Using Meta-Analysis in the Social Sciences to Improve Environmental Policy

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Abstract

Policymakers have recently looked to the social sciences for effective strategies to address environmental issues, including how to change people's environmental behaviors. During that time, social scientists have been challenged to improve how they assess, summarize, and convey the state of environmental social science. Meta-analysis, the quantitative review of existing research using data from multiple studies, is one method researchers use to assess the state of knowledge and share best practices. Development of new data reporting standards and systems would improve not only environmental social science, but also the interface between environmental social sciences and policymakers. In particular, dynamic meta-analyses, or frequently updated meta-analyses, would ensure that policymakers have access to up-to-date findings and would allow policymakers to examine subsets of studies that best approximate relevant contexts for new policies. These new standards for conducting and reporting meta-analyses would allow environmental social scientists to more effectively

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inform policy, and would help policymakers understand and assess the latest developments in the field.

Keywords
Meta-analysis · Environmental policy · Social sciences · Behavior change

1 Using Meta-Analysis in the Social Sciences to Improve Environmental Policy

Survey results suggest that people are increasingly concerned about environmental issues, including climate change, drought, and flooding (Aschwanden 2016). Given these well-documented threats to the environment, there is a continuing need to find cost effective approaches to changing individuals' environmental behaviors (e.g., efficient technology purchases, energy and water conservation; Gifford 2014). For example, individual and household behaviors are estimated to have a substantial impact on greenhouse gas emissions, and in turn, on climate change (Carrico et al. 2011; Dietz et al. 2009; Vandenbergh and Gilligan 2015). To more effectively influence these environmental behaviors, we need policies informed by sound social science that help people engage in behaviors that benefit the environment, and at the same time are not too costly or onerous to the individuals being asked to change their behavior. As policymakers look to harness the social sciences to help address environmental problems, they confront challenges in accessing and interpreting the results of myriad social science studies. The use of meta-analytic approaches can enable social scientists to assist in the rapid dissemination of best practices.

By focusing on use of meta-analytic approaches across the social sciences, we argue that improvements to the conducting and reporting of meta-analyses will aid policymakers in their ability to promptly and effectively craft policy that targets pressing environmental issues. Specifically, we largely focus here on individual level environmental behavior change. First, we outline why social science meta-analyses can improve the translation of social science research into environmental policy by both guiding policymakers on how to craft environmental policy and increasing the credibility of social science research. Second, we discuss how improving environmental social science meta-analyses would better ensure that policymakers are equipped with needed information when crafting effective environmental policy. Third, we explore a relatively new approach to meta-analysis, dynamic meta-analysis, which would provide policymakers with the most up-to-date data relevant to environmental policy, and provide those data in a way that policymakers can more easily adapt to their needs. Finally, we briefly cover additional ways in which meta-analyses could code primary articles to provide policymakers with additional information they may desire when crafting policy. By

improving how social scientists approach meta-analyses, environmental social scientists will be better positioned to inform policy that reflects the latest empirical trends and best practices.

2 Relevance of Environmental Social Science to Policymakers

As a whole social scientists have struggled to inform and guide environmental policy (Carrico et al. 2015; Clayton et al. 2015; Steel et al. 2004). With research relevant to policymakers being conducted by environmental social scientists of all stripes, including economists, communication scientists, psychologists, and sociologists, there is an opportunity to improve how effectively social scientists inform policymakers. But, these efforts require more attention.

We use the term policymaker in a general sense to refer to any individual concerned with developing and implementing policies or actions regarding environmental protection. This includes elected officials, but also program managers in an advocacy group or corporate firm who are looking to affect some kind of environmental outcome (e.g., the carbon footprint of a company) or behavior (e.g., home energy use; Vandenbergh 2013). Because policymakers often attempt to influence environmental outcomes at a larger scale than environmental social scientists typically study, environmental policymakers are usually unable to simply extract a finding or use an intervention from the environmental social science literature and immediately put it into practice. Additionally, in the literature on environmental behavior change interventions targeting individuals' behaviors, it is not always clear to social scientists themselves which behavior change efforts are the most effective at influencing these behaviors (Schultz 2015). This fact makes it hard for policymakers to use best practice intervention options. And, even when there are clear findings in the literature, environmental social scientists do not always effectively share their findings with the wider community (Hallegatte and Mach 2016).

An additional barrier that makes it difficult to translate social science findings into environmental policy is policymakers' perceptions of the environmental social sciences. Recent reviews in a number of social science and health disciplines have suggested that social science research may not be as reproducible as once hoped, including in psychology (Open Science Collaboration 2012, 2015), economics (Chang and Li 2015), and the health sciences (Arrowsmith 2011). Given this recent attention, policymakers may deem social science literature as untrustworthy or unreliable. Thus, there are a number of factors that currently make it difficult for environmental social scientists to assist policymakers with evidence-based policy development. Use of meta-analysis, and in particular improvements to how social scientists use and report meta-analyses, could help ensure that policymakers draw appropriate insights from environmental social science, and use these insights in the design of laws, policies, and programs.

