DIFFUSION OF META-ANALYSIS, SYSTEMATIC REVIEW, AND RELATED RESEARCH SYNTHESIS METHODS: PATTERNS, CONTEXTS, AND IMPACT

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ABSTRACT

Laura Sheble: Diffusion of Meta-Analysis, Systematic Review, and Related Research Synthesis Methods: Patterns, Contexts, and Impact
(Under the direction of Diane Kelly)

Like collaboration and interdisciplinary scholarship, research synthesis methods are used to integrate science knowledge. Unlike collaboration and interdisciplinary scholarship, research synthesis is a scientific method researchers apply to systematically and explicitly integrate knowledge from primary research studies to estimate the best answer to a specific question based on accumulated research findings. This study investigates the diffusion and impact of research synthesis methods at the macro- and meso-levels. At the macro-level, diffusion from 1972-2011 is described using bibliometric methods. Relatively modest engagement with the methods in the 1970s and 1980s was followed by increased engagement across a greater diversity of fields in the 1990s. Engagement with the methods continued to increase and spread across fields through the first decade of the 2000s. Engagement with research synthesis methods was strongly correlated with engagement with evidence-based practice (ρ=0.893, $p < 0.001$) and the number of years a field engaged with the methods ($\rho = 0.706$, $p < 0.001$), moderately correlated with engagement with past research ($\rho = 0.403$, $p < 0.001$); and modestly correlated with Biglan class ($\rho = 0.279$, $p = 0.011$). Five fields, Evolutionary Biology, Conservation Biology, Social Work, Women's Studies, and Information and Library Science were selected for investigation at the meso-level. Content analysis, topic modeling, and qualitative summaries of literature at the intersections of these fields and research synthesis contextualize the diffusion process and reveal differences and similarities across field contexts. Bibliometric evaluation indicates that adoption of research synthesis contributes to changes in collaboration patterns: a greater number of authors contribute to research syntheses than research reviews in fields where collaboration on research reviews is low. This study provides some evidence that use of the methods has refined rather than replaced roles of traditional research reviews in Social Work; and illustrates interactions between innovations and use contexts. Innovations and their contexts are modified through adaptations influenced by historical contexts, values, and goals that intersect with the innovation use context.

To Kiyan, with love

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CHAPTER 1. INTRODUCTION

Like collaboration and interdisciplinary scholarship, research synthesis methods are used to integrate science knowledge. Unlike collaboration and interdisciplinary scholarship, research synthesis is a scientific method researchers apply to systematically and explicitly integrate knowledge from primary research studies to estimate the best answer to a specific question based on the accumulation of scientific findings. Additionally, research synthesis methods are often used with the intention of translating research-based knowledge for use in professional practice and policy contexts.

Following the development of contemporary procedures of research synthesis methods in the 1970s by psychology and education researchers, the methods, under the labels "systematic review" and "meta-analysis" became an integral component of the evidence-based practice (EBP) movement that revolutionized how research is done in the health and medical sciences. In psychology, research synthesis is credited with providing empirical procedures that enable cumulation of knowledge (Hedges, 1987). Diffusion of the methods has been driven in part by the EBP movement, and in part by beliefs in the benefits of the accumulation of scientific knowledge and consensus formation. Receptivity across science fields has varied.

Skeptics suggest limitations in how research synthesis is applied; restrictions related to the characteristics of studies that can be synthesized; and exclusion of experiential knowledge and professional expertise limit the integrative capacity of the methods. In fields in which research synthesis is the preferred method of research review, it may be argued that knowledge, evidence, and understandings gained through methods or processes that are not congruent with prevalent forms of research synthesis are at best, ignored; at worst, delegitimized.

The politics of knowledge notwithstanding, research synthesis has changed approaches to research integration within and at the boundaries of many fields of science. This is consequential for Information and Library Science because use of the method requires intensive use of information systems by researchers; and changes in research practices associated with the method may affect bibliometric patterns.

