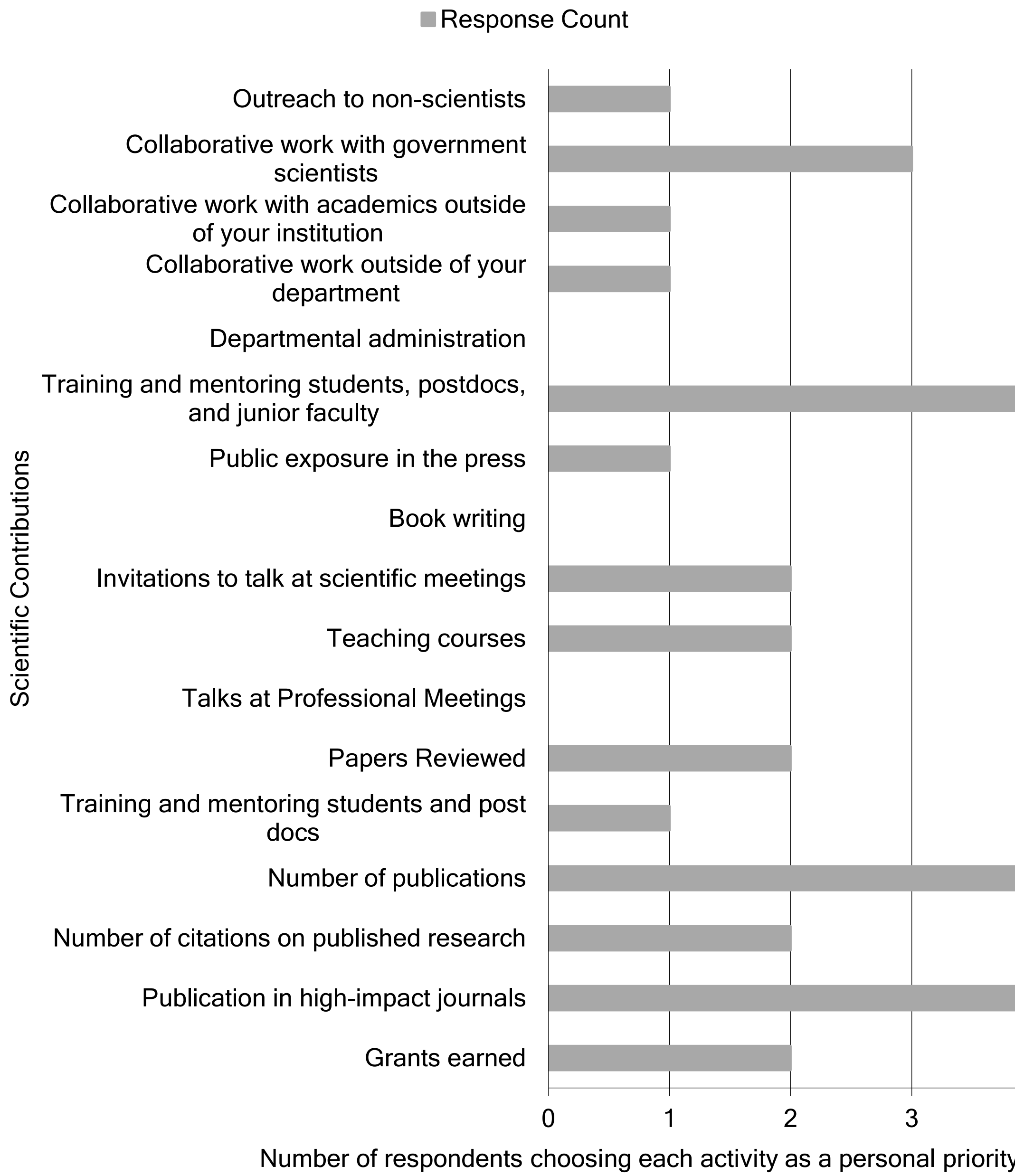

Figure 9. Responses of academics to the question: "Thinking about all of the possible measures of scientific contribution that are possible, please select your own top five priorities."

Results are reported as the number of responses for each activity. N = 6.

Finally, respondents were asked if they thought that the way their institution evaluated their work affected their behaviors. All six respondents answered "yes" to the question.

Interviews

During discussions about departmental incentives, most interviewees focused on what they saw as two activities most highly valued by their institution: high impact publications and grant dollars awarded (in particular, grants that include overhead costs). Academic A described how the pressure to publish high impact research can create a dynamic tension for faculty:

> *It's kind of an interesting dichotomy. Generally within a wildlife biology program, it's recognized that you're producing your research for a particular audience, and so putting it out there in a place the audience will see it is a good thing, and if it gets used, that's an even better thing. But it's not always in journals with the highest impact factor. So you'll see a dynamic tension sometimes in an academic setting where people really, really want you to be publishing in high profile journals, but it's like, managers don't read those. It's stuff that has very little chance of impacting policy.*

Academic C explained how funding pressures, in addition to the need to publish, can influence the behavior of faculty:

> *If you're a young academic or even if you're not young as an academic, two of the most important criteria in which your performance is judged is the amount of money that's brought in and the number of publications that you produced. So yeah, you're encouraged to produce the relationships that are necessary to achieve that, and wildlife biologists do that variously. So some of them would be very tuned into their state agencies because that's their interest, or that's what they've become good at. And others will be less. So it kind of depends a little bit. When the state is paying for the research, the demand that the research be useful is very high. If your funding mainly comes from sort of like NSF, then the demand is that it would be excellent and advance knowledge. All those avenues are open to any young scientist to figure out what works for them.*

While Academic C suggested that academics have some freedom to choose a path that works for them, other interviewees emphasized the constraints that the need for funding puts on faculty priorities and behaviors. For example, Academic D described how young faculty are especially impacted by the need to get grants that come with overhead, or indirect, money:

> *New faculty don't have much incentive to go after collaborations with management agencies, especially at the state level, because it doesn't pay. New faculty also require much bigger startups, for some reason, and so when you want to ask for a lot of money coming in new, you'd better generate lots of money too. And that's not grant money; that's overhead money, and you aren't going to do that working with states. So there's a big disincentive for professors to work with managers and state agencies and people that are actually making the decisions and managing the resources, I think.*

Academic B echoed this sentiment, saying: "*It hurts us that those Fish, Wildlife, and Parks and Fish and Wildlife Service grants come in at zero or very low indirect. And that is something that I worry about a lot. I think that's a huge issue.*" He elaborated on this, explaining the impact that it has had over time:

> *When I started here 30 years ago, probably half to two-thirds [of funding] came from the state. Most of the rest came from federal government, and that was Fish and Wildlife Service, Forest Service, Park Service. Now, NSF does a lot. Some private foundations, EPA, Department of Defense…they all pay indirect. We've got about 45 or 50 graduate student projects that are all funded. There's one… maybe two or three [that are state-funded]. So that's gone from half down to 5%, roughly.*

Academic D also described some of the ultimate impacts that the current rewards and incentives systems in the universities are having:

> *I'd much rather be working with in management and helping establish policy than playing the academic and NSF game, to be honest. Those people who are making the decisions on the ground that affect resources that I care about and a lot of*

society cares about, not academics. I think academics are motivated very differently than managers, and I don't necessarily think that they're motivated in ways – or rewarded in ways that make them motivated to be well-grounded in what's needed to establish policy and help managers do things that are positive for society. I just don't think the reward system is there.

It's not the papers, the grantsmanship. All that is a mechanism to keep the money flowing, to be able to train people well, to get them out in the field, to be good scientists. If you play the academic game, and you chase the overhead dollars and get the biggest publications in the splashiest journals and build up those clique groups of scientists where everybody cites each other's papers and berates everybody else's, you're doing a great job of promoting yourself as an academic and being successful in the NSF world, but you're not having an impact on management very much.

Interviews and Surveys with Decision-makers

Theme 1: Role in Wolf Management Decisions

Surveys

Decision-makers were asked whether, in their current or a previous position with a government agency, they had ever participated in the process of creating wolf management plans. Eleven of the 12 respondents indicated that they had participated in this process. These 11 respondents were asked to briefly describe the role they had played in creating these plans. Respondents indicated that they had co-authored, peer-reviewed, or edited state management plans. Some respondents also indicated that they had chaired technical committees that authored the plans and presented plans to state review boards.

These 11 respondents were also asked to indicate the sources of information that they had used when creating wolf management plans. One-hundred percent of respondents indicated that they had used published scientific papers as well as expert opinion from outside of their group when writing wolf management plans (Figure 10). Additionally, 91% of respondents indicated that they had used 1) other existing management plans, 2) published reviews, and 3) edited books. Seventy-three percent indicated that they had used personal communications (personal accounts). Six respondents (50%) listed other sources of information that were not included in the list of information sources provided in the question. Other sources of information that were listed included: staff and departmental data and expertise (n = 3), stakeholder input (n = 2), and laws and regulations (n = 1).

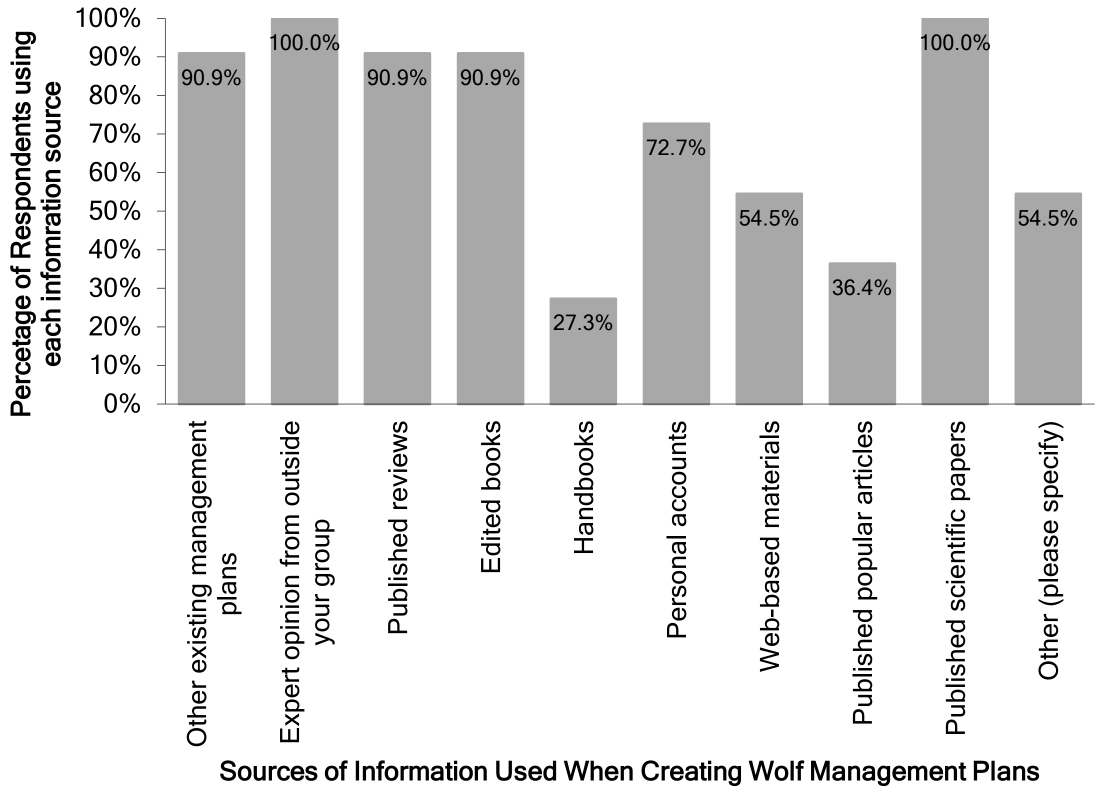

Figure 10. Responses to the question: "In addition to your own (your group's) expert knowledge, what other sources of information are used to create management plans? (Check all that apply)."
Results are reported as the percentage of respondents that chose each information source. N = 11.

All respondents were asked if they had participated in the process of creating wolf regulations. Eleven of the 12 respondents indicated that they had participated in this process. These 11 respondents were asked to briefly describe the role they had played in the process of creating wolf regulations. Respondents indicated that they had been involved with either writing regulations (n = 6) or conducting a formal review of regulations (n = 6). The 11 respondents were also asked to indicate the sources of information they had used when creating wolf regulations. One-hundred percent of respondents indicated that they had used published scientific papers when creating wolf regulations (Figure 11). Additionally, 91% of respondents indicated that expert opinion from outside their group had been used. Eighty-two percent indicated that 1) management plans and 2) published reviews were used to create wolf regulations. Other sources of information that were listed included: staff and departmental data and expertise (n = 1) and stakeholder input (n = 1).