3 Using Meta-Analysis to Bring Primary Environmental Social Science Research to Policymakers

Given these concerns, environmental social scientists need tools to not only allay concerns policymakers have about the state of the social sciences, but also to provide clear road markers for how environmental policy development should proceed. Meta-analysis is one such tool that can inform evidence-based policy-making. Meta-analysis is the quantitative summary and comparison of studies examining a similar phenomenon (Cumming 2014). For example, meta-analyses have considered the effect of behavior change interventions on environmental behaviors and outcomes, including use of informational messages (Delmas et al. 2013), feedback on one's behavior (Karlin et al. 2015), use of financial incentives (Maki et al. 2016), and social influence approaches such as behavioral modeling or use of community block leaders (Abrahamse and Steg 2013). These meta-analyses provide a quantitative summary of how large a change in environmental behavior or environmental outcome we can expect when using a behavior change technique. For example, Delmas et al. (2013) considered the effect of providing homeowners with home energy audits on home energy use, finding across 156 studies that audits on average led to a 14% decrease in household energy use. In other areas of the environmental social sciences, meta-analysis has been used to explore the factors most strongly linked to belief in anthropogenic climate change (Hornsey et al. 2016) and the effect of environmental regulation on firm and country competiveness (Cohen and Tubb 2016).

Meta-analysis is an approach distinct from literature reviews and qualitative assessments of prior research. Sometimes referred to as narrative reviews, literature reviews are a selective survey of the research on a specific topic, generally attempting to provide a broad overview (Ressing et al. 2009). Systematic reviews differ from traditional literature reviews in that they follow a specified search process to locate primary research articles (or unpublished data sets) related to a topic, including explicit definitions of inclusion and exclusion criteria and the search strategy and search terms. Systematic reviews survey article databases and leading scholars to locate all of the potential articles or unpublished studies on a specific topic, and then an initial review of articles is conducted to determine study inclusion eligibility (Uman 2011). Rigorous systematic reviews tend to use a flow diagram to document the identification, inclusion, and exclusion of studies through the systematic review process (see Fig. 1). A meta-analysis builds upon a systematic review by extracting relevant quantitative data from articles included in the systematic review, often in combination with qualitative coding of primary articles for study characteristics (e.g., quality of the study, aspects of the sample, or intervention characteristics). Rigorous meta-analyses also tend to test for publication bias in the included articles, to better estimate whether the meta-analytic effects are representative of the potential population of all relevant studies (Macaskill et al. 2001; Rothstein et al. 2005).

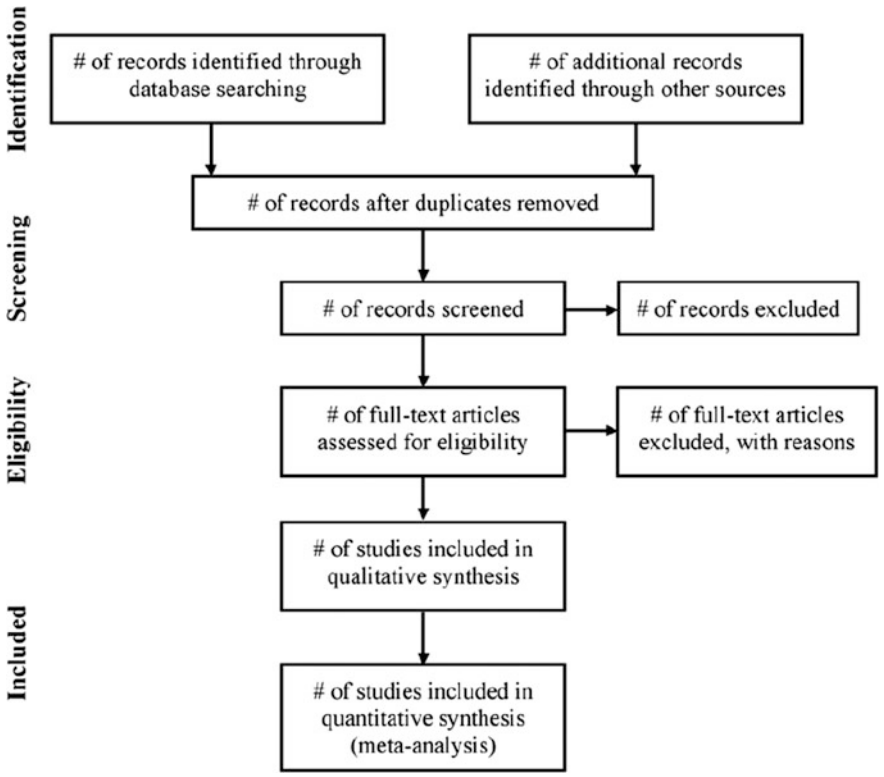

Fig. 1 Flow of information through the phases of a systematic review. Borrowed with permission from Moher et al. (2009)