Past research has focused on adoption and use of research synthesis in specific fields, generally by members of those fields. Some researchers advocate use of research synthesis methods (e.g., Ankem, 2005; Garrett & Thomas, 2006; Madden & Paul, 2011; Rosenberg & Donald, 1995; Saunders, McDowall, & Rojon, 2011; Sutherland, Pullin, Dolman, & Knight, 2004; Urquhart, 2010; Whiston & Li, 2011), critique how research synthesis is implemented (e.g., da Silva, Santos, Soares, Franca, & Monteiro, 2010; Gates, 2002; Stewart, 2010; Tirilis, Husson, DeCorby, & Dobbins, 2011), and examine specific elements of the use of research synthesis, such as search and literature retrieval (Glanville, Lefebvre, Miles, & Camosso-Stefinovic, 2006; Krieger, Richter, & Austin, 2008; Whiting et al., 2011; Yoshii, Plaut, McGraw, Anderson, & Wellik, 2009) or implementation of meta-analytic techniques (e.g., Vetter, Rücker, & Storch, 2013). In the social sciences, there has been an ongoing effort to develop or adapt methods to enable researchers to synthesize findings of studies across diverse research traditions (Sandelowski, Voils, & Barroso, 2006; Strike & Posner, 1983; Suri & Clarke, 2009). Initiatives related to translational science focus on developing research synthesis methods to fit needs in practice and policy contexts.

In work focused on the impact of research synthesis, Murphy (2003) and DeGeest and Schmidt (2010) examined developments in the field of industrial and organizational psychology following adoption of psychometric validity generalization meta-analysis beginning in the late 1970s[1]; Miller and Pollock (1994a) analyzed the challenges and potential benefits of meta-analysis as an innovation in social psychology; and Boyle (2012) examined the transformation of research methods and research culture in complementary and alternative medicine (CAM) during the period in which the Office of Alternative Medicine (OAM)[2] and funding for complementary and alternative medicine were initiated at the National Institutes of Health (NIH). Cadotte, Mehrkens, and Menge (2012) found that in ecology, the number of papers, datasets, species, and range of publication dates has increased in meta-analytic studies over time; and that meta-analyses, when compared to papers in the same issue of the same journal, are written by larger groups of authors. About 15% of these authors were associated with a synthesis center (e.g., the National Center for Ecological Analysis and Synthesis, NCEAS).

Recently, a few comparative studies have been performed: Researchers in criminal justice (Wells, 2009) and social work (Lundahl & Yaffe, 2007) examined trends in the use of meta-analysis in their own fields versus that of others. Wells found adoption of meta-analysis in criminal justice was lagging that in psychology and sociology; and Lundahl and Yaffe found production and commentary on meta-analyses in social work lagged that of psychiatry, psychology, and nursing; but was similar to

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[1] Psychometric validity generalization (VG) meta-analysis is a type of meta-analysis "conducted to determine whether a particular psychological construct, test, or measure" is a valid predictor across a variety of contexts

[2] The OAM is now called the National Center for Complementary and Alternative Medicine (NCCAM).

family studies. Meanwhile, in the medical and health sciences, systematic reviews of systematic reviews (umbrella reviews or overviews) (Smith, Devane, Begley, & Clarke, 2011) have arrived (Moore & Jull, 2006), though there continue to be questions about the scalability of the systematic review approach as it is currently implemented (Bastian, Glasziou, & Chalmers, 2010), as well as whether different types of reviews and research syntheses are better for different purposes (Card, 2012; Dijkers, 2009; Gurevitch, Curtis, & Jones, 2001).

Purpose, Objectives, and Research Questions

The intent of this study is to describe the diffusion of research synthesis across science; examine and compare contextual factors within and across science fields that may influence adoption and lead to methodological adaptations; and investigate whether and how research synthesis has affected research practices as reflected in collaboration and citation patterns. This study was conducted in three stages, briefly outlined below.

Stage I: Diffusion of Research Synthesis Methods

While researchers have studied the use of research synthesis from the perspective of a number of fields at different times, how these pieces can coherently be placed within the broader context of the science system is unclear. Additionally, while past studies provide information about positive cases, those in which research synthesis is used; negative cases, fields that have not engaged with research synthesis, generally have been outside the scope of these studies. Therefore, in order to develop a broad overview of the diffusion of research synthesis, contextualize past research, and set the stage for more granular investigations, historical and developing trends in use of research synthesis methods across science are described and mapped at the macro level. This first stage is guided by the following research question:

RQ 1: When and to what extent has research synthesis diffused across fields of science?