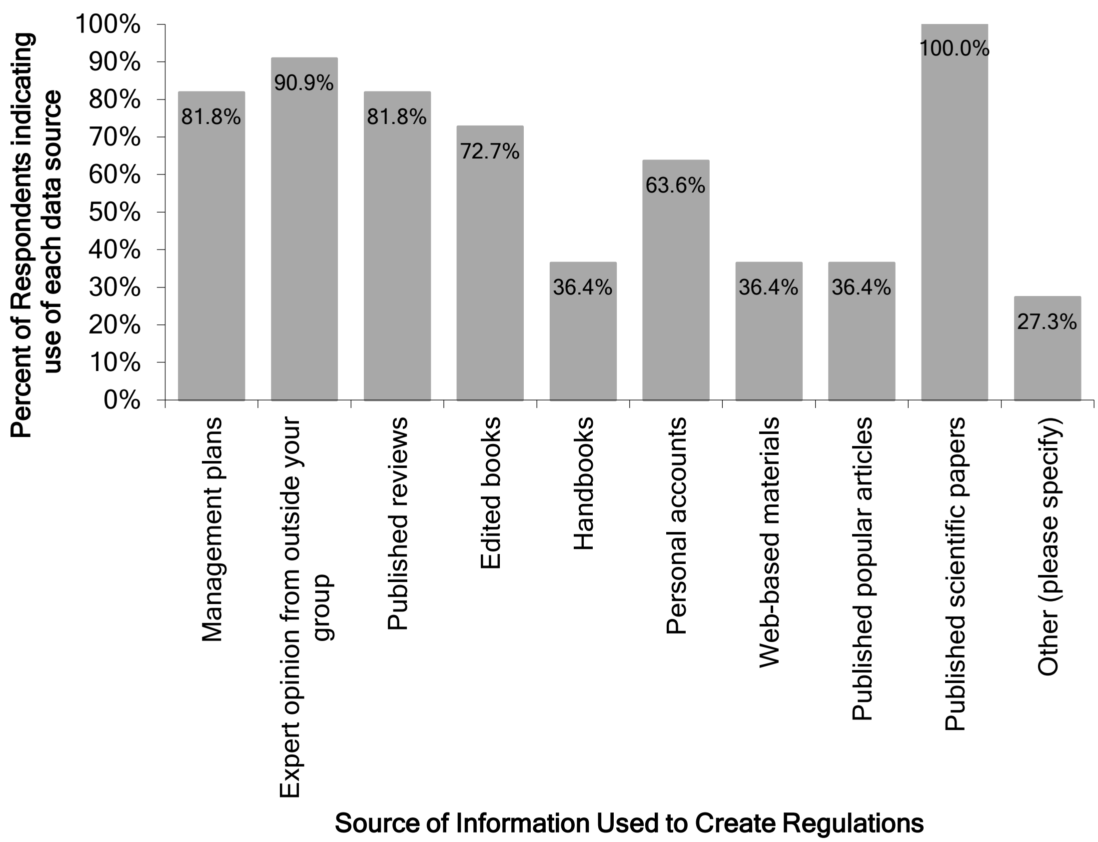

Figure 11. Responses to the question: "In addition to your own (your group's) expert knowledge, what other sources of information are used to create regulations? (Check all that apply)."
Results are reported as the percentage of respondents that chose each information source. N = 11.

Interviews

Interviewees were asked to describe the role that they had in wolf management decision-making as well as the role that science played in their jobs. In addition to providing descriptions of their jobs, some interviewees described their relationship to science and scientific publications. The following sample of quotes from five interviewees is representative of the diversity of the interviewees and the role of science in their job.

Decision-maker A: "*My goal every day is to be a scientist. I rarely achieve it. If I'm lucky, I'll get to be a biologist.*"

Decision-maker B: "*Most of us in the wildlife management field are kind of classically trained biologists, where we were told it isn't true unless it's published in a peer-reviewed article, and you can't write anything without citing it. So we're sort of rooted in that*."

Decision-maker C: "*I still do research. We publish.…We've been involved in the research end of it and the realities of that and how they conflict sometimes with the management end of things*."

Decision-maker D: "*I don't even consider myself a scientist, really. I consider myself a manager*."

Decision-maker E: "*One of the reasons I decided to enter politics was to try to occupy one of the seats at the decision-making table with my science background. Because I can speak to the basics, like peer-reviewed literature.*"

Many of the decision-makers who were interviewed talked about the fact that they or their agency conducted much of their own research. For instance, Decision-maker F commented: "*The best way, I think, to have research incorporated is to have your own staff do it.*" With regard to research conducted in his program, Decision-maker A stated: "*We try and be as academically rigorous as we can, but at the same time apply it with a real-world prism.*"

Decision-maker D explained the effectiveness of the model used by his agency, which encourages staff to conduct their own research, saying:

> *We have some really top notch scientists that are very productive and doing projects and publishing literature that people are really interested in, cutting edge new information that I think is valuable to wildlife management, and not only in [our state], but other places. So it seems to be a good model.*

Some interviewees also talked about the importance of not only conducting their own relevant research, but also publishing that research. Decision-maker F stated:

> *…they're [publications] useful when you get in the final stages of rule-making and stuff, and you have literature cited, because then the court looks at that stuff. "How did you determine survival rates of wolves?" "Well, your honor, we collared 2,000." We had this published in a peer-reviewed journal, which is the standard for meeting the court thing. It's no longer arbitrary and capricious. It's gone through a formal process; it's got professional, independent peer review.*

Decision-maker F also said:

> *I'm a huge one for publication, not only for the publication, but if you're gathering data, and you never look at it and analyze it, you don't really know if you're gathering what you should or how to analyze it. So I'm a big one on "You've got to stop; you've got to write it up. I'm not going to let you do anything more until you stop and do that."*

He continued: *"I've got 120 publications of various types and things like that -- co-author, author; most of those were done on evenings and weekends. Which is very tough to do. But you can do it, if you have it built in."*

Similarly, Decision-maker A stated:

> *But I have put on our team's #1 priority publications, and we've got 68 in the last 18, 19 years that's peer-reviewed. We probably have four or five more book chapters, a couple books, tons of popular articles, lots of technical reports. So we're really trying to get the information out there for science, and probably more importantly, management.*

Despite the focus of many agencies on publishing their own research, some decision-makers indicated that publishing was not without challenges. For example, Decision-maker F explained that the culture in some agencies didn't do enough to support and reward scientific publication:

> *They have to reward that some way, other than "You got a publication. The report I asked you for last week was late, so you're doing this other shit?" Hey, that probably rarely happens that way, but the [agency] talks about publications, how science is the forefront and stuff. So it's like, what management structures do you have in place to reward people who publish? My guess is they'll just be like "What?"*

Theme 2: Access to and use of Scientific Literature

Surveys

Respondents were asked a series of questions about how they accessed scientific literature that was not conducted by their own organization and how it was used in their organization.

Respondents were asked how often they had used published scientific papers to support their decision-making. Ninety-two percent (n = 11) of respondents indicated that they had very frequently (n = 8) or frequently (n = 3) used scientific publications to support their decision-making. One respondent indicated that they had rarely used such documents to support decision-making.

The one respondent who indicated that they had rarely used scientific publications was asked why they did not use scientific publications more frequently. The respondent indicated that scientific publications were 1) too difficult to access and 2) too time-consuming to read given the respondent's already existing workload.

The 11 respondents who indicated that they had very frequently or frequently used published scientific papers to support their decision-making were asked how they generally located and accessed the publications. One hundred percent of respondents (n = 11) indicated that literature had been recommended by colleagues (Figure 12). Ninety-one percent of respondents (n = 10) had used their own personal collection of scientific papers, and 82% (n = 9) indicated that they had used web searches to locate and access scientific papers. Less frequently used methods were electronic searches of library databases (64%, n = 7), use of employer's collections (64%, n = 7), and a manual search of literature in a library (18%, n = 2).

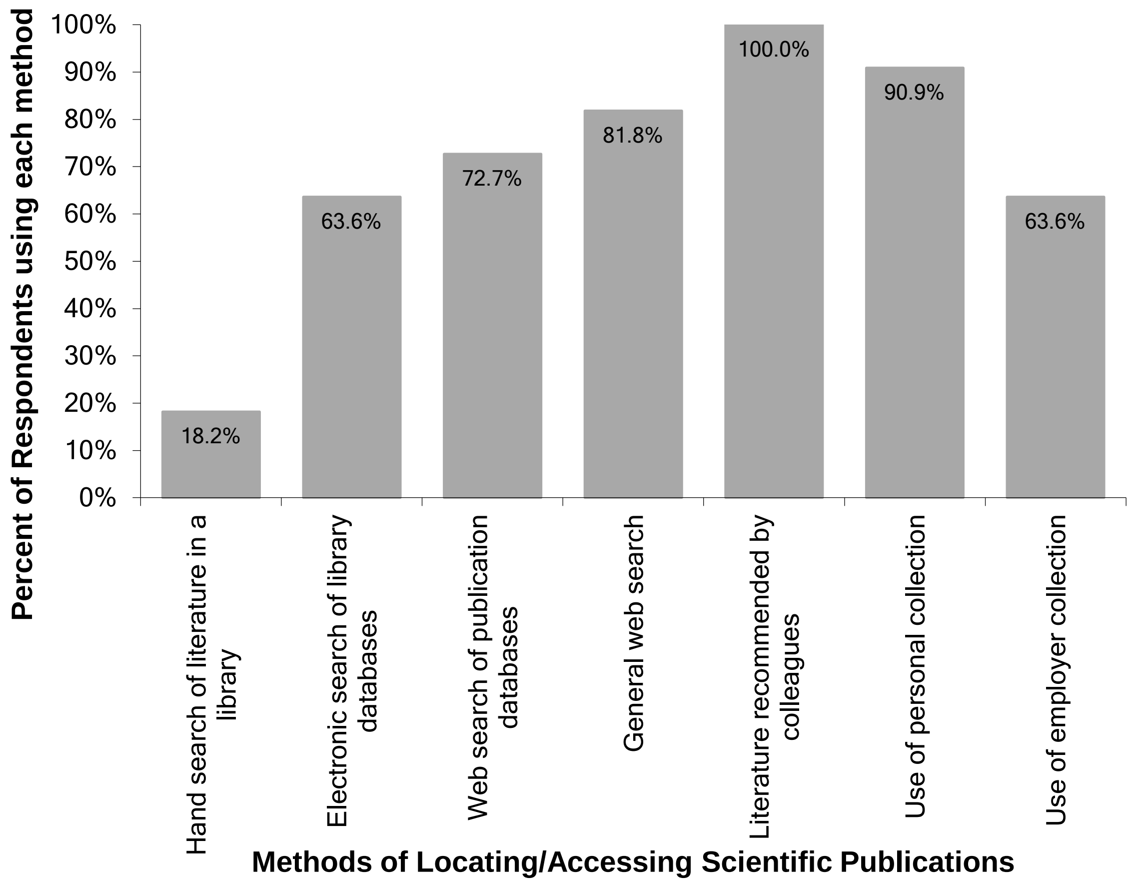

Figure 12. Responses to the question: "When using published scientific papers, how do you generally locate and access them? Select all that apply."
Results are reported as the percentage of respondents that chose each method. N = 11.

All respondents were given a list of 11 journals that published articles that were relevant to wolf management (based on data discussed in Chapter 4) and asked to indicate how relevant each journal was to their own work. All 11 journals, except *Molecular Ecology*, were rated as at least somewhat relevant ($M_w \geq 2.5$) to respondents' work

(Figure 13). Respondents indicated that two journals, *Wildlife Society Bulletin* and *Journal of Wildlife Management*, were very relevant to their work (M_w = 3.92 and M_w = 3.83, respectively).

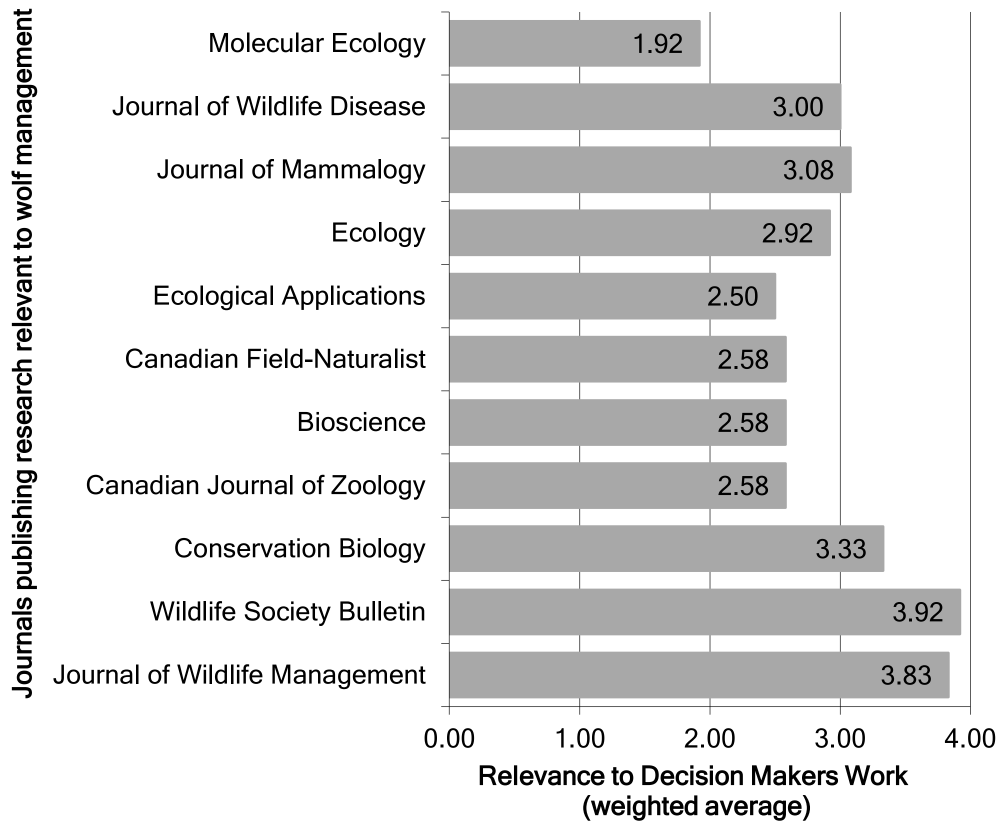

Figure 13. Responses of academics to the question: "Please rate how relevant you think each journal below is to your own work
1 = not relevant; 2 = a little relevant; 3 = somewhat relevant; 4 = very relevant. Results are reported as weighted averages of the responses. N = 12.