A strength of meta-analysis is its ability to provide an overall quantitative picture of a phenomenon or relationship. This provides increased confidence in the findings in a literature, and gives policymakers some sense of the size of the expected effect for that phenomenon or relationship. For example, even though primary research is conflicted on whether use of social norm messaging leads to towel reuse in hotels, meta-analytic evidence suggests there is strong support for the effect of social norm-based messages on towel reuse (Scheibehenne et al. 2016). Meta-analyses can also help policymakers appreciate how effects may vary across contexts. For example, meta-analysis has revealed that although providing individuals with feedback on their energy use can lead to 8 to 12% savings in energy use on average (Karlin et al. 2015). However, context and nuance also matters as providing more frequent feedback—more often than once a month—tends to lead to stronger effects as compared to providing less frequent feedback.

It is important to acknowledge that meta-analysis cannot erase weaknesses that already exist in some literatures (Bangdiwala et al. 2016), as a meta-analysis is only as good as the articles it relies on. If a literature contains too few studies, or too

many poorly designed studies, a meta-analysis may produce unreliable estimates of effects. If a literature has too many studies all exploring the identical research question, a meta-analysis will be unable to consider differences between studies (e.g., how studying households versus office employees may affect the direction and size of the effect). If a meta-analysis combines primary studies that are too distinct from each other, this can lead to meta-analytic results that are difficult to interpret. Meta-analyses should discuss these issues explicitly, and when appropriate provide additional analyses that attempt to resolve these issues (e.g., conduct separate analyses with and without studies deemed to be poorly designed).

Meta-analysis can not only provide an overall picture of a given relationship in environmental social science research, but it can also help social scientists build credibility with policymakers and the public regarding concerns over study replication. By averaging effects over a number of studies, and thus increasing the sample sizes used to pinpoint an effect, both scientists' and policymakers' confidence in the direction and size of effects should increase as use of meta-analysis becomes more common. Thus, meta-analyses have a number of clear strengths that can aid policymakers over and above single primary studies on social-scientific topics of relevance to environmental policies.

4 Improving the Ability of Meta-Analyses to Inform Environmental Policymakers

More effective detailing, standardizing, and reporting of meta-analysis would also help address current shortcomings in the literature and improve the ability of social scientists to inform environmental policy. Current meta-analyses often lack vital details that are present in the primary sources that would be useful to policymakers. These include specific details about how interventions were designed or implemented in primary studies, and how interventions affect specific groups of people. These problems in part arise because we lack a norm that encourages researchers across the social sciences to provide standard information when conducting and reporting meta-analyses.

For example, social-psychological meta-analyses on environmental topics often fail to report specifics about the types of interventions that were used in primary sources. Osbaldiston and Schott (2012) detail interventions at a general level (e.g., rewards or feedback), but are unable to discuss specifics of these interventions beyond this basic level because of coding decisions. Alternatively, Karlin et al. (2015) discuss differences between types of feedback approaches (e.g., informational, normative) and frequency of feedback (e.g., monthly, daily). More consistent understandings of, and coding for, types of interventions by meta-analyzers would give clearer guidelines to policymakers on how to craft their own interventions. For example, in the health sciences researchers have categorized the interventions linked to healthy eating and exercise behavior change into distinct categories, allowing for more reliable comparisons of the effectiveness of different categories

of interventions (e.g., Abraham and Michie 2008; Michie et al. 2013). One eventual goal, with a commonly accepted coding scheme for environmental interventions, would be to produce materials guiding policymakers on how to design interventions or policies in sufficient detail that would replicate approaches from the literature. With their focus on coding numerous articles across a literature, meta-analyses are poised to offer these kinds of insights to environmental policymakers.

Another important consideration is how different interventions influence different types of individuals or segments of society. For example, if a primary article examines how financial incentives influence home energy efficiency, the article may report how these interventions influence men versus women, single versus family households, or low versus high income households. Policymakers often target their policies towards specific individuals or groups, and thus the direction and size of the effect of incentives on these different groups is of value to policymakers. However, meta-analyses inconsistently examine how interventions affect different groups across a literature.