Stage II: Contexts of Diffusion and Adaptation

Though we often describe patterns of diffusion at the macro level, the decisions to adopt and adapt innovations occur in specific contexts. In Stage II of this research, I investigate the intersection of a select number of fields and research synthesis in more depth. Goals of this stage are to refine estimates of diffusion and develop an understanding of the contexts of research fields as they relate to the extent and nature of diffusion and adaptation within the fields. Selection of fields for this meso-level examination of diffusion of research synthesis methods is informed by observations at the macro level. The four selected fields are paired within the biological and social sciences; and based on the extent to which research is typically more "pure" or "applied". A fifth field, Information and Library Science (ILS), was selected in advance because key research problems in ILS align with procedures essential to performing research synthesis, including literature search and retrieval and information organization and management. Three questions guide Stage II:

RQ2.1. To what extent has research synthesis diffused within the selected fields?

RQ2.2. How do field contexts influence adoption and use of research synthesis?

RQ2.3. What trends emerge when adoption and use are examined across science fields?

Stage III: Impact of Research Synthesis Methods

The intent of the third stage of this project is to assess the impact – or shifts in practice – associated with use of research synthesis methods. Two elements of scholarly communications are examined: collaboration patterns associated with producing reviews and syntheses; and use of published reviews and syntheses as reflected in citation patterns. Stage III research was guided by the following research questions:

RQ 3.1: How do research syntheses and traditional literature reviews differ in terms of the number of collaborating authors?

RQ 3.2: How do research syntheses and traditional literature reviews differ in terms of the extent to which they are used by researchers?

RQ 3.3 What do findings of RQ3.1 and RQ3.2 reveal when compared across science fields?

Significance

From an information and library science perspective, whether researchers in a given field use research synthesis methods and the contexts of their use are important for a number of reasons. Like traditional literature reviews, research syntheses often draw on and are intended to integrate past research. Research syntheses differ, however, in that research synthesis methods proscribe how researchers should approach "*communing with the literature*" (White, 1994, p. 43). While it is generally assumed that studies reviewed in traditional research reviews are selected based on researcher expertise and experience, research synthesis methods texts (e.g., Cooper & Hedges, 1994; Littell, 2008b) and guidelines (Sander & Kitcher, 2006) generally advocate systematic and transparent methods of (a) research literature search and retrieval and (b) research study selection. These differences have implications for information organization and management and are likely to affect researcher needs and expectations related to information resources and services. The importance of information infrastructures that support centralized access to literature (Bastian, et al., 2010; Eady, Wilczynski, & Haynes, 2008; Lukasik, 2000; Toews, 2011), and to a lesser extent, use of bibliometric approaches to facilitate literature retrieval (Harris, Beatty, Lecy, Cyr, & Shpiro, 2011) for the purposes of review and research synthesis has been recognized by researchers in their own fields. These topics have received some direct attention in ILS research (Chen & Chen, 2005; Dang et al., 2009; Hood & Wilson, 2001; Porter, Kongthon, & Lui, 2002; Small, 1986), and are strongly related to broader research interests in specialties that focus on information retrieval, scholarly communications, bibliometrics, and science literature visualization. ILS skills and research are relevant to the practice and continued development of the methods research synthesis. In the health sciences and medicine, ILS practitioners play key roles as consultants to and members of research teams that perform research syntheses (Beverley, Booth, & Bath, 2003; Harris, 2005; Knight & Brice, 2006; McKibbon, 2006; Shell, Hofstetter, Carlock, & Amani, 2006; Swinkels, Briddon, & Hall, 2006).

Increased use of research synthesis may affect construction, perceptions, and use of research reviews. To date, reviews have generally been treated as a relatively homogeneous type of publication in science literature studies, though this does not necessarily reflect perspectives across science fields. Traditional narrative reviews may be replaced by research syntheses; or writers of traditional reviews may selectively adopt characteristics of research synthesis. Finally, in some fields, researchers have suggested that secondary analysis of *data* collected in the context of multiple studies should be considered a type of research synthesis (e.g., individual participant data (IPD) meta-analysis, Cooper & Patall, 2009; Riley, Lambert, & bo-Zaid, 2010; Mengersen, Gurevitch, & Schmid, 2013), which suggests links with data archiving and curation research.