Respondents were asked to list any other journals that were relevant to their work. Six respondents provided the names of 15 additional journals (Table 11). With the exception of *Western Association of Fish and Wildlife Agencies,* which was listed by four of the six respondents, each journal was listed by one respondent.

Table 11. Journals listed in response to: "Please name any additional journals that are relevant to your work."

American Midland Naturalist
Ecological Monographs
Ecology and Evolution
Human Dimensions of Wildlife
Journal of Animal Ecology
Journal of Climate
Journal of Zoology
Nature
Oikos
Restoration Ecology
Science
Transactions of the Wisconsin Academy of Science, Arts and Letters
Western Association of Fish and Wildlife Agencies
Wildlife Biology
Wildlife Monographs
Various Law Journals

Each journal was listed by one respondent, with the exception of Western Association of Fish and Wildlife Agencies, which was listed by four of the six respondents.

Respondents were asked to rate how easily they were able to access articles in each of the journals listed in Q11. The *Journal of Wildlife Management* and the *Wildlife Society Bulletin* were rated as the journals most easily accessed by the respondents — 75% of respondents indicated that they could easily access each of these journals (Figure

14). *Journal of Mammalogy* was also rated as easily accessible by more than half of the respondents (58%).

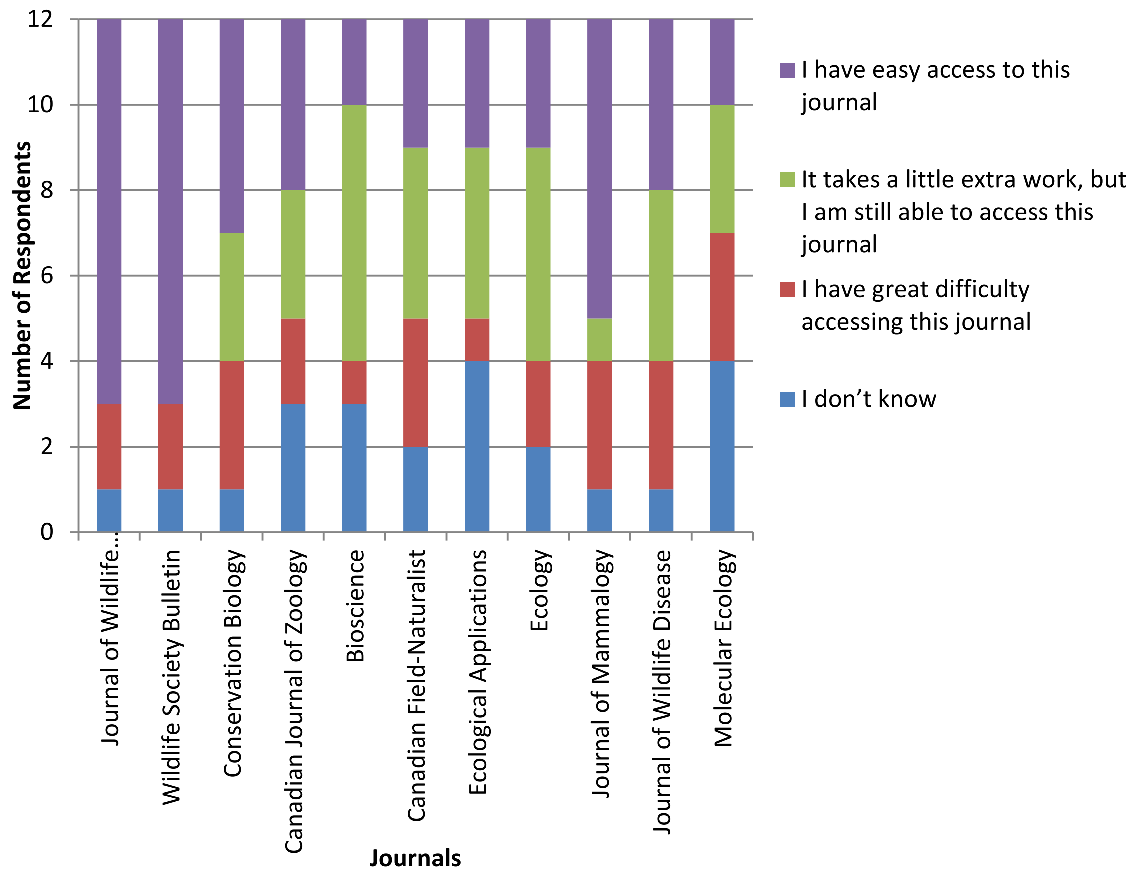

Figure 14. Responses to the question: "How easily can you access articles in each of these journals?"
N = 12

Interviews

Interviewees were asked to discuss how they accessed and used science from sources outside of their agency.

Several interviewees mentioned the important role that professional networks played in alerting them to new, relevant science. For example, Decision-maker F stated: *"All the wolf people still talk with each other in a small group, so they'll be like 'Did you see this paper on genetics of wolves in Italy?', or something. It's like, 'Oh yeah,' and then it gets shipped around so everybody gets an example of that."*

Decision-maker A also mentioned the importance of these networks: *"If a wolf paper comes out, I'll hear about it. So I actually don't have to work hard for those."*

Decision-maker B also mentioned professional networks: "*I guess my sources of scientific literature are sort of an informal circle of people that I know who are doing similar work to me.*" Accessing papers through networks was also mentioned by Decision-maker G: "*The usual way that it goes around is then you get the PDF, and you send it out to all these people, and they send it. So if you're in the network, you get it. If you're not in the network, you never see it."*

Decision-maker F mentioned that the popular press can also be a good source of information about new science:

> *The concepts [in a research publication] start being talked about in the popular press and stuff. That's how a lot of managers will pick up stuff, is just their biologist will say, "I got interviewed by Time Magazine, and there's a little thing coming out on this." Going into the popular press is a good way to get managers exposed to stuff, or the biologist. If they're really interested, then they'll actually read the paper and do that stuff.*

Decision-maker B mentioned that conferences, like the Midwest Wolf Stewards meeting, which brings together managers and academics, are a good place to gather information:

> *…these conferences [Midwest Wolf Stewards meetings] are really good. Besides the formal agenda and the presentations, there's all the informal after hours over a beer and "What do you like about this trap?" or "How does that work for you?" So I think they're really useful tools. I encourage wildlife professionals to get out and circulate, go to these kind of things.*

But he also mentioned that it can be difficult to attend some relevant conferences: *"I'd like to get to one [Wildlife Society meeting], but it's a struggle with time and budgets and whatever to get to these things that you're not able to drive to."*

Decision-makers also talked about how the internet has helped them have greater access to papers. Decision-maker B said:

> *The internet has made all the difference in the world as far as accessibility to publications. Before, it was hard copies; it was subscriptions to journals, where you just had hard copies, and they just weren't as user-friendly. So the internet has really changed the accessibility to a lot of scientific literature.*

Decision-maker B later noted that there is a down-side to the plethora of research that is available:

> *Our agency has … the ability basically to track down any publication that I would be interested in and get it to me, and now there's some internet-based websites that have a lot of that available. So the information is out there. I think for a lot of us, it's kind of information overload sometimes, and sorting through that or filtering it, what's useful for you, I think has always been a challenge no matter what form it came in.*

Decision-maker A also talked about the challenges that come with the fact that there are so many journals publishing papers that are relevant to his job. He said:

> *I view publishing as almost just like a storm front. Here's this – and it's different in the last 20 years, but there's so much information out there, and everybody's so competitive that it can be about them, not necessarily what's the best way forward. So there's just massive publications out there. But you've got this advancing storm front, and you try and just keep up with it. You try to keep up with the significant parts of it, and then you make decisions based on that.*

Decision-maker H also mentioned the difficulties associated with keeping up with the current literature:

> *Just within my job itself, the various readings I need to do, and then to be able to read to keep up my knowledge of the scientific literature is always a big challenge. I mean, to be a scientist, in part you have to just enjoy sitting around on a Sunday afternoon reading the journals in order to keep up.*

Decision-maker G said:

> *When I started in the business, if you were reading Ecology and the Journal of Wildlife Management and Wildlife Bulletin, you were probably gathering up – my perception would've been maybe 70% of what was out there. In this day and age, there's so many journals out there that it's difficult to get your arms around it, really. So that makes it even worse. It is a head-scratcher. I try to keep up with the literature and try to apply that in management circumstances. Every now and then, I trip on something that has a big impact. You read it eight times, pretty soon you have it memorized; you incorporate it into management. I don't know how common that is, to be honest with you.*

Despite the large number of publications that are available, some decision-makers indicated that there is little time available to devote to reading. For example, Decision-maker F said:

> *So it [science] definitely has a role, but scientific publications, a lot of managers I know never read them. They have biologists that are supposed to read them, but even most biologists don't. With the cutbacks and all that stuff, more biologists,*

they have more and more to do so they do less and less reading. Now there are so many more journals, what you have now is there's so much information, you can't possibly process it all or read it all. So as the job, if you're a biologist, their job gets bigger and bigger and bigger, the science gets narrower and narrower and narrower. Finding out what – keeping current literature is a huge problem, and there's – I'm not sure of the percentage, but I would say a small minority of biologists ever read scientific literature.

He continued by describing some of the competing demands on his time:

You've got credit card training and equal opportunity and handicap training. So you're just stuck at your computer, doing not biology stuff. Unless you have a real interest in keeping up with the literature and think that the science is useful, it's very hard for a scientific publication to make it in.

Decision-maker I discussed the time constraints faced by decision-makers and explained that decision-makers often need scientific information to be presented to them in an easily accessible and digestible format. But he went on to explain that he doesn't think that making scientific research accessible is the sole responsibility of academics:

They [managers] kind of want to be spoon-fed. They don't want to take responsibility for doing that themselves. If you can help facilitate that somehow, make them want to do that, I think we're better off. So I think it's very important to make this stuff accessible.

…to get away from the blaming of the scientists. They're doing what they're supposed to do; we don't want them to have to become accountants or psychologists or human resources people. We want them to be scientists, so they have to speak like scientists. But I think it's incumbent upon an agency like ourselves to have a team of people that can help get the messages out.

So if we have scientists and outreach specialists and web designers and social media experts and press people and spokespeople, if we have a big coherent cadre of people that can promote those works, then that research will be better because it will be used more frequently for decision-making. I don't think we can make it incumbent upon the scientists to get it on the way, to make sure there's press releases. We have to have other people help them do that. So you have to kind of take a team approach to that.

Some interviewees discussed how they filtered the vast amount of information available to them. Decision-maker J explained how research gets to decision-makers in his agency:

> *But for us, the area biologists apply the science. If there's advocates or conservation groups or even your national groups that want to funnel new information, it needs to get to the area biologist in the western states, because all the area biologists – now I think they're calling them game managers or wildlife program managers – they're the filter between the headquarters and the field. But that science all needs to get to them. They formulate prescriptions. They all come to me, we get together, and it's just like a peer review. Sometimes we bring in external folks; many are controversial, and we just have at it, and then we leave with a recommendation.*

Other interviewees talked about the importance of outlets that provide digests of recently published research. The Wildlife Society and their publication, *Wildlife Professional,* were specifically mentioned. For example, Decision-maker B said:

> *If that Wildlife Professional is laying there, I'm going to pick it up and read it, and if something piques my interest, and it's something that applies to work, I can go track it down via an internet or another source if I need citations for a project or paper I'm working on. So I'm a real fan of that publication.*

He also said:

> *Every Friday I get a little email from the Wildlife Society, and it's kind of a little hot topics of the week kind of thing. During the field season, I'm usually too busy to look at that, but during the off-season, I'll scroll down through there, and I'll click on a couple items just to keep up with – some of it's directly related to my work, and some of it's just general interest. But I think the Wildlife Society has made huge advances in the last couple years in how they communicate with their membership.*

Other decision-makers mentioned the role that name recognition and personal relationships can play in the use of some science over other science. Decision-maker B stated:

> *I tend to take a pretty critical eye when I look at whether it's a presentation at a conference like this, whether it's a publication. Almost the first thing I look at – the kind of things that I filter for are I look at the name, and there's some name recognition, and I know that some people are always producing quality research. A lot of times I'll read their stuff even if it doesn't apply to me, just because I know it's going to be quality.*

Decision-maker C also said:

> *Some scientists are listened to more. You try to make the net as wide as possible to minimize that. You don't avoid it. Some scientists are more charismatic than others. What do you do? Some of them are brilliant, and they're in the back, and they're really quiet, and they don't say anything. Nobody pays them any attention. Other ones are out there drinking beer, "Yeah, this is what we need to do." "Oh, this guy must be right." So a lot of that plays into it.*

In many interviews, decision-makers brought up the fact that even though there was a vast amount of scientific information available to them, this information needed to be balanced with other inputs.

Decision-maker I said:

> *Science has definitely got a role to play, and it's not a small role. It's actually a very, very big role, but it's not as big as most people on the advocacy side of the world would like it to be. They want science to make the decisions. They say, "Well, the science says this, then that's obviously what we should do." But they fail to realize that the science does not make decisions; people do.*

He continued:

> *In [our state], we're bound by law to use sound science, yet that sound science has to be tempered by the fact that science doesn't make decisions; people make decisions. So at some point, you can only take the science so far. The people that*

are involved in the sociopolitical arena take over, they make the decisions, and then, of course, it's up to us to implement those decisions. It's a complex, very complex relationship, I think.

Interviewees explained that politics can play a role in decision-making about wolf management. For example, Decision-maker A said:

Your average person is more tuned into wolf issues where wolves occur than arguably any other wildlife. Then you have national constituencies that don't live with wolves who are plugged into wolf issues. So you literally have extreme political pressure to do different things, so even though you might get a significant paper that is a breakthrough, or you are dealing with this information front that's always pushing ahead, you just might not be able to do it, because it's too political.