As a whole, improved and consistent reporting standards in the environmental social sciences would aid our ability to inform environmental policymakers. The health sciences literature can point us toward a more effective synthesizing and reporting of environmental research. Use of meta-analysis is a quickly growing area of focus in the social sciences, and health sciences more specificially (Ioannidis 2016; Sutton and Higgins 2008). The health sciences are often concerned with influencing behaviors, including individual behavior change. Health science researchers arguably also have a longer history of exploring, through use of both primary and meta-analytic research, the most effective interventions and policies targeting behavior change. There has been a drastic increase in meta-analytic research in the health sciences (Ioannidis 2016), something the environmental social sciences may mirror moving forward. Finally, there are simply more researchers, research centers, collaborations, and funding opportunities for health researchers; hence they have been examining how to improve meta-analyses for a longer time period.

Given disappointment over past efforts to adequately report necessary components of reviews and meta-analyses, the PRISMA group (Moher et al. 2009) proposed improvements to meta-analytic reporting in the health sciences (Table 1). This approach could be further adapted to ensure that the conducting and reporting of environmental social science meta-analyses are better prepared to inform and guide environmental policymakers. Coding for additional key study elements of primary articles, in addition to the standard PRISMA reporting items, would be useful in the environmental social sciences. These elements include consistent reporting of demographic information across studies when available, such as the sample gender ratio, age, race, socio-economic status, political ideology, and family household size. Coding for study quality, including blinding of participants and experimenters, when relevant, type of randomization, and attrition for longitudinal studies (e.g., Wells and Littell 2009) would help consumers of meta-analyses better determine study quality. Finally, aspects of the social context of each study can help guide policymakers efforts to tailor policies to specific situations, including the

Table 1 PRISMA checklist of items to include when reporting a systematic review or meta-analysis

Section/Topic	#	Checklist Item	Reported onPage #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both	
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known	
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS)	
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number	
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale	
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched	
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated	
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis)	
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators	
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made	
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level) and how this information is to be used in any data synthesis	
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means)	

(continued)

Table 1 (continued)

Section/Topic	#	Checklist Item	Reported onPage #
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis	
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies)	
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram	
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations	
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome-level assessment (see Item 12)	
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group and (b) effect estimates and confidence intervals, ideally with a forest plot	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15)	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16])	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., health care providers, users, and policy makers)	
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review level (e.g., incomplete retrieval of identified research, reporting bias)	
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research	
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review	

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setting in which the study took place (e.g., households, workplace offices, public settings), and the populations targeted (e.g., general public, students, construction workers). Increased standardization of reporting in meta-analyses would also help shine light on when primary studies are not doing an effective job of reporting these dimensions.

5 Developing Dynamic Environmental Meta-Analyses

Given the recent push in the social and health sciences to share data and more fully report methods and results, the environmental social sciences have the opportunity to explore ways to more dynamically and systematically update meta-analyses with new, relevant primary studies, including unpublished research. This would help the environmental social sciences move toward a truly dynamic, constantly informed field ready to propose and update best policies. Development of cutting-edge environmental policy necessitates cutting-edge meta-analyses. Instead, environmental social sciences are currently underprepared to provide such up-to-date guidance. For example, classic meta-analytic research on the psychological factors linked to environmental behavior was conducted in 1986 (Hines et al. 1986/1987). Only in 2007 did researchers update this meta-analysis to provide a more complete picture of the then-current knowledge of the psychological factors linked to environmental behavior (Bamberg and Möser 2007). Some organizations, such as Cochrane Collaboration (Moher et al. 2008), have proposed standards for how best to update meta-analyses over time, particularly in the health sciences. The occasional updating of meta-analyses on environmental topics is certainly preferable to never updating them, but the time that lapses between updates can sometimes lead to available meta-analyses being far outpaced by the literature.

Instead, a dynamic meta-analytic approach in the environmental social sciences —similar to an idea briefly considered in the past (Whitehead 1997) and more recently explored by Page and Moher (2016), which they called "living cumulative network meta-analysis"—could be prepared to constantly provide the most up-to-date findings to policymakers, and provide the results in a way that policymakers could tailor to their needs. By partnering with such open science websites as Open Science Framework and Psychfiledrawer.org, environmental meta-analyzers could maintain an open database of studies that have examined a given environmental social science phenomenon or relationship, creating both an overall database across studies and one that would allow researchers to explore specific subsets of studies to better appreciate distinct contexts (e.g., types of environmental outcomes or demographics). Similar efforts are being discussed in other fields, including efforts led by Vivli, which aim to share clinical data across studies and labs to provide an overall database of research findings (Panko 2016). Other efforts are also underway to create neutral, data sharing platforms in the medical sciences (Bierer et al. 2016).