From another perspective, it is important for informetricians to know about use of research synthesis because widespread use of the methods may contribute to changes observed in patterns in the citation system (Persson, Glänzel, & Danell, 2004; Wallace, Larivière, & Gingras, 2009), including trends towards increasing levels of co-authorship (Cronin, 2001; Leahey & Reikowsky, 2008; Morris & Goldstein, 2007; Persson, et al., 2004) and shifts in how research is used and evaluated. In some fields, collaboration is considered beneficial to literature review and synthesis activities because (a) it enables triangulation between researcher evaluations of the relevance and quality of research, (b) the large scale of some research synthesis projects, and (c) needs for multiple types of expertise as it relates to topic-based knowledge and role differentiation associated with instrumental specializations. Review practiced as a collaborative research study differs substantially from the traditional notion of reviews as a genre dominated by expert researchers using the sole authorship model to share perspective as well as research-informed expertise (Peters & van Raan, 1994; c.f., Cooper, 1986) to "shape the literature of a field into a story in order to enlist the support of readers to continue that story" (Myers, 1991, p. 45).

Beliefs related to hierarchies of evidence that are based on research design, and expectations regarding the most appropriate types of research to reference may influence how researchers select papers to reference; and how those selections are evaluated by others. Examination of a set of National Institutes of Health funded grant proposals led Greenberg (2009) to suggest that researchers use citations to mobilize knowledge in support of proposal applications; and neglect or distort research findings contrary to proposed research. Greenberg found that through citation bias, some research may garner unfounded authority, which may distort understandings of what has been found through research. Additionally, changes in publication guidelines and standards made in part to accommodate the needs of researchers who perform syntheses (e.g., APA Publications &

Communications Board Working Group, 2008) or based on beliefs related to hierarchies of evidence, which often place systematic reviews at or near the top (see, e.g., Merlin, Weston, & Tooher, 2009), suggest that research synthesis may indirectly impact citation patterns (Bhandari et al., 2004; Montori, Wilczynski, Morgan, Haynes, & the Hedges Team, 2003; Patsopoulos, Analatos, & Ioannidis, 2005).

This study has the potential to contribute to diffusion research within ILS. There have been a few studies of diffusion processes across science at a broad level (e.g., Kiss, Broom, Craze, & Rafols, 2010), that focus on research methods (Tonta & Darvish, 2010) or topics related to research evaluation (e.g., Zhang, Thijs, & Glänzel, 2011), and that incorporate a comparative approach (e.g., Martens, 2011). This research seeks to focus these approaches on a topic that has had broad implications for research in a number of fields. By examining the impact – or outcomes of the use of research synthesis, conceptualized as shifts in practice when compared to reviews as measured by citations, I corroborate whether, to what extent, and how use of research synthesis methods is important from the perspective of the audience of research authors. Similarly, through examination of collaboration patterns, this study will provide evidence on whether and to what extent collaborative practices have shifted with the adoption of the methods. Focus on variation and outcomes in a comparative context provides the opportunity to examine how disciplinary cultures and practices moderate use and acceptance of research synthesis, and perhaps enables us to theorize how contextual factors limit and facilitate acceptance of this complex type of innovation.

Outside of ILS, a study of the diffusion of research synthesis methods is likely of interest to researchers and others who have engaged with use and development of the methods, those involved with the evaluation and publication of reviews, and researchers interested in scientific integration and synthesis more broadly. There has been relatively little research related to the diffusion of research methods and practices in general. The current research has the potential to add to this literature and further our knowledge of how methods diffuse, which may be of interest to methodologists more generally, as well as researchers in cognate fields engaged in complementary lines of research such as the sociology of social research (Leahey, 2008) and metaknowledge research (Evans & Foster, 2011).

CHAPTER 2. LITERATURE REVIEW

The literature reviewed below provides an overview of research synthesis, the diffusion of innovations, the conceptual framework that guides this inquiry, and the functions of research synthesis and traditional literature review in scholarly communications. Literature on research synthesis and diffusions is vast, and therefore I have selected research most relevant to my study. I have included a somewhat extended discussion of the historical development of research synthesis – which centers primarily on psychology and medical and health sciences, fields that contributed heavily to the early development of research synthesis – to contextualize the diffusion process and suggest important factors related to the diffusion of this family of methods.