Decision-maker A also stated that he thinks many wolf decisions at the legislative level are purely political:

I do think that a lot of wolf decisions are just purely political, so science doesn't matter. Period. Doesn't matter what that front is, doesn't matter what that individual paper is, doesn't even matter what maybe a very influential expert thinks. It's got to be this way. You might even go so far as to say wolves are immune to science. And that's hard to say, because I see quotes in the paper all the time, "We're doing this because it's science-based," and I always roll my eyes and go, "That's just a sound bite."

Decision-maker E echoed some of these concerns:

As a legislator, I'm going increasingly fascinated by the persistent disregard for science in legislative bodies. I certainly don't see my colleagues in the legislature going out of their way to read peer-reviewed articles. They would have you believe the newspaper is good enough. I've tried to get my colleagues to recognize you have to go [to the peer-reviewed literature] – not that the peer-reviewed literature doesn't have its own set of problems. It's nothing more than a human endeavor. All human endeavors are hamstrung by human foibles. Scientists are no different. They're not above petty differences and arbitrary decisions that advance a personal agenda. But in the scheme of things, peer-reviewed literature, I think, on technical matters like wolf recovery or climate change tend to be more useful than a newspaper article.

Decision-maker C explained that he believes that science is used by decision-makers but that the broader context and politics of a situation are also taken into account. He stated:

> *In order to succeed in the bigger scale, you had to come to that conclusion that that kind of politics is real. It had nothing to do with not using science. It's just the reality is that science is not going to drive this thing in the public. You're going to make good decisions based on science, but if you don't incorporate politics… you can't come into a ranching community and go, "You know, the good thing about it is that wolves are going to keep the elk out of your willows, and they're going to grow up along the rivers. They're going to kill your cattle, your horses, your dogs, your sheep, but you're going to have willows coming back up." They're going to be like "Get off my property." It won't work. So that's where politics would come in, and it's not that you came into politics or even that you used politics in your decision. But you have to be streetwise, smart, and if you're not, it doesn't work.*

Some interviewees also talked about what science can and cannot do and how a lack of understanding of the limitations of science can lead people to believe that science is not being used in decision-making. For example, Decision-maker I stated:

> *The only thing that science does is allows us to articulate and understand the consequences of doing this versus that or doing nothing versus that, whatever. That's what science is supposed to do, is help us understand the consequences of our management actions. They don't make the decision. Science does not make the decision.*

Decision-maker C provided an example of what science can and cannot do:

> *The states want to hunt [wolves] to regulate population growth; we use science to say, "Here's what you can do." We use science to say, "Wolf populations that are stable and in good shape, it takes this kind of level of mortality to maintain that or control that growth." Or, if you have livestock problems, we use science to say, "Here's all these different things that you can do to resolve them. One of them is killing wolves." We use science to say, "Wolf populations are not affected by this type of mortality at this size at this rate." Other people go, "I can't believe you're*

doing this. I feel like this." Science doesn't answer those human value questions, and so we get criticized a lot that "You guys aren't using science." What they're really saying is… it's cognitive dissonance. Everybody looks for things that support what they perceive is the right – how the world works. When they don't see that or experience it, they either dismiss it or figure out some kind of bias. So people that really like wolves look for science to support that perspective. People that hate wolves look for science that supports that perspective. The science is really a consensus of opinion, and it's a bell-shaped curve, and you can always find the outliers. But the bell-shaped curve says – and that's what we use. That's the science we use. It doesn't say somebody can't come up with a science to support "You don't need to hunt them. We can all learn to live together and we can do this and this, and there could be millions of wolves."

So we get criticized a lot of times of "The Service doesn't use science. Here's so-and-so and so-and-so to show that you need 5,000 wolves in order to have a recovered program." The other side says, "We hate your guys. The science says you don't need any wolves, and they're killing all the livestock, the elk are in bad shape." We always use science, but the science doesn't address some of those "I feel" value systems questions, and so it's really easy to be open to criticism of "Your science sucks."

Decision-maker C also said:

We always get in those conflicts, and it's really easy to use your science to show how the other side's wrong. If you use science in its totality, you come up with different answers than if you use what you think is the right science. And if you're a scientist, which we're trained as scientists, the whole idea is to drop that preconceived notion and go, "I'm just going to put the blinders on, collect data, look for evidence, patterns, analyze it, give it statistical significance, and come up with conclusions and not have preconceived notions. I'm going to test hypotheses, or I'm going to challenge things." Most of the public doesn't look at things that way. Even science has its own bias, but you try to minimize it, or at least account for it. All these things come up. Science doesn't answer those questions all the time.

He continued:

Wolves are very symbolic, and that's legitimate on both sides. "I love them," "I hate them." And science doesn't address those questions. It's just a false expectation that somehow science is going to address – science is very good at going, "If you do this, this, and this… this, this, and this will be a logical outcome" or "Here's the probability that this will be a logical outcome." It looks for patterns; it looks for give you a little bit of predictive ability of what may *happen in the future. But as far as saying "Is this good?", science doesn't do that. And when it doesn't, people go, "Wow, you're not using science." People have a real misconception about the limits of what science can do.*

Theme 3: Interactions with Academic Researchers

Surveys

Respondents were asked to describe how they had interacted and collaborated with academic scientists. First, respondents were asked to indicate how often they had collaborated with researchers who were based at academic institutions. Seventy-five percent of respondents said that they had very frequently (n = 8) or frequently (n = 1) collaborated with academic scientists. The remaining 25% (n = 3) of respondents said that they had sometimes collaborated with academic scientists.

Respondents were asked to briefly describe their collaborations with academic scientists. Collectively, the twelve respondents listed 23 types of collaboration, which fell into seven categories (Figure 15). The most frequently mentioned type of collaboration (n = 5) was serving as a co-investigator on a research project. Additionally, co-authoring publications and funding research were each mentioned by four respondents.

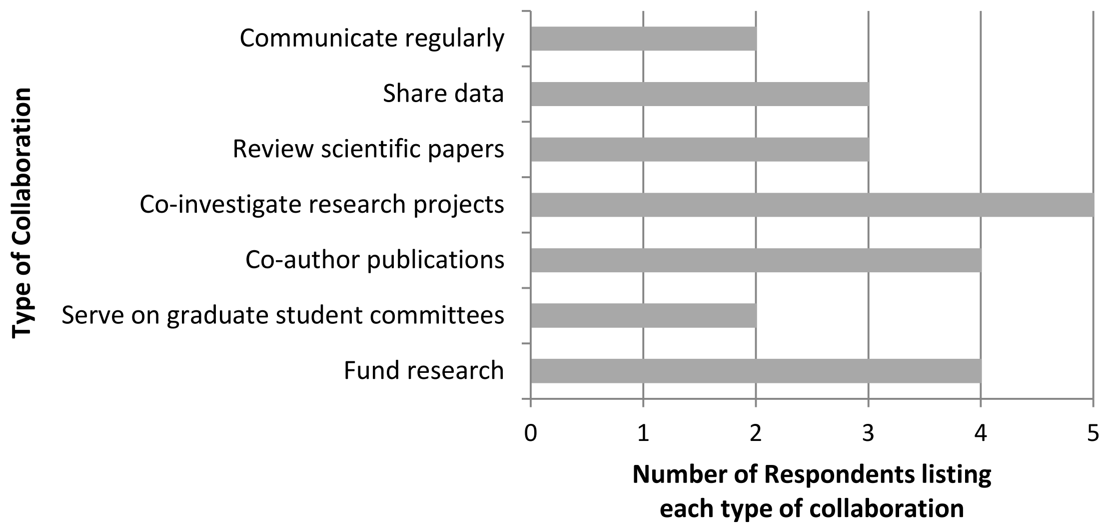

Figure 15. Responses to: "Briefly describe the nature of your collaborations (provide examples as appropriate)."
Responses were organized into seven categories and are reported as the number of respondents that mentioned each type of collaboration. N = 12.

Respondents were asked what they saw as the greatest benefits of collaborating with academic-based scientists. Ninety-two percent (n = 11) indicated that working with academics allowed them to 1) complete research they wouldn't otherwise have time to complete and 2) conduct research that they wouldn't otherwise have the expertise to complete (Figure 16). More than three-quarters of respondents also indicated that working with academics increased their credibility with stakeholders (83%) and allowed them to conduct research they wouldn't otherwise have the tools to complete (75%).

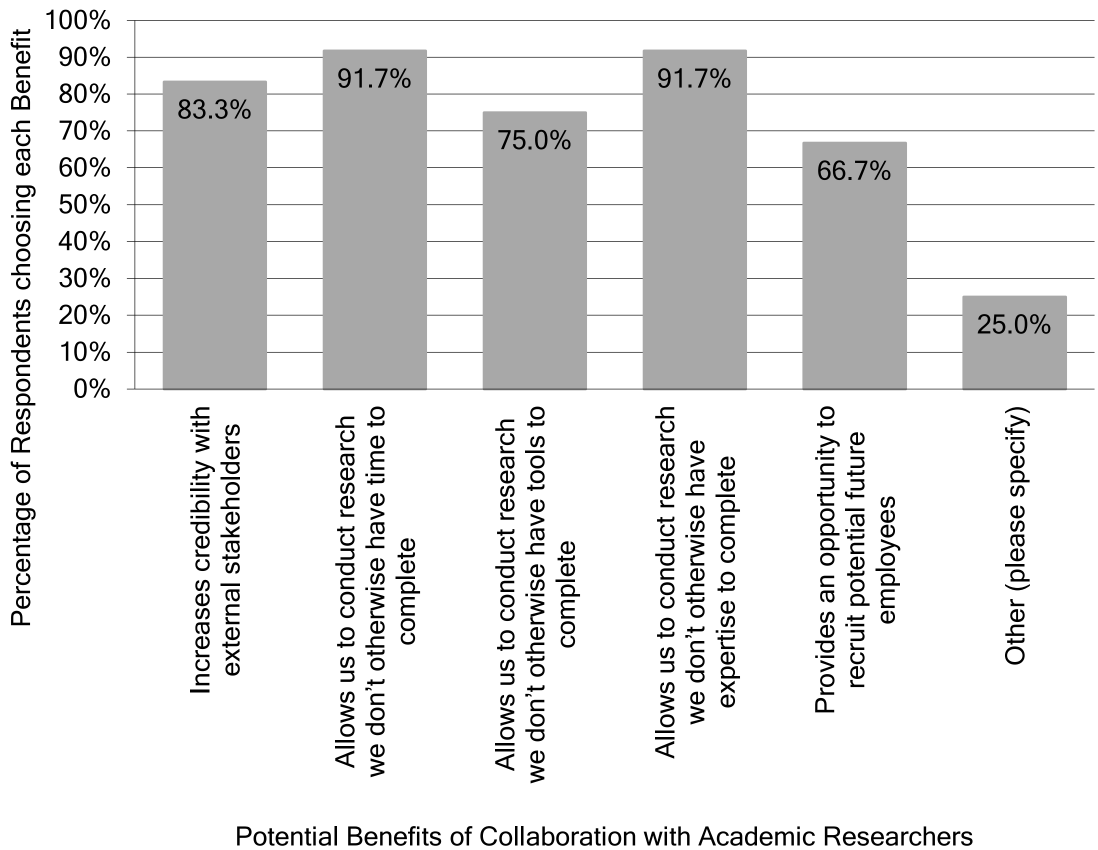

Figure 16. Responses to the question: "What do you see as the greatest benefits of collaborating with academic-based scientists? Select all that apply."

Respondents were asked what they saw as the greatest barriers to collaborating with academic-based scientists. Twenty-five percent (n = 3) of respondents indicated that working with academics was too time consuming (Figure 17). Three other potential barriers were each selected by 17% of respondents: 1) Their work is not relevant to my job, 2) Academic scientists are not interested or willing to collaborate, and 3) My department does not encourage collaboration.

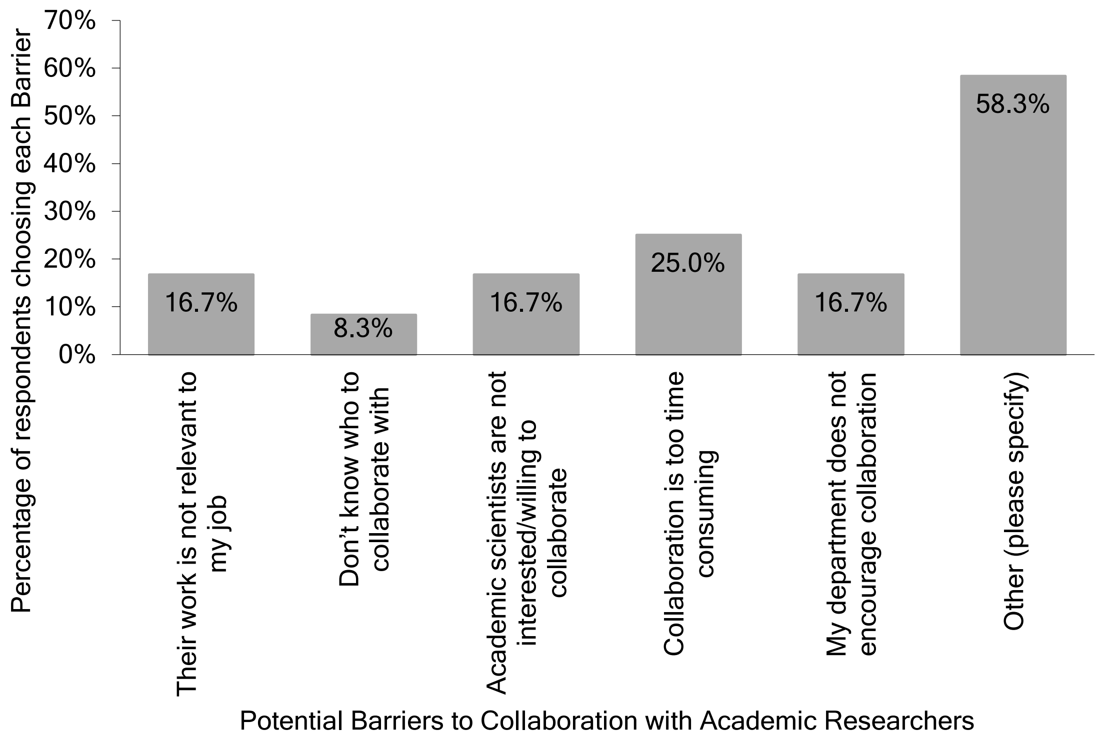

Figure 17. Responses to the question: "What do you see as the greatest barriers to collaborating with academic-based scientists? Select all that apply."