Ideally, researchers would enter information from each study into a public database, guided by an updated PRISMA reporting standard, including the phenomenon or relationship studied, the direction and magnitude of the effect, and other core characteristics of the intervention and sample. This information could be entered by the primary researcher or social scientists interested in maintaining a meta-analytic database on a topic related to their own research. These databases would be hosted by one of the aforementioned online repositories, and whenever policymakers needed the latest up-to-date synthesized findings on a given intervention or for a specific relationship, the data could be downloaded and used by the policymaker. Alternatively, and ideally, these databases would come with the ability to request information about a specific relationship online through an easy user interface, and the relevant results would be produced for the policymaker. To the extent that it is possible, databases could also be linked or nested within one another, so a policymaker could consider all possible interventions that may be effective at reducing employee energy use in the workplace, or they could specifically look at energy feedback software for decreasing energy office use.

An additional benefit of creating an open-source, dynamic system for meta-analyses is that it will send a clear signal to researchers about the types of variables and details they need to measure and report in their primary research articles. This could include standards emphasized in an updated set of PRISMA-like guidelines tailored to the environmental social sciences, such as reporting on intervention or sample characteristics, but also additional interdisciplinary concerns such as the unexpected effects of environmental intervention and policy efforts (e.g., "rebound effects"; Gillingham et al. 2013). Thus, dynamic meta-analyses could guide research and reporting norms to improve the entire environmental social science research enterprise.

An approach resembling a dynamic reporting of meta-analyses would ensure that environmental social scientists are proposing cutting-edge findings when policymakers are designing policy. We strongly encourage other researchers, including social scientists outside the environmental field, to bring their own ideas and tools to such an enterprise, but the approach is appealing enough to deserve further attention. There are potential shortcomings, of course, such as uncertainty about who would publish new meta-analyses with the statistics gathered and how frequently. These repositories also need to contain complete, easy to discern data with relevant codebooks, in order to not become "data dumpsters" (Merson et al. 2016). This may mean that an official body, which would probably require consistent funding, would maintain and update these databases. The logistics would need to be determined and adapted over time, but if we want to create a dynamic social science truly ready to inform cutting-edge policy, and policy that is ideally tailored to specific groups or contexts, a more dynamic approach to environmental social science meta-analyses is something we need to consider.

6 Additional Considerations for Improving Environmental Policy Efforts

Finally, social scientists conducting primary or meta-analytic research must also improve their ability to discuss other important types of information and evidence relevant to policymakers. First, we need to consider how our interventions influence change in environmental outcomes or behaviors over time (e.g., Rothman 2000). Meta-analyses in the environmental behavior change area have tended to find a significant drop in the number of studies that report follow-up effects over time compared to studies reporting initial change in outcomes or behavior (e.g., Lokhorst et al. 2013; Maki et al. 2016). Policymakers want to understand not only the expected magnitude of change, but also the persistence of the behavior change—how *long* change can be expected to be maintained.

Second, we need an improved grasp of the supplemental effects of our interventions, including how interventions influence a wide range of environmental and social outcomes, not just the behaviors or outcomes specifically targeted by the intervention (sometimes called "behavior spillover" or "rebound effects"; Gillingham et al. 2013; Thøgersen 1999; Truelove et al. 2014), including whether they influence the spread of environmental outcomes across social networks (e.g., Smith and Christakis 2008; Noonan et al. 2011; Darley and Beniger 1981). Similarly, working across traditional disciplinary boundaries would help environmental social scientists incorporate variables and outcomes from each other's studies. For example, how interventions affect outcomes such as overall personal well-being (e.g., Zhang et al. 2014) is vital to appreciating the effects of environmental policies, as are the economic effects on individuals, private firms, and public entities. And, relatedly, we need to better determine estimates of the economic costs of our interventions, to ensure we are designing interventions that can be taken to scale with limited financial barriers (Barker et al. 2016; Carnall et al. 2016; Castelnuovo et al. 2016; Ho et al. 2016; Whelan et al. 2016). This would help ensure that environmental social scientists have a complete picture of all of the positive and negative effects of environmental policies.

Third, we need to consider behaviors that both have the largest influence on important environmental outcomes ("technical potential"; Dietz et al. 2009) and the behaviors and outcomes that we have a reasonable chance of influencing ("behavioral plasticity"; Dietz et al. 2009). Policymakers want to target behaviors that have the greatest influence on pressing environmental issues, and thus primary and meta-analytic research must focus on these behaviors of interest. As a whole, if primary studies report these types of considerations, meta-analyzers should code for (or at least comment on) behavior maintenance, behavior spillover, technical potential, and behavioral plasticity. When unable to code for them, meta-analyzers can spur on additional work in these areas by advocating for improved measurement and reporting of these dimensions by primary environmental social science researchers.