Research synthesis

Research synthesis is a document-based empirical research method in which primary research reports are analyzed with the goal of generating new knowledge or interpretations. Research synthesis involves formulating a research problem, retrieving relevant literature, evaluating, analyzing, and synthesizing data, and interpreting the results. The importance of presenting and disseminating findings is often emphasized in research synthesis, and therefore reporting findings is considered the concluding step in the process of a synthesis. Generally, researchers engaging in research synthesis strive to adhere to transparent and systematic procedures (c.f., Noblit & Hare, 1988; Pawson, 2006). As with other research methods, study characteristics vary with the nature of the research questions, the goal of the study, and the epistemological and ontological orientations of those conducting the study. As a documentary method in which reports of previous research studies form the basis of evidence, the characteristics of a synthesis will be determined in part by the nature and extent of previous studies; and the availability and documentation of these studies in reports.

The "synthesist" (Cooper & Hedges, 2009) uses recorded research reports as surrogates for direct observation (Alvarez-Dardet & Ruiz, 1993). In a sense, documents serve as a bridge that affords the researcher access to the primary study, mediated by the researcher, documentary genre conventions, and systems that enable access to reports (Platt, 2006). Oxman (1994) likens the process of research synthesis to a survey: "In a review a question must be posed, a target population of information sources identified and accessed, appropriate information obtained from that population in an unbiased fashion, and conclusions derived" (¶13). Oxman's description highlights the similarity of the process of research synthesis to that of other methods of empirical research. A close examination will also reveal that research synthesis, like other methods, offers the researcher opportunities for creativity, and necessitates potentially difficult decisions.

Research syntheses are conducted for a variety of reasons. For example, research synthesis methods may be chosen for studies intended to build or examine theory based on existing evidence; map out research previously performed in an area in preparation for future research; support policy or professional practice development; or resolve questions related to ambiguous or conflicting findings across primary research studies. Studies that use research synthesis methods may be narrow and focused, or broad and exploratory in nature. A narrow, focused study might be performed to estimate a specific parameter of interest as accurately as possible based on existing evidence. A broader study might be conducted to explore variation in research findings, test competing hypotheses

(Chamberlin, 1890; Pawson, 2006), or develop theory (Lajeunesse, 2010; Miller & Pollock, 1994b; Pawson, 2006). Researchers have augmented syntheses with novel primary data collection. For example, in a study designed to compare three models purported to explain the relationship between negative mood and helping behaviors, Carlson and Miller (1987) incorporated assessments made by expert judges to examine the degree to which theoretical variables presented in models received empirical support in experimental contexts as documented in research reports.

Methods of research synthesis: Diversity and processes

In the case of research synthesis, epistemic and ontic beliefs are revealed by how the method is used, from criteria used to select primary studies, study evaluation or appraisal, analysis, synthesis (or interpretation), and presentation (or representation) of findings. Research syntheses that can broadly be described as post-positivist are prevalent in research fields such as medicine and psychology, which are also the most prolific producers of research syntheses. This tradition generally focuses on synthesizing quantitative evidence from primary research, though some studies incorporate qualitative research either through quantitative analysis of qualitative data, or by using qualitative findings to inform or structure the synthesis. Research synthesis methods developed for an interpretive perspective include Noblit and Hare (1988; Thorne, Jensen, Kearney, Noblit, & Sandelowski, 2004). Realist synthesis can be considered a third category. Realism is sometimes discussed as a "middle road" between post-positivist naturalism and relativism (e.g., interpretivism), perhaps because both quantitative and qualitative data are compatible with a realist perspective – though this is a simplistic view of realism (see, e.g., Elster, 2007; Hedström & Swedberg, 1998).

As these different types of research synthesis suggest, the method is continuing to be developed such that it may be more accurate to refer to research synthesis as a family of methods that a researcher may adopt in the context of research in which s/he believes analysis of data from reports of prior studies is likely to culminate in new knowledge or understandings of central interest to a question or problem. Across different types of synthetic studies, researchers generally strive for transparency; and develop an inquiry such that it may be described procedurally. Different approaches diverge in how procedural components are implemented, the nature and timing of steps, and other factors such as the degree to which the steps may be iterative. Table 1 presents research synthesis as presented by Cooper and Hedges (1994) from a post-positivist orientation; and Noblit and Hare (1988) from a meta-ethnographic interpretivist orientation. This presentation is intended to illustrate the processes of two select but diverse approaches to research synthesis in summary form. Similarity between (I) Cooper and Hedges (1994, 2009) and (II) Noblit and Hare (1988) may be traced in part to the influence of Cooper and Hedges on Noblit and Hare (Thorne *et al.*, 2005). However, similarities in processes across research synthesis methods are noted in methodological writings by several authors (e.g., Gough, 2004).