Seven respondents listed additional barriers that were not included in the list provided. These responses were grouped into four categories: lack of funds, lack of trust, too much bureaucracy, and cultural differences. Table 12 shows some representative comments in each of these categories.

Table 12. Additional responses to the question: "What do you see as the greatest barriers to collaborating with academic-based scientists?"

Barriers	Examples of Comments on Survey
Lack of Funds	Lack of funding Cost and lack of funds
Lack of trust	Inappropriate use or sharing of data Disclosure of information that jeopardizes wolves
Bureaucracy	Difficulties developing adequate MOUs Technology, purchasing and contracting road blocks
Cultural Differences	Agency people are responsible for the resource/decision. Academics never are, so risk to them is less, causing them to write positions/ideas that an agency person cannot defend/get behind Life is about small steps and nuance. Academics always want big steps with a bang Many academics argue - how can you argue with science? But many do [argue with science], and academics don't get that - and in the end it hurts science. Some academics can be perceived as naive to the reality of conservation, and when other factors, such as the reality of dealing with humans, results in best possible management practices rather than the pure biologically ideal solution, they are hurt and confused.

Interviews

Interviewees were asked about their interactions and collaborations with scientists at academic institutions. Many described close working relationships with academics. For example, Decision-maker H said:

> *We've always had scientists involved in our advisory teams on doing our wolf management. We try to get things published in the scientific literature. We're not as good at it within the state agencies as university folks are, but we've collaborated with a lot of other scientists, and I've always often felt sort of guilty*

that we gather huge amounts of data, and I'm always looking for opportunities to help share and make more use of that data.

Decision-maker A said:

…this fall I'm organizing a meeting with all of the collaborators who have worked with the [project], and I would say all but a couple are from universities. All said and done, it will be about 15 different people plus grad students, so over 20 having a face-to-face meeting about what we need to do next, what are the important issues, how do we deal with wolves being delisted, how do we deal with making the research count towards management, how do we make decisions, things like that. So yeah, we're pretty involved with the university/academic side of things.

Decision-maker C said:

It's been a very personal program, and with university people as well. So that's driven a lot of the discussion, so that when something comes up, it's not like you go to find "Hi, I'm so-and-so" for the first time. You know the people. Everybody is a working relationship, and the universities go, "Wow, I have a grad student coming up. This would be a really good project for us to take on." There's an ongoing working relationship between everybody in the universities, the feds, the state programs.

Interviewees indicated that close collaboration between academics and decision-makers right from the start of a project can lead to some of the most useful research. Decision-maker C described two different approaches to research:

Projects that are more productive involve coming first to say, "Huh, I have an idea. What do you think?" If you just go off on your own, you might hit something that's cool, but you might get off in the ozone, and it's like, "Wow, that's cool. Next."

He continued with another example of these different approaches:

This professor came, and we all sat down, "What kind of things would be helpful for you guys?", and we said "Here's what would be helpful to us." The academics say, "Here's the kind of questions," and we all worked to design a *research project. There's other people who just want to do research, "Do black wolves have the genetic makeup to have disease resistance?" It's like, that's cool, but that's not going to help management.*

Some interviewees elaborated on how their relationships with universities and academics work. Decision-maker C provided an example:

> *When we bring in graduate students or universities, we fund it, we do this, and then we step back a lot of times and say, "We're not trying to bias this. Whatever you find, that's good science." So we're not trying to find "How do we get a university grad student to come up with an answer that we want?" We use science, university students, all that whole part, to go, "We don't know. Come up with what you think the best answer reflects your data, your evidence, your fieldwork, all that. We do it in a university, and we separate us out. We're partners in it, but we don't try to say, "We want you to prove 1, 2, 3, 4, 5." We want you to collect data and say, "What do you think about 1, 2, 3, 4, 5?", and they publish in the peer-reviewed papers. We're part of that process, but we always try to go at it as "We don't know." It's not "We need something to show that we're right." It doesn't work well that way.*

Decision-maker F provided an additional example:

> *Let's say you have a study you want done. You go to a university to do it, which is the best way to do that stuff, because graduate students are young and enthusiastic; they're cheap. They have to publish before they can get their stuff out. So if you have a longer term project, like the effect of wolves on prey populations – everybody's been working on that for decades. So what you do is you think of an area you want to work, you think of a project you want to do, and maybe you chunk it up into research projects, like three Master's theses. Then you've got three different people working on stuff, and that person's going to get their degree, and they're going to be gone. And in the Northern Rockies right now, all of our graduate students now lead the wolf recovery efforts for the states in the West. It's a good way to mentor people and get them up through the process. So then you've got three Master's students done; they publish, hopefully, a paper or two out of each of those papers. Then from that, then you can set up a Ph.D. project to use those three to put it into one study to move it along. What you get is you get a chance to work with a professor in the university; you get a chance to work with graduate students. Because you've initiated the research and told people what things you want to do, you have a little bit more focus on the real management issues.*

Decision-maker C described how his agency supports academic researchers, particularly graduate students, without directly supplying grant money:

> *We'll get our graduate students under a certain professor, and the professor will come up with university funding for a stipend…or some kind of salary. The student might be a research assistant or a TA, to teach class. But… a lot of this kind of science is field…so the Service was being logistically helpful, so we supply vehicles, we capture wolves. It's very expensive to capture wolves. So we would do all that free, and we would contribute to the project where we would. If collars die or get killed, we would keep replacing them to keep the project going. We would provide logistics, vehicles, equipment, flights, those kind of things, that way, to help the project out. So we fund in-house that way with what we have. We do a lot of that. And that gets around some of the politics. Some areas, they love to take money; other areas, the overhead makes it so prohibitive that it's not something…*

Interviewees talked about some of the benefits of working with academics. One of these benefits is the inclusion of a diversity of perspectives. Decision-maker C explained:

> *We use the metaphor – it's like fishing. We try to throw the net as wide as you can. What you don't want is Frank, Joe, and Mary, Frank, Joe, and Mary, Frank, Joe, and Mary, so you have this whole literature base of three people's opinions about how the world works, which may or may not have anything to do with how the world works. So the more you stay diversified – we bring in people that are hardcore academics or biometricians, which most of us aren't, or bring in people that are social scientists that bring in opinions, or economists, those kind of things, that sometimes they look at things that we never even thought of.*

Decision-maker E also explained the benefits of diverse teams with an example:

> *Individuals matter, and some are better at certain aspects of the building of science and bridging it to policy than others. I believe that what ultimately works best is a team that has lots of pieces that can work together. [Practitioner A] for example, if we looked at his CV, you would find a lot of boots on the ground work and very little presence in peer-reviewed literature. OK? Now you look at [Academic J], a much more obvious presence in the peer-reviewed literature but no time in the field in the context of wolf recovery. Now Academic J has become a confident and quite capable field biologist …but all of the field work …is based on research objectives. [Academic J] has never sat down on a kitchen table with a rancher that just lost a calf that's pissed off. So [Practitioner A] and [Academic*

J] together are far better able to advance recovery than [Practitioner A] or [Academic J] alone. …So it has been my observation with all of these teams that that blending is very, very, very important. Then you will bump into people that are kind of capable of existing in both worlds. I would put myself in that camp.

Decision-maker C explained that academics have the ability to see things from a different perspective:

It's a very nice blend of needs for management and having universities that are a little bit more objective and can step out of the management crises, day-to-day stuff, and design projects that address questions that we're looking for answers to. So we do that a ton, with all different – Montana, Idaho, Wyoming -- different grad students from all over, on anything from real basic wolf biology, predatory/prey biology, attitudes, all kinds of different issues. Some of them stay in academic and stay in research; some of them work for agencies.

Similarly, Decision-maker F said:

So that's also when you need academic research that can stay above the day-to-day fray. I mean, if you've been with managers, the phone's ringing 50 times a day, and it's all kinds of problems, and there's a meeting, and there's the personnel stuff, and there's budgets. You don't have time to do good science. That's what academics in science can do.

Another benefit of collaboration that was mentioned by several decision-makers was that collaborations allowed them to get to know students who could become future employees. Decision-maker C said:

Those people have been the perfect people to come onto the program, because they gained experience working under the Fish and Wildlife Service as a grad student, and we encourage them to work in the field and to be involved in the day-to-day. That's a perfect source of people to start new programs, so as the states come onboard, it was a perfect match for them to take people that actually had some wolf experience, and they became the basis of their program. It's worked really well.

Similarly, Decision-maker F said:

> *We're going to be replaced someday, so you need to develop talent and get people coming up through the ranks, and then when you have people work as graduate students, it's a very good way to see who gets along with people, who's a good worker, who's not, who's sharp. The kind of skills you need, you can see. Then it's like, "Yeah, you should be an academic" or "Yeah, you should go into this." That kind of stuff. That takes 10, 15 years to start developing that kind of base.*

Decision-maker F explained how graduate students also help them work better with certain stakeholders:

> *…we get a lot of other people involved, graduate students are typically viewed – a lot of times, they're from local community. Some old geezer walks up to your farm door versus some young kid, like "Oh, I'm Samantha, I'm doing…" So it's a lot less threatening, so that's a good way to do it.*

Decision-makers also explained that working with academics helps to make the science seem less biased than it might seem if it was coming directly from an agency. Decision-maker F explained:

> *There's a lot of different reasons to do science. You work with universities, develop relationships; universities are perceived less biased than the individual agencies. So if you get a study from the Fish and Wildlife Service versus USDA Wildlife Services, as soon as they publish something, all the wolf advocates are just like, "Oh, we hate those guys… When we publish something, some farmer who is having damage is like, "Those guys never help me. They're just out there studying how many cattle I'm losing." So universities are a good way to get the perception of an unbiased study and unbiased relationships. [Agency A] might have a difficult time working directly with [Agency B] …but the states, the tribes, everybody can pour a little bit of resources into a perceived unbiased group, like a university or an academic.*

Finally, decision-makers talked about some of the barriers to working with academics. Decision-maker F explained how decision-makers and academics are coming at things from very different cultures. This can manifest in the form of the time that is taken to do a project:

> *So you can understand why [a] refuge manager, who has no direct control over them or their time or what they say, is very reluctant to put them [academics] on a program, because the #1 thing you'll hear after four years is, "Well, what we really need is more data." The classic thing. It just becomes this bottomless hole.*

Decision-maker F also said:

> *It's also got its cost, because the manager that's got limited money and stuff is like, "I give this guy a contract for $100,000 for five years; that money's tied up. I don't know what I'm going to get. The problem isn't getting fixed for five years or four years." That's why there's a little bit of separation.*

Decision-maker F also talked about the different foci and priorities of academics and decision-makers:

> *You've got the academic. He or she, their tenure is based upon publication. They're all about getting the publications. They're about high profile; they're climbing the career ladder. Which everybody does. The manager has no interest in that at all. So you've got these competing vested interest kind of thing.*

Finally, Decision-maker A explained one additional potential difference between academics and decision-makers:

> *But wolves really do wear you down. I mean, it is not a job; it's a lifestyle. They take big chunks out of you personally, emotionally, psychologically. Just surviving is important. So the people who do it for a living are slightly different than the people who are doing it just to get another publication.*

Discussion

The interviews and surveys discussed in this chapter provide some insights into the role that science plays in management decision-making, how some academics and decision-makers collaborate, and whether academic institutions support such collaborations. Responses to the survey questions generally reflected comments made during the interviews.

Overall, there were some overarching trends in the survey and interview data from both groups. First, surveys and interviews with academics revealed that they engaged in traditional dissemination activities, such as publication in peer-reviewed journals and presentations at conferences, but that they tailored these activities to sources that were of relevance to decision-makers, such as publication in *the Journal of Wildlife Management* and the *Wildlife Society Bulletin* or presentations at conferences such as the annual meeting of the Wildlife Society. Second, academics felt that engaging with decision-makers was an important part of their job as a scientist but acknowledged that these activities were not always highly regarded by their academic institutions. Many academics alluded to a need to balance "bridging the gap" activities with other activities that had a higher academic impact, such as obtaining grants that include overhead costs and publishing in high impact journals.

There were also two major trends that emerged from interviews with decision-makers. First, most decision-makers thought of themselves as scientists. As such, they felt a responsibility to not only read and utilize information from the scientific literature in their decision-making, but also to conduct and publish their own research. Second, decision-makers saw collaboration with academic scientists as vital to their job. They mentioned three major benefits of these collaborations: 1) they could conduct research that they would not otherwise have the time, tools, or expertise to complete; 2) scientific results and conclusions may be viewed as less biased than if they conducted the research on their own; and 3) collaborations provided an opportunity to interact with and train the next generation of decision-makers in their field. While decision-makers did acknowledge some barriers to working with academics, most of these were related to the personalities and perspectives of individual academics (such as an inability to understand the broader constraints and politics of a situation).