Even after environmental social science meta-analyses have informed new environmental policies, it is worth acknowledging that the research process does not end there. Research on intervention fidelity suggests that we need to be cognizant of whether policymakers are truly sticking to the best environmental practices outlined by meta-analyses (Damschroder et al. 2016). One could view the meta-analytic enterprise, to the extent that it interfaces with policy, to be an iterative process that leads to new insights, new policies, and new questions deserving of further empirical exploration.

7 Barriers to Improving Environmental Social Science Meta-Analyses

We must acknowledge that a number of barriers exist that make implementation of the aforementioned recommendations difficult. For example, even though social scientists have recently pushed for greater transparency in research (Open Science Collaboration 2012), they have also been slow to adopt these new practices. Meta-analyses can only be of quality when primary research is of quality and reported on in a manner that allows for others to use in a meta-analysis, and thus primary researchers should be nudged to consider how their work influences future meta-analyses. However, asking researchers to adjust how they report their primary research to improve meta-analytic efforts will not be sufficient. In a "publish or perish" world, researchers need incentives to improve their practices. Thus, journal editors and research funders should also push for new standards with the end goal of increasing the quality of both primary research and meta-analyses, and thus the promise of exporting our work to policymakers. This could include new requirements for publishing primary empirical results (such as requiring standard measures of the size of effects) and new expectations from funders that primary researchers should enter their results in online dynamic meta-analyses.

Another barrier stems from how to fund and manage the creation and maintenance of dynamic meta-analyses. Ideally, either leadings scholars on a given topic or paid staff associated with a research center would manage dynamic meta-analyses. Regardless of who maintains these publicly available meta-analyses, stable funding would be required at some level.

Finally, scholars or staff who maintain a specific dynamic meta-analysis would potentially need to be available on occasion to assist policymakers, or liaisons between policymakers and scholars, with how to examine and understand certain sets of relevant results. Online tutorials and handbooks would need to be developed that would help policymakers, but inevitably there would also have to be someone available who could occasionally respond to inquiries. This type of guidance would be important in order to make using these meta-analyses as easy as possible to use, and to improve their ability to inform environmental decision-making. Ideally, the results would also be consistently reported in such a way that would make them easy for policymakers to understand. Building off of work by David Kenny and his

Data to Text programs (Kenny 2014) would be an ideal step, as these programs take output from statistical programs and translate it into a narrative that describes the results and how to properly interpret them. Such an approach would make it far easier for non-statisticians to understand the results of dynamic meta-analyses. Also, given concerns about the quality of primary studies included in meta-analyses, policymakers should also have access to easy to understand summaries of the quality of the studies included in the meta-analysis, and the ability to exclude poorly designed studies from reports of meta-analytic results. This may be difficult to implement, as it is unlikely any scholar entering their study information would deem their own research of poor quality. Yet, policymakers require that information to understand the confidence that the scientific community currently places in the results.

8 Conclusion

Meta-analysis is a tool that can help the environmental social sciences drastically improve their ability to inform environmental policy. To improve its exportability, environmental social scientists must improve the conducting and reporting of their meta-analytic research to better inform policymakers. They must also explore ways to create data reporting structures that are prepared to dynamically convey up-to-date best practices to policymakers. Taking these steps will improve the exportability of the environmental social sciences toward more effective designing and implementing of environmental policies that are better able to address the pressing environmental problems of our day.

References

Abraham, C., & Michie, S. (2008). A taxonomy of behavior change techniques used in interventions. *Health Psychology, 27,* 379–387.

Abrahamse, W., & Steg, L. (2013). Social influence approaches to encourage resource conservation: A meta-analysis. *Global Environmental Change, 23,* 1773–1785.

Arrowsmith, J. (2011). Phase II failures: 2008−2010. *Nature Reviews Drug Discovery, 10,* 1.

Aschwanden, C. (2016). Democrats—and republicans—are growing more worried over climate change. http://fivethirtyeight.com/features/democrats-and-republicans-are-growing-more-worried-over-climate-change/.

Bamberg, S., & Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology, 27,* 14–25.

Bangdiwala, S. I., Bhargava, A., O'Connor, D. P., Robinson, T. N., Michie, S., Murray, D. M., et al. (2016). Statistical methodologies to pool across multiple intervention studies. *TBM, 6,* 228–235.

Barker, P. M., Reid, A., & Schall, M. W. (2016). A framework for scaling up health interventions: Lessons from large-scale improvement initiatives in Africa. *Implementation Science, 11,* 1–11.

Bierer, B. E., Li, R., Barnes, M., & Sim, I. (2016). A global, neutral platform for sharing trial data. *The New England Journal of Medicine, 374,* 2411–2413.

Carnall, M., Dale, L., & Lekov, A. (2016). The economic effect of efficiency programs on energy consumers and producers. *Energy Efficiency, 9,* 647–662.