Table 1. Processes of research synthesis from two diverse perspectives

	I. Cooper and Hedges (1994)	II. Noblit and Hare (1988)
Steps of the research process	Problem Formulation Literature Search Data Evaluation Data Analysis Interpretation of Results Public Presentation.	Identification of a research interest; Deciding what is relevant to the initial interest; Reading studies; Deciding how studies are related; Translating studies into one another; Synthesizing translations; Expressing the synthesis.
Emphasis on iterative nature of synthesis?	To an extent. For example, refinement of problem based on findings in the literature search phase advocated.	Identification of relevant literature may be; analysis likely to be highly iterative.

	I. Cooper and Hedges (1994)	II. Noblit and Hare (1988)
Criticisms	Narrow range of research designs considered.	Literature selection purposive. If repeated, different results likely.

Historical overview of research synthesis

Historical accounts identify the 1960s and 1970s as critical to the development of research synthesis (e.g., Glass, McGaw & Smith, 1981). A turning point was reached when Gene Glass described the statistical analysis of findings from a large number of independent studies in a presidential address to the American Educational Research Association (Kulik & Kulik, 1988) and subsequently published two landmark papers. In the first, Glass (1976) discussed the difference between primary data analysis, secondary data analysis, and "meta-analysis", a term he coined to describe the use of statistical methods to examine the results of multiple compatible primary studies in combination and synthesize the data. The second paper, by Smith and Glass (1977), used meta-analytic techniques to adjudicate between conflicting opinions expressed in reviews about the relative efficacy of drug treatments alone versus drug treatments with psychotherapy for psychological disorders. In combination, these publications served to heighten awareness of meta-analysis (Kulik & Kulik, 1988). While Glass notes (Glass, McGaw & Smith, 1981) that others, including Robert Rosenthal and Light and Smith (1971), had been working with similar methods at the time, most prior work might be described as the "pre-history" of research synthesis though this might be due more to a lack of continuity, connection, and widespread awareness of other work rather than large conceptual differences between meta-analytic approaches and prior statistical analyses of primary research reports (see, e.g., Cochran, 1937; Leitch, 1958).

Two important types of early (pre-history) works that are frequently identified in histories of research synthesis include methodological advances – especially from statistics – and early reviews that used systematic approaches to literature review and integration. More recently, Bastian, Glasziou, and Chalmers (2010) provided a broader perspective of the history of "the development of trials and the science of reviewing trials" (p. 2) in medicine, which includes the development of information indexes and systems (e.g., *Index Medicus*, MEDLINE, trial registries), organizations (e.g., the Office of Technology Assessment (OTA), the Cochrane Collaboration, the Agency for Healthcare Research Quality Evidence-based Practice Centers (AHRQ - EPC)), regulations (e.g., Food and Drug Administration Amendments Act of 2007), and guidelines such as evidence hierarchies, practice guidelines, publication guidelines (e.g., MARS[3], JARS[4], MAER-Net[5]), and reporting standards (e.g., PRISMA[6], MOOSE[7], QUORUM[8]), in addition to landmark studies and publications.

Within science, diffusion of enabling technologies and techniques (Altman, 2000; Altman & Goodman, 1994) and reconciliation of epistemic beliefs with approaches to synthesis (Strike & Posner, 1983) influence the nature of research syntheses, and likely both the extent to which research synthesis methods are used and the importance of synthesis publications across fields. A secondary

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[3] MARS: Meta-analysis Reporting Standards (APA Publications & Communications Board Working Group, 2008).

[4] JARS: Journal Article Reporting Standards (APA Publications & Communications Board Working Group, 2008).

[5] MAER-Net: Meta-analysis of Economics Research Reporting Guidelines (Stanley et al., 2013).

[6] PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Moher, Liberati, Tetzlaff, & Altman, 2009).

[7] MOOSE: Meta-analyses Of Observational Studies in Epidemiology (