The surveys and interviews discussed in this chapter were conducted with two objectives: to gather additional information to fill in some of the gaps in the "bridging the gap" literature (as discussed in Chapter 1) and to better understand some of the patterns in the bibliometric data discussed in Chapter 4. Overall, the information obtained in the surveys and interviews does meet these two objectives, and this is discussed in detail in Chapter 6. Unfortunately, the small sample sizes made it difficult to analyze the survey data statistically.

There were a few factors that led to the small sample sizes. First, there are relatively few managers and policy-makers who are deeply involved with wolf management issues in the two regions of focus. In fact, the number of decision-makers who participated in this study was a large proportion of the number of eligible participants. Expanding the sample would mean broadening the study area to include wolf management in the northwest and southwest regions of the U.S. The wolf management situations in these regions are very different from the Northern Rocky Mountain (NRM) and Western Great Lake (WGL) regions (i.e. different species in the southwest, few wolves in the northwest). Therefore, it did not make sense to include these decision-makers in the current study. In contrast, there are several additional academics who could have participated in this study. For example, 20 academics were recruited to participate in the survey, but only six participated. However, several replied to the recruitment email to say that, although the study seemed important, they did not have time to participate. Others indicated that they would participate but that they wouldn’t have time in the next month or two.

Despite the small sample size, the survey and interview data provide some potential insights into data from other studies as well as the bibliometric data discussed in Chapter 4 of this dissertation. These connections are discussed in Chapter 6.

CHAPTER 6: CONCLUSIONS AND NEXT STEPS

The study described in this dissertation had three goals: 1) to provide additional data about proposed barriers and solutions to bridging the gap between research and decision-making; 2) to better understand the role that institutional incentives, which often place an emphasis on academic impacts, may have in the persistence of this gap; and 3) to explore the idea of creating a standardized method to measure the non-academic impacts of scientific activities, as a potential way to incentivize behaviors that bridge the gap. This chapter discusses the results of the study within the context of these three goals and concludes with a discussion of the broader contributions, as well as the limitations of this study, and suggested next steps for future research.

“Bridging the Gap” Data

A review of the “bridging the gap” literature suggested that there are several potential barriers and solutions to bridging the gap. However, as discussed in Chapter 1, there is a lack of data to support many of the suggestions made in the literature. The current study provides new data about the purported barriers and solutions to bridging the gap. Below, the results of the case study on wolf management decision-making in the U.S. are discussed in relation to these barriers and solutions. For this discussion, the seven barriers and eight solutions identified in Chapter 1 are collapsed into six categories as follows: Accessibility, Relevance, Cultural Differences, Relationships, Advocacy, and Educating the Next Generation.

Accessibility

Much of the conservation biology "bridging the gap" literature suggests that many important research findings never make their way to decision-makers. For instance, Pullin (2003) asked management plan compilers about the sources of information they used to support their decision-making. Only 23% of respondents indicated that they used published scientific papers. When asked why they didn't generally access scientific information to support their decision-making, 65% of management plan compilers indicated that scientific literature was too time consuming to locate and access. In contrast, 100% of decision-makers surveyed in the current study, who had created wolf management plans or regulations, indicated that they used published scientific literature to support decision-making. Further, data from the bibliometric analyses indicated that decision-makers had access to a wide variety of journals. For example, 52 of the 60 journals publishing relevant research were cited in federal regulations. Data from the surveys and interviews suggested that decision-makers learned of and obtained journal articles in several ways — the most common being through colleagues and friends, use of their personal collection, and general web searches. On the whole, most decision-makers seemed fairly confident that they weren't missing a lot of relevant literature.

A bigger problem for decision-makers in the current study was finding time to read all of the potentially relevant literature (including literature from other disciplines that could have indirect, yet important, connections to their own work), and several participants commented on this during interviews. This is consistent with data from the literature. For example, Pullin (2003) found that 60% of management plan compilers said that the literature was too time consuming to read. However, in the current study, most decision-makers indicated that they felt that keeping up with the literature was an important part of their job and that they tried to read as much as possible, which often meant doing so outside of working hours.

Relevance

The literature suggests that many authors are not writing articles that are of high relevance to decision-makers. For example, Fazey et al. (2005) found that, according to authors of papers published in three of the top conservation biology journals (*Biodiversity & Conservation*, *Biological Conservation*, and *Conservation Biology)*, only 20% of their papers had high relevance to policy and only 37% to management. In contrast, 100% of academics surveyed in the current study felt that their research was either very relevant or relevant to both managers and policy-makers. Further, when asked who the main audience for their research was, respondents rated scientists at government agencies and policy-makers highest (4.83 and 4.5 on a five-point rating scale, respectively).

Perhaps relatedly, while Fazey et al. found that authors believed that their research had been utilized only 33% of the time, 83% of academics in the current study felt that their research was at least sometimes used by managers, and 50% felt it was sometimes used by policy-makers. However, bibliometric data from the current study suggests that the frequency that academic research is actually used by decision-makers may, in fact, be closer to the results of Fazey et al. For instance, only 22% of academics authoring papers in the set of All-Relevant Literature authored papers that were included in the set of HMI data.

The higher rates of perceived use of academic research by survey respondents may be an artifact of the particular sample of academics who responded to the survey. In addition to being a small sample, there is a chance that academics who were willing to take part in the survey were also more likely to engage in activities that helped their research to bridge the gap (e.g. the academics who said that they did not have time to respond to the survey may also not have time to collaborate with decision-makers).

The “bridging the gap” literature also suggests that scientific publications may be too complex or technical for decision-makers to use. For instance, Pullin (2003) found that 25% of management plan compilers thought that scientific literature was too technical and difficult to interpret in the context of their decision-making. This idea was not reflected in the interviews or surveys with decision-makers in the current study. Perhaps this is because most of the decision-makers who participated in this study had graduate-level science degrees (some holding Ph.D.s). The scientific background of respondents perhaps made it less likely that they would find many scientific publications to be too technical or complex to interpret.

To solve issues related to relevance and accessibility, the “bridging the gap” literature suggests that academics should write up their results in a way that facilitates use by decision-makers. The results of this study show some support for this idea. Some decision-makers indicated that they preferred to see short, succinct write-ups of research results, such as those found in the *Wildlife Professional*. However, some decision-makers indicated that they preferred to scan abstracts themselves rather than rely on such summaries. Many of the decision-makers in this study said that they read the abstracts of relevant publications and then decided if they wanted to read the entire paper. However, a few interviewees mentioned the fact that they had a difficult time keeping up with research from outside their discipline that might be relevant to wolf management. In this case, short, focused write-ups of research that, at first-glance, may not seem relevant to wolf management could help decision-makers to draw connections that may not be otherwise apparent.

While most of the decision-makers in this study had good access to relevant literature, some did mention that broad dissemination of research through non-traditional mechanisms such as press-releases, websites, and blogs could help researchers reach a broader audience. This could help bring information to the public who could then have an impact on the decision-making process, particularly at the legislative level.

Recent “bridging the gap” literature mentions the benefits of Twitter as a mechanism for reaching broad audiences (e.g. Darling et al. 2013; Parsons et al. 2014). This was one mechanism that was not mentioned by any participants in this study. This may be a reflection of the fact that many of the interviewees may not be Twitter-users themselves, and therefore, unaware of any potential benefits. However, this may change in the future, as an increasing number of decision-makers as well as journalists are using Twitter (Darling et al. 2013; Parsons et al. 2014).

Cultural Differences

The "bridging the gap" literature indicates that the different cultures that exist in the worlds of academia and decision-making can be a barrier to bridging the research and decision-making gap. This idea was recurrent in the interviews and surveys that were conducted for this study. For instance, many decision-makers remarked that though science plays an important role in decision-making, part of their job is to take the broader context of the situation into consideration before making a decision. This is supported by government documents such as a National Park Service report, which states that decision-making must be based on "best available sound science, accurate fidelity to the law and long-term public interest" (National Park Service 2012, p. 17). The lack of appreciation of the broader context that decision-makers operate in may be one of the main reasons that there is a perception that science is not playing a role in decision-making.

In addition to this disconnect, other cultural differences can serve as barriers to bridging the gap. For instance, decision-makers mentioned that they often operated under different time schedules than academic researchers and that they had to take the concerns of multiple stakeholders into account when making decisions.

Perhaps as a result of these cultural differences, many decision-makers are conducting and publishing their own research. This is supported by data from the bibliometrics analyses as well as the interviews and surveys. Government employees were the first authors on 28% (n = 189) of the publications in the All Relevant set of literature. Additionally, comments from decision-makers during the interviews suggest that many view research and publishing as an essential part of their job. They have been trained as scientists (holding Masters Degrees and Ph.D.s) and strongly believe that part of being a scientist is publishing their own research.

It is interesting to note that some decision-makers indicated that their organization did not place enough value on publications in peer-reviewed journals. This is in direct contrast to academics that indicated that their organization placed too much value on publications in peer-reviewed journals.

Relationships

The literature suggests that one of the most important facilitators of moving science into the realm of decision-making is personal contact between scientists and decision-makers (Brownson et al. 2006). This idea is supported in the current study in the results of the interviews and bibliometric analyses. During interviews, both academics and decision-makers stressed the importance of forming good relationships. They suggested that relationships can impact the degree to which research is acknowledged, trusted, and ultimately, used in the decision-making process. Further, the results of the bibliometric analyses indicated that collaboration between academic researchers and decision-makers can increase the management impact of research. For instance, 61% of articles that had a High Management Impact (HMI) in this study were authored by a team that included at least one government employee.

The literature also suggests that academics should build relationships with hired advisory staff for elected officials (Brownson et al. 2006). This is supported in part by comments by one of the decision-makers, who is a policy-maker. His comment that most legislators consider newspaper articles to be a good source of scientific information indicates that scientists need to do a better job of reaching out to this group. However, in the case of the particular legislator who participated in this study, reaching out to his staff may not have been the most effective way to interact with him. This legislator was very interested in meeting face-to-face with scientists and, in fact, this interview was the longest of all interviews conducted because of his interest in the topic. While the most appropriate methods of interacting with policy-makers will vary depending on personalities and the particulars of a situation, it is important to keep in mind that scientists may sometimes find that they can work directly with policy-makers.

Advocacy

When some academics think about forming relationships with decision-makers, they worry that they will be seen as advocates, and the "bridging the gap" literature often cites fear of the appearance of advocacy as one of the barriers to bridging the gap. Advocacy was not mentioned as a barrier by any participants in the current study. However, one interviewee did explain how he balances his dual roles as a scientist and a private citizen (page 90).

Educating the Next Generation

The "bridging the gap" literature suggests that students need to be better trained and taught skills that will help them to bridge the gap. In this case study, both academic and decision-maker interviewees mentioned the important role that graduate students play in bridging the gap. For instance, Academic A described graduate students as follows:

> *It's a valuable connection. I've got several graduate students that are working on projects funded by agencies, and it is just really cool what a bridge they are,*

> *because they're working with agency biologists and agency researchers and bringing all that back here, and the agency is getting a benefit of all the expertise at the university. So it really forms ties that play out into the future.*

Academic D described how he trained graduate students so that they are better prepared to bridge the gap:

> *You teach them to be good scientists, good thinkers, good collaborators, critical thinkers, and to respect how hard it is to make management decisions. Because that's much harder than being an academic and a researcher, because you have to make those decisions whether or not you have the information or not, and a lot of people care. Everybody cares, and everybody thinks they can do it better than you do. So that's a much more challenging job, but also one where the rubber hits the road, where people actually do make a difference.*

Many decision-makers in this study indicated that they were working on projects with graduate students. Placing graduate students into government agencies to conduct their research can help them to learn many of the skills that are recommended in the "bridging the gap" literature. If graduate students are trained properly and have skills to bridge the gap, we may be close to seeing the last academic generation who laments the gap between academia and decision-making.

Institutional Incentives

Many of the suggested solutions to bridging the gap require academic researchers to engage in research-related activities that are not highly valued or rewarded at their institution. The results of this study are consistent with the broader body of literature on the types of behaviors that are valued and incentivized at universities. Similar to Abbot et al. (2010), this study found that academics believed that their institutions placed the most emphasis on activities that had an academic impact, such as publications in high impact journals, grants and income from federal sources, and grants and income from state sources. Activities that were related to bridging the gap, such as outreach to non-scientists and government scientists, were given less emphasis. This suggests that though the sample size in the current study was small, the institutional pressures faced by the respondents are very similar to the general population of academics.

There are two distinct ways to surmount the barrier created by this incentive structure. Researchers who want to bridge the gap while still engaging in the activities valued by their institution can either 1) “play both games” at once or 2) try to change the existing incentives system.

Playing Both Games

In interviews, academics described the challenge of trying to excel at activities that had traditional academic impacts while still having an impact on decision-making. One goal of this study was to understand if it was possible to do both simultaneously.

One of the primary measures of academic success noted in the literature, as well as in this study’s interviews and surveys, was publications in high impact journals. This study analyzed bibliometric data to try to understand whether some of the publications in high impact journals also had a high management impact. In order to examine this, a measure of what is considered to be a high or low impact journal needed to be determined. There is no standard for what is considered a high Journal Impact Factor, as this varies from one discipline to another. According to the 2012 Journal Citation Report, the median Impact Factor for 136 journals that are included in the category “Ecology” (this category includes many of the wolf-relevant journals) was 1.94. Using this as a measure of the typical impact of journals in the field, 48% (n = 84) of the HMI articles were published in journals with an Impact Factor that was greater than the median for ecology journals. Further, 39% (n = 67) of the HMI articles were published in a journal that had an Impact Factor greater than 3.0. Assuming that similar benchmarks are taken into consideration by academic departments, almost half of the articles that could be seen as having a High Management Impact were also published in high Impact Factor journals. This suggests that academics can publish in high impact journals while still bridging the gap.