Carrico, A. R., Vandenbergh, M. P., Stern, P. C., & Dietz, T. (2015). US climate policy needs behavioural science. *Nature Climate Change, 5,* 177–179.

Carrico, A. R., Vandenbergh, M. P., Stern, P. C., Gardner, G. T., Dietz, T., & Gilligan, J. M. (2011). Energy and climate change: Key lessons for implementing the behavioral wedge. *Journal of Energy & Environmental Law, 18452,* 61–67.

Castelnuovo, G., Pietrabissa, G., Cattivelli, R., Manzoni, G. M., & Molinari, E. (2016). *Not only clinical efficacy in psychological treatments: Clinical psychology must promote cost-benefit, cost-effectiveness, and cost-utility analysis. Frontiers in Psychology 7*. doi:10.3389/fpsyg.2016.00563.

Chang, AC., & Li, P. (2015). *Is economics research replicable? Sixty published papers from thirteen journals say "usually not*." Finance and Economics Discussion Series 2015-083, Washington: Board of Governors of the Federal Reserve System. http://dx.doi.org/10.17016/FEDS.2015.083.

Clayton, S., Devine-Wright, P., Stern, P. C., Whitmarsh, L., Carrico, A., Steg, L., et al. (2015). Psychological research and global climate change. *Natura Climate Change, 5,* 640–646.

Cohen, M. A., & Tubb, A. (2016). The impact of environmental regulation on firm and country competitiveness: A meta-analysis of the porter hypothesis. http://ssrn.com/abstract=2692919.

Cumming, G. (2014). The new statistics: Why and how. *Psychological Science, 25,* 7–29.

Damschroder, L. J., Goodrich, D. E., Kim, H. M., Holleman, R., Gillon, L., Kirsh, S., et al. (2016). Development and validation of the ASPIRE-VA coaching fidelity checklist (ACFC): A tool to help ensure delivery of high-quality management interventions. *Translational Behavioral Medicine, 6,* 369–395.

Darley, J. M., & Beniger, J. R. (1981). Diffusion of energy-conserving innovation. *Journal of Social Issues, 37,* 150–171.

Delmas, M. A., Fischlein, M., & Asenio, O. I. (2013). Information strategies and energy conservation behavior: A meta-analysis of experimental studies from 1975 to 2012. *Energy Policy, 61,* 729–739.

Dietz, T., Gardner, G. T., Gilligan, J., Stern, P. C., & Vandenbergh, M. P. (2009). Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions. *Proceedings of the National Academy of Sciences of the United States of America, 106,* 18452–18456.

Gifford, R. (2014). Environment psychology matters. *Annual Review of Psychology, 65,* 541–579.

Gillingham, K., Kotchen, M. J., Rapson, D. S., & Wagner, G. (2013). The rebound effect is overplayed. *Nature, 493,* 475–476.

Halletatte, S., & Mach, K. J. (2016). Make climate-change assessments more relevant. *Nature, 534,* 613–615.

Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1986/1987). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *Journal of Environmental Education, 18,* 1–8.

Ho, F. Y., Yeung, W., Ng, T. H, & Chan C. S. (2016). The efficacy and cost-effectiveness of stepped care prevention and treatment for depressive and/or anxiety disorders: A systematic review and meta-analysis. Scientific Reports 6. doi:10.1038/srep29281.

Hornsey, M. J., Harris, E. A., Bain, P. G., & Fielding, K. S. (2016). Meta-analyses of the determinants and outcomes of belief in climate change. *Nature Climate Change*. doi:10.1038/NCLIMATE2943.

Ioannidis, J. P. A. (2016). The mass production of redundant, misleading, and conflicted systematic reviews and meta-analyses. *The Milbank Quarterly, 94,* 485–514.

Karlin, B., Zinger, J. F., & Ford, R. (2015). The effects of feedback on energy conservation: A meta-analysis. *Psychological Bulletin, 141,* 1205–1227.

Kenny, D. A. (2014). Data to text. Retrieved from. http://davidakenny.net/dtt/datatotext.htm#MA.

Lokhorst, A. M., Werner, C., Staats, H., van Dijk, E., & Gale, J. L. (2013). Commitment and behavior change: A meta-analysis and critical review of commitment-making strategies in environmental research. *Environment and Behavior, 45,* 3–34.

Macaskill, P., Walter, S. D., & Irwig, L. (2001). A comparison of methods to detect publication bias in meta-analysis. *Statistics in Medicine, 20,* 641–654.

Maki, A., Burns, R. J., Ha, L., & Rothman, A. J. (2016). Paying people to protect the environment: A meta-analysis of financial incentive interventions to promote proenvironmental behavior. *Environmental Psychology, 47,* 242–255.