However, it is important to note that three of the five most frequently occurring journals in the HMI data set had an Impact Factor that was less than 2.0 — *Wildlife Society Bulletin* (0.95), *Journal of Wildlife Management* (1.64), and *Journal of Wildlife Disease* (1.27). These three journals accounted for 25% of all of the literature cited in the HMI data set. Similarly, when decision-makers were asked to rate the relevance of journals to their work, these same three journals were ranked as highly relevant. This indicates that decision-makers are not choosing what they read based on Journal Impact Factors.

In addition to looking at the Impact Factors of journals that had management impacts, this study also looked at citation rates as a measure of impact. Specifically, this study explored the question: "Are articles that are highly cited in the peer-reviewed literature also having an impact on management decision-making?" In this study, 41% (n = 30) of the articles that had a High Academic Impact also had a High Management

Impact. While 30 publications out of the 730 relevant papers in the data set may seem small, it shows that it is possible for research to have dual impacts. Perhaps if more researchers are aware that these two types of impacts are not mutually exclusive, they may find that making some small adjustments to their publications and behaviors will allow them to begin to have both types of impacts.

Two academics who were interviewed for this study serve as good models of academics who are successfully "playing both games" by bridging the gap while succeeding in their faculty positions. For instance, Academic C is the author of papers that were included in both the HAI and HMI data sets. A review of his curriculum vitae indicates that he has achieved success in his career, earning tenure at his academic institution, an h-index of 17, and multiple grants from the National Science Foundation and National Park Service. At the same time, he is highly respected by decision-makers (he was specifically mentioned several times during interviews with decision-makers) and has served on wolf management planning groups both within and outside of the U.S.

Academic A is based within a university department but also serves in a dual role as the head of a government cooperative research unit. This academic is encouraged to collaborate with decision-makers and base his research on questions that are of value to their work. While he says that he is still in a *"publish or perish world"* he indicated that "*people that evaluate my research productivity formally consider impact more broadly than just the impact factor of the journals, and so if I can point to policies that I have influenced or my research has informed, then I get credit."*

He continued:

> *My research productivity is evaluated every four years, and as part of that process, I turn in what they call a research scientist record. It's this long, gory document where I make the case for my research, among other things. As I'm describing all my different research projects, what we're doing, what we've done, I can point to the Federal Register or something like that and say, "See? They cited my work here and here and here," and if somebody really wants to, they can go look it up. Or if there's a statewide management plan that cites my work or something like that.*

These two academics represent two different approaches that enable them to have successful academic careers, while still bridging the gap and having a real impact on decision-making.

Changing the Culture

While the idea of affecting cultural change in academic departments may seem overwhelming to some, there are signs that it is possible. Recent attention to the inadequacies of traditional measures of impact (e.g. American Society for Cell Biology 2012; National Institutes of Health 2013) suggest that there is movement in this direction. Further, some institutions such as the National Science Foundation (NSF) are placing more emphasis on the "broader impacts" of research (http://www.nsf.gov/bfa/dias/policy/merit_review/), and there is some precedent for the NSF to spur cultural change at U.S. academic institutions. One decade ago, the National Science Foundation (NSF) began to place greater emphasis on interdisciplinary research and encouraged such, both within the foundation as well as at universities, by developing programs that only funded interdisciplinary research. Studies have shown that this has had a positive impact on the interdisciplinarity of researchers and academic institutions funded through these programs (Porter & Rafols 2009; Garner et al. 2012, 2013). Relatedly, it is believed that graduate students funded through interdisciplinary programs will continue to engage in interdisciplinary research and generally increase the value of interdiscplinarity at academic institutions across the U.S. (Soo-Siang Lim, pers. comm.).

Though faculty may feel hindered by some of the constraints of their departments, graduate students seem to be doing a good job of bridging the gap in this case study. Perhaps, similar to interdisciplinary research, graduate students could play a role in bringing a culture of bridging the gap to academic institutions. If graduate students are trained and encouraged to bridge the gap now, they could be the force that helps to change academic incentives and priorities in the future.

Measures of Impacts

Cultural change in academic institutions could also be facilitated by the availability of new measures of non-academic impacts. This study proposed a way to measure the impact of scientific publications on decision-making. Measuring this impact could be accomplished, in part, by measuring citations in decision-making documents such as federal regulations. As discussed in Chapter 3, this method was chosen for a few reasons: 1) bibliometric measures are an already accepted and familiar way to measure impact; 2) citations are fairly easy to count; and 3) the method is relatively transparent and objective.

There are some other distinct advantages to this method. For instance, there are existing mechanisms that could be extended to begin to track the data used to assess decision-making impacts. For example, ORCID is a tool that aims to provide all researchers with a unique identifier that is linked to different outputs and activities (orcid.org). This is being used by a wide variety of institutions, including publishers, universities, and funding agencies. The system offers flexibility for researchers to document a variety of impacts. If the system were extended to explicitly include ways to document citations in regulations or management plans, and if these impacts were regularly recorded in ORCID by researchers, this could serve as an easy way for departments to assess the "Management Impacts" of faculty. Further, large databases such as Google Scholar and Scopus could also provide opportunities for easy tracking of these management impacts. For instance, all federal regulations since 1994 are electronically available at Federalregister.gov, and many include the list of the sources used to support decisions. If, in addition to tracking citations in journals, Google Scholar began to also track citations in federal regulations, this could facilitate the evaluation of potential management impacts of individual researchers.

Limitations of this Study and Next Steps

One limitation of the current study was the small sample of academics participating in the interviews and survey. Future studies should aim to include a larger sample of academic researchers who may more broadly represent the population of academics conducting relevant research.

Additionally, some of the things that made wolf management in the U.S. an ideal case study -- such as a long history, a large body of related publications, and the need to consider inputs from different sources -- also make it potentially different from many other situations. For instance, wolf management is a highly controversial topic. One effect of this controversy may be that decision-makers place a greater emphasis on publishing and citing peer-reviewed literature than they would if they were involved with an issue that was not subject to such a high degree of scrutiny. Additional case studies using similar study methods should be completed to understand how results may be different when related to lower-profile, less controversial topics.

Conclusions

This study has made four contributions to the "bridging the gap" dialogue. First, it provided a concise summary of the vast body of conservation biology "bridging the gap" literature and brought to light some of its shortcomings. Second, this study added some empirical evidence to the body of literature by contributing data that, in some cases supports, and in other cases challenges, the assertions in the "bridging the gap" literature. Third, it suggests two examples of ways that conservation biologists might begin to deal with one of the biggest barriers to bridging the gap – institutional incentives — and it provides examples of characteristics of research and researchers that are successfully having dual impacts. Finally, it suggests a new way to measure management impacts: a Management Impact Index.

Overall, the results of this study suggest that 1) science seems to play a role in decision-making; 2) science that is having an impact on decision-making is often the result of collaboration between academic scientists and government employees, hence developing good relationships with government scientists is a valid solution to bridging the gap between research and decision-making; 3) scientists based in academia can have a dual impact — they can conduct research that is published in top-tier journals and that is highly cited while still having an impact on policy and management decisions; and 4) analyzing citation data from federal regulations and other similar “decision documents” could provide a new way to measure the impact of scientific research on decision-making.

The development of a new impact index — a Management Impact Index — could provide academic institutions with an objective, transparent, and accessible way to assess non-academic impacts of faculty. An index that measures the management impact of scientific research can change the way that both academic institutions and publishers value applied research and outreach to decision-makers. This, in turn, could provide motivation and incentives for researchers to engage in these activities. This increased interaction and cooperation between researchers and decision-makers could lead to the development of better decisions, and ultimately, better policies.

APPENDIX ONE: SCIENTIFIC PUBLICATIONS USED TO SUPPORT DECISION-MAKING IN TWO REGIONS

Inputs to Decision-Making

The five federal regulations (see pages 45 & 46 for list of regulations) ranged in length from 39 to 65 pages. Across the five regulations, there were a total of 1,005 sources of information cited in the bibliographies. After removal of duplicate citations (i.e. sources that were cited in more than one regulation), there were 552 unique sources cited. The number of citations per regulation ranged from 126 to 243. Across the five regulations, the most frequently cited sources of information were peer-reviewed journal articles (35%), state-issued reports (13%), edited scientific volumes (11%), federal government-issued reports (5%), and personal communications (5%). Other sources of information cited include dissertations and theses, press releases, and conference proceedings (Table 13).

Table 13. Sources of information cited in five federal regulations.

Source of Information	Number of Citations	Percentage of all Citations
Journal	348	35%
State Report	127	13%
Book-Edited Volume	108	11%
Federal Government Report	55	5%
Letter/ Personal Correspondence	50	5%
Unpublished Report	42	4%
Federal Government Management Plan	35	3%
Book	34	3%
State Government Plan	31	3%
Conference Proceedings	30	3%
M.S. Thesis//Dissertation	18	2%
Magazine	15	1%
News Release	13	1%
Guidelines – State	12	1%
Report - Non-Profit	11	1%
Report – Academic	10	1%
Legislation	8	1%
Guide – Provincial	6	1%
Federal Regulations	4	0%
Report – International	4	0%
Report - Private Corporation	4	0%
Report - Provincial Government	4	0%
Website	4	0%
Agreement	3	0%
Book- Non Profit	3	0%
Fact Sheet - Provincial Government	3	0%
Reference	3	0%
Application	2	0%
Guidelines – Citizen	2	0%
Guidelines – Federal	2	0%
Memorandum of Understanding	2	0%
Newsletter	2	0%
Plan – Tribal	2	0%
Working Paper - Non Profit	2	0%
Court Document	1	0%
News Story	1	0%
Proposal – State	1	0%
Report – Tribal	1	0%
Technical Review	1	0%
Unpublished Article	1	0%

While the use of different information sources varied across regulations and regions, journal articles were the most highly cited information source in all five regulations, accounting for 30–41% of the citations (Table 14). There was greater variation in the use of state-issued reports. Regulations from the Western Great Lakes (WGL) region cited more state reports than Northern Rocky Mountain (NRM) region regulations, accounting for 17-19% versus 4-6% of all citations in the two regions, respectively. The practice of citing personal communications also differed in the two regions — 12% of the citations in NRM regulations were personal communications, but personal communications accounted for less than 1% of the citations in the WGL regulations.

Table 14. Most highly cited sources of information in five federal regulations.

	% of all Citations in Regulations (N = 1,005)	2006 WGL (n = 126)	2009 NRM (n = 191)	05-2011 WGL (n = 221)	2011 NRM (n =224)	12-2011 WGL (n = 243)
Journal (Peer-reviewed)	35%	32%	36%	30%	41%	33%
State Reports	13%	18%	6%	19%	4%	17%
Book (Edited Volume)	11%	7%	15%	10%	10%	11%
Federal Reports	5%	5%	5%	4%	8%	5%
Personal Communication	5%	1%	12%	0%	12%	0%

Of the 1,005 citations in the five regulations, 348 were from peer-reviewed published journal articles. After removal of duplicate citations (i.e. articles that were cited in more than one regulation), there were 174 unique published articles cited. Of these articles, 110 had been cited in more than one of the five regulations, but only 21 articles were cited in regulations in *both* regions. So, while it is common (63% of the time) that an article be used to support multiple regulations, it is less common (12% of the time) that an article be used to support decisions in both regions.

Characteristics of Peer-Reviewed Literature used in Decision-making in the Two Regions

Data on the characteristics of peer-reviewed literature cited in regulations in each region was collected according to methods described in Chapter 4. Statistical analyses of the characteristics were not performed. Instead, a summary of the descriptive characteristics is provided.

a) Publication Journal

The 348 citations in the federal regulations came from a total of 52 different journals. Overall, the most highly cited journal was the *Journal of Wildlife Management*, followed by the *Wildlife Society Bulletin* and *Conservation Biology* (Table 15). These three journals also ranked among the top five in both of the regions. Despite these similarities, there were some regional differences in journal usage. For instance, *American Midland Naturalist*, the *Canadian Journal of Zoology*, and *Journal of Mammalogy* were among the most frequently cited sources of information in the WGL (cited 19, 13, and 12 times, respectively). These journals were cited much less frequently in the NRM regulations (cited 4, 0, and 2 times, respectively).

Table 15. Journals most frequently cited in five federal regulations, by region.

Journal	Times Cited in Five Regulations*	Times Cited in WGL regulations*	Times Cited in NRM regulations*
J. of Wildlife Management	**39**	**13**	**26**
Wildlife Society Bulletin	**37**	**24**	**13**
Conservation Biology	**32**	**14**	**18**
American Midland Naturalist	**23**	**19**	4
Journal of Wildlife Disease	**21**	9	**12**
Journal of Mammalogy	14	12	2
Canadian Journal of Zoology	13	**13**	0
Canadian Field Naturalist	13	7	**6**
Molecular Ecology	12	7	5

* The five most frequently occurring journals in each data set are noted in bold.

b) Journal Impact Factor

The mean Impact Factors were calculated for the five most frequently cited journals in the regulations in each of the two regions (Table 16). Given the considerable overlap in journal usage in these two regions (three of the top five journals were the same in the two regions), it is not surprising that the mean Impact Factors of the most highly cited journals in the NRM and WGL's regulations are very similar (1.82 and 1.65, respectively).

Table 16. Impact Factors of the most frequently cited journals in five federal wolf regulations, by region.

Top 5 Journals in WGL Regulations	Impact Factor	Top 5 Journals in NRM Regulations	Impact Factor
Wildlife Society Bulletin	0.95	Journal of Wildlife Management	1.64
American Midland Naturalist	0.667	Conservation Biology	4.355
Conservation Biology	4.355	Wildlife Society Bulletin	0.95
Journal of Wildlife Management	1.64	Journal of Wildlife Disease	1.271
Canadian Journal of Zoology	1.5	Canadian Field Naturalist	0.04
	***M* = 1.82**		***M* = 1.65**

c) Research Topic

All cited publications were categorized into one of ten topic areas (Table 17). Across all regulations, the most frequent topics were genetics (19%), human and social issues (16%), wolf management issues (12%), and natural history of wolves (12%). The most frequently cited topic areas in the NRM were human and social issues (19%), natural history (15%), and management issues (14%). In contrast, the most frequently cited topics in the WGL were genetics (22%), habitat (15%), and disease (14%). These results may reflect the different concerns and issues associated with wolf management in these two regions of the U.S.

Table 17. Topics of papers cited in five federal wolf regulations, by region.

Topic	Percent of All citations*	Percent of NRM citations*	Percent of WGL citations*
Disease	11%	11%	**14%**
Dispersal	7%	6%	12%
Genetics	**19%**	12%	**22%**
Habitat	11%	5%	**15%**
Human/Social Issues	**16%**	**19%**	13%
Impact on Prey	4%	6%	0%
Management	**12%**	**14%**	9%
Natural History	**12%**	**15%**	11%
Policies	5%	6%	4%
Trophic Cascades	5%	7%	0%

* The three most frequently occurring topics in each data set are in bold.

d) Author affiliations

Of the 174 articles cited in regulations, author information was obtained for 165 of the articles (information was not available for 9 of the articles). There were a total of 650 authors listed on the 165 articles. Of these, there were 355 unique individuals (after removal of duplicate authors) that contributed to these publications.

In both regions, the majority of the first authors had an academic affiliation — 61% in the NRM and 54% in the WGL (Table 18). An additional 31% and 42% were affiliated with a state or federal government office in the NRM and WGL regulations, respectively. The remaining first authors (8% in NRM and 4% in WGL) had another affiliation such as non-profit, tribal, or private corporation.

Table 18. Affiliations of first authors on publications cited in five federal wolf regulations, by region.

First Author Affiliation	All High Management Impact Literature	Literature cited in Western Great Lakes Regulations	Literature cited in Northern Rocky Mountain Regulations
Academic	59%	54%	61%
Government	36%	42%	31%
Other	6%	4%	8%

e) Author Collaborations

Team sizes ranged from 1 to 19 authors (*M* = 3.92, *SD* = 3.26). Twenty-eight percent and 29% of teams in the WGL and NRM, respectively, were comprised of all academic researchers (Table 19). Teams that were comprised of all government (state or federal) employees authored 27% and 15% of the articles in the WGL and NRM, respectively. Thirty-six percent and 38% of articles in the WGL and NRM, respectively, were authored by teams that included both academic and government researchers. The remaining papers were authored by teams that included authors with other affiliations (e.g. non-profit and industry).

Table 19. Types of author collaborations on publications cited in five federal wolf regulations, by region.

Teams Include:	All High Management Impact Literature	Literature cited in Western Great Lakes Regulations	Literature cited in Northern Rocky Mountain Regulations
Academic Only	29%	28%	29%
Government Only	22%	27%	15%
Both Academics and Government Employees	37%	36%	38%
Academic and those with "Other" Affiliation	10%	8%	12%
Government and those with "Other" Affiliation	2%	0%	6%
"Other" Only	0%	0%	0%

APPENDIX TWO: SURVEY INSTRUMENTS

(Note: text in italics did not appear on actual survey)

Survey Questions for Academics

This study is focused on scientific research that is relevant to wolf conservation and management. We realize that you may conduct other research that is not relevant to this topic. When completing Sections I and II of this survey, we ask you to think about your "wolf-relevant" research when answering questions in Section I

Section I: Your Research

1. Please briefly describe your research as it relates to wolf conservation and management.
   [Text box]

2. What are the main outlets for dissemination of your research findings?
   [Likert Scale: 5. Very Frequently, 4. Frequently, 3. Sometimes, 2. Rarely, 1. Never]
   - Peer-reviewed Journals
   - Edited volumes
   - Presentations at professional scientific meetings *(if response is 1 or 2, skip question 4)*
   - Presentations at State or Federal Government meetings
   - Outreach to the public
   - Other. Please explain and provide examples if appropriate.

3. What journals do you see as most appropriate for publication of your research results?
   [Textbox]

4. Which professional scientific meetings do you most frequently attend?
   [Textbox]

5. Please briefly describe the types of State or Federal Government meetings you have presented at, if any.
   [Textbox]

6. What types of outreach activities, relevant to your research, do you conduct?
   [Textbox]

7. Who is the main audience for your research?
   [Likert Scale: 5. Very Frequently, 4. Frequently, 3. Sometimes, 2. Rarely, 1. Never]
      - Scientists based in academia
      - Scientists at State or Federal government agencies
      - Policy makers
      - Public
      - Other. Please explain.

8. How relevant do you think your research is to wolf managers in state and federal government agencies?
   [Likert scale: 5. Very Relevant, 4. Somewhat Relevant, 3. A Little Relevant, 2. Not Relevant, 1. Don't Know]

9. How often do you feel your research is utilized by Federal and State wolf managers?
   [Likert Scale: 5. Very Frequently, 4. Frequently, 3. Sometimes, 2. Rarely, 1. Never]

10. How relevant do you think your research is to policy decision making?
    [Likert Scale: 5. Very Relevant, 4. Somewhat Relevant, 3. A Little Relevant, 2. Not Relevant, 1. Don't Know]

11. How often do you feel your research is utilized by policy makers?
    [Likert Scale: 5. Very Frequently, 4. Frequently, 3. Sometimes, 2. Rarely, 1. Never]

<u>Section 2: Your Collaborations</u>

12. Have you worked directly with state or federal wolf managers?
    [Likert Scale: 5. Very Frequently, 4. Frequently, 3. Sometimes, 2. Rarely, 1. Never]
    (*If response is 1 or 2, skip question 13*)

13. In what capacity have you worked with state and/or federal wolf managers?
    [Text box]

14. Have you ever participated in the process of creating wolf management plans?
    [Yes, No] (*if no, skip question 15 and 18*)

15. Please describe the role you played in the process of creating wolf management plans?
    [Text box]

16. Have you participated in the process of writing regulations related to wolf management?
    [Yes, No] *(if no, skip question 17 and 19)*
17. Please describe the role you played in the process of creating wolf regulations?
    [Text box]

<u>*Section 3: Motivations and Incentives*</u> (adapted from Abbott et al. 2010)

For this next section of questions, please think about all of your academic activities (not just those related to wolf-relevant research).

18. Do you feel that your academic department values your contribution to the creation of wolf management plans?
    [Yes, No, Don't Know. Please Explain.)

19. Do you feel that your academic department values your contribution to the creation of wolf regulations?
    [Yes, No, Don't Know. Please Explain.)

20. How much emphasis do you think your department places on the following measures and scientific activities during performance reviews and decision on advancement and tenure?
    [Randomize order of choices. Use Likert Scale: 5: Considerable Emphasis, 4. Some Emphasis, 3. Little Emphasis, 2. No Emphasis, 1. Don't know)
    - Grants and income from federal sources
    - Grants and income from state sources
    - Grants and income from other sources
    - Publications in high-impact journals
    - Number of citations of published research
    - Teaching courses
    - Invitations to talk at scientific meetings
    - Book writing
    - Public exposure in the press
    - Training and mentoring students, postdocs, and junior faculty
    - Departmental administration
    - Collaborative work outside of your department
    - Collaborative work with academics outside of your institution
    - Collaborative work with government scientists
    - Outreach to non-scientists
    - Papers Reviewed
    - Talks at Professional Meetings
    - Other, Please Explain.

21. Does your department/institution provide any other incentives to collaborate with government scientists (besides placing emphasis on the activity during performance reviews and tenure decisions)?
    [Yes, No]

22. Does the way your institution evaluates your work affect your behavior (For example, if your institution counts up your publications, do you focus particularly on publication quantity)?
    [Yes, No]

23. Thinking about all of the possible measures of scientific contribution that are possible, please select **your** top 5 priorities. [Randomize order of choices. Allow to choose 5 responses]
    - Grants earned
    - Publication in high-impact journals
    - Number of citations on published research
    - Number of publications
    - Training and mentoring students and post docs
    - Papers Reviewed
    - Talks at Professional Meetings
    - Teaching courses
    - Invitations to talk at scientific meetings
    - Book writing
    - Public exposure in the press
    - Training and mentoring students, postdocs, and junior faculty
    - Departmental administration
    - Collaborative work outside of your department
    - Collaborative work with academics outside of your institution
    - Collaborative work with government scientists
    - Outreach to non-scientists

Survey Questions for Decision Makers

Section I: Information Inputs

1. In your current or any previous positions with a government agency, have you ever participated in the process of creating wolf management plans?
   [Yes, No] (*if no, skip question 7 & 8)*

2. Briefly describe the role you played in the process of creating wolf management plans?
   [Text box]

3. In addition to your own (your group's) expert knowledge, what other sources of information are used to write management plans?
   [Randomize response choices, select all that apply]
    - Other existing management plans
    - Expert opinion from outside compilation group
    - Published reviews
    - Edited books
    - Handbooks
    - Personal accounts
    - Web-based materials
    - Published popular articles
    - Published scientific papers
    - Other. Please explain.

4. Have you participated in the process of writing regulations related to wolf management?
   [Yes, No] *(if no, skip question 10 & 11)*

5. Briefly describe the role you played in the process of creating wolf regulations?
   [Text box]

6. In addition to your own (or your group's) expert knowledge, what other sources of information are used to write regulations?
   [Randomize response choices, Select all that apply]
    - Management plans
    - Expert opinion from outside compilation group
    - Published reviews
    - Edited books
    - Handbooks
    - Personal accounts
    - Web-based materials

- Published popular articles
- Published scientific papers
- Other. Please explain.

<u>Section II. Use of Scientific Literature</u>

7. In your job, how often do you use published scientific papers to support your decision making?
   [Likert Scale: 5. Very Frequently, 4. Frequently, 3. Sometimes, 2. Rarely, 1. Never]
   (If 4 or 5, skip question 13, If 1 or 2, skip question 14)

8. What are the main reasons that you do not use scientific papers more frequently?
   [Select all that apply]
   - Not relevant to my job
   - Too time consuming to locate
   - Too difficult to access
   - Too time consuming to read
   - Too technical to interpret in context of my decision making
   - Too specific to interpret in context of my decision making
   - I rely on others to provide me with information published in scientific literature
   - Other. Please explain.

9. When using published scientific papers, how do you generally locate and access them?
   [Select all that apply]
   - Hand search of literature in a library
   - Electronic search of library databases
   - Web search of publication databases
   - General web search
   - Literature recommended by colleagues
   - Use of personal collection
   - Use of employer collection
   - Other. Please explain.

10. Please rate how relevant you think each journal below is to your own work. [Randomize choices. Likert Scale: 5. Very Relevant, 4. Somewhat Relevant, 3. A Little Relevant, 2. Not Relevant, 1. Don't Know]
    - Journal of Wildlife Management
    - Wildlife Society Bulletin
    - Conservation Biology
    - Canadian Journal of Zoology-Revue Canadienne De Zoologie
    - Bioscience
    - Canadian Field-Naturalist
    - Ecological Applications
    - Ecology
    - Journal of Mammalogy
    - Journal of Wildlife Disease
    - Molecular Ecology

11. Please name any additional journals that are relevant to your work. [Series of text boxes]

12. Below is a list of scientific journals that you indicated are relevant to your job. Please rate how easily you can access articles in each of these journals. [Likert Scale: 4. I have easy access to this journal, 3. It takes a little extra work, but I am still able to access this journal, 2. I have great difficulty accessing this journal, 1. I don't know.]
    - Journal of Wildlife Management
    - Wildlife Society Bulletin
    - Conservation Biology
    - Canadian Journal of Zoology-Revue Canadienne De Zoologie
    - Bioscience
    - Canadian Field-Naturalist
    - Ecological Applications
    - Ecology
    - Journal of Mammalogy
    - Journal of Wildlife Disease
    - Molecular Ecology

Section III: Collaborations

13. How often do you collaborate with researchers who are based at academic institutions ("academic scientists")? [Likert Scale: 5. Very Frequently, 4. Frequently, 3. Sometimes, 2. Rarely, 1. Never] *(If 1 or 2, skip Question 14)*

14. Briefly describe the nature of your collaborations (provide examples as appropriate). [Text box]

15. What do you see as the biggest benefits of collaborating with academic-based scientists?
    [Choose all that apply]
    - Increases credibility with external stakeholders
    - Allows us to conduct research we don’t otherwise have time to complete
    - Allows us to conduct research we don’t otherwise have tools to complete
    - Allows us to conduct research we don’t otherwise have expertise to complete
    - Provides an opportunity to recruit potential future employees
    - Other. Please Explain.

16. What do you see as the biggest reasons that you have not collaborated with academic scientists?
    [Select all that apply]
    - Their work is not relevant to my job
    - Don’t know who to collaborate with
    - Academic scientists are not interested/willing to collaborate
    - Collaboration is too time consuming
    - My department does not encourage collaboration
    - Other. Please explain.

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