Merson, L., Gaye, O., & Guerin, P. J. (2016). Avoiding data dumpsters—toward equitable and useful data sharing. *The New England Journal of Medicine, 374,* 2414–2415.

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., et al. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine, 46,* 81–95.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLOS Medicine, 6,* e1000097.

Moher, D., Tsertsvadze, A., Tricco, A., Eccles, M., Grimshaw, J., Sampson, M., & Barrowman, N. (2008). When and how to update systematics reviews. Cochrane database of systematic reviews 1. doi:10.1002/14651858.MR000023.pub3.

Noonan, D. S., Hsieh, L. C., & Matisoff, D. (2011). Spatial effects in energy-efficient residential HVAC technology adoption. *Environment and Behavior, 45,* 476–503.

Open Science Collaboration. (2012). An open, large-scale, collaborative effort to estimate the reproducibility of psychological science. *Perspective on Psychological Science, 7,* 657–660.

Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science, 349,* 943–951.

Osbaldiston, R., & Schott, J. P. (2012). Environmental sustainability and behavioral science: Meta-analysis of proenvironmental behavior experiments. *Environment and Behavior, 44,* 257–299.

Page, M. J., & Moher, D. (2016). Mass production of systematic reviews and meta-analyses: An exercise in meta-silliness? *The Milbank Quarterly, 94,* 515–519.

Panko, B. (2016). Industry-backed project aims to become one-stop shop for clinical research data. *Science*. doi:10.1126/science.aag0554.

Ressing, M., Blettner, M., & Klug, S. J. (2009). Systematic literature reviews and meta-analyses. *Deutsches Ärzteblatt International, 106,* 456–463.

Rothman, A. J. (2000). Toward a theory-based analysis of behavioral maintenance. *Health Psychology, 19,* 64–69.

Rothstein, H. R., Sutton, A. J., & Borenstein, M. (2005). Publication bias in meta-analysis. In H. R. Rothstein, A. J. Sutton, & M. Borenstein (Eds.), *Publication bias in meta-analysis—prevention, assessment, and adjustments hoboken* (pp. 1–7). NJ: Wiley.

Scheibehenne, B., Jamil, T., & Wagenmakers, E. (2016). Bayesian evidence synthesis can reconcile seemingly inconsistent results: The case of hotel towel reuse. *Psychological Science, 27,* 1043–1046.

Schultz, P. W. (2015). Strategies for promoting proenvironmental behavior: Lots of tools but few instructions. *European Psychologist, 19,* 107–117.

Smith, K. P., & Christakis, N. A. (2008). Social networks and health. *Annual Review of Sociology, 34,* 405–429.

Steel, B., List, P., Lach, D., & Shindler, B. (2004). The role of scientists in the environmental policy process: A case study from the American west. *Environmental Science & Policy, 7,* 1–13.

Sutton, A. J., & Higgins, J. P. T. (2008). Recent developments in meta-analysis. *Statistics in Medicine, 27,* 625–650.

Thøgersen, J. (1999). Spillover processes in the development of a sustainable consumption pattern. *Journal of Economic Psychology, 20,* 53–81.

Truelove, H. B., Carrico, A. R., Weber, E. U., Raimi, K. T., & Vandenbergh, M. P. (2014). Positive and negative spillover of pro-environmental behavior: An integrative review and theoretical framework. *Global Environmental Change, 29,* 127–138.

Uman, L. S. (2011). Systematic reviews and meta-analyses. *Journal of the Canadian Academy of Child and Adolescent Psychiatry, 20,* 57–59.

Vandenbergh, M. P. (2013). Private environmental governance. *Cornell Law Review, 99,* 134–137.

Vandenbergh, M. P., & Gilligan, J. M. (2015). Beyond gridlock. *Columbia Journal of Environmental Law, 40,* 217–303.

Wells, K., & Littell, J. H. (2009). Study quality assessment in systematic reviews of research on intervention effects. *Research on Social Work Practice, 19,* 52–62.

Whelan, M. E., Goode, A. D., Eakin, E. G., Veerman, J. L., Winkler, E. A. H., Hickman, I. J., et al. (2016). Feasibility, effectiveness and cost-effectiveness of a telephone-based weight loss program delivered via a hospital outpatient setting. *Translational Behavioral Medicine, 6,* 386–395.

Whitehead, A. (1997). A prospectively planned cumulative meta-analysis applied to a series of concurrent clinical trials. *Statistics in Medicine, 16,* 2901–2913.

Zhang, J. W., Piff, P. K., Iyer, R., Koleva, S., & Keltner, D. (2014). An occasion for unselfing: Beautiful nature leads to prosociality. *Journal of Environmental Psychology, 37,* 61–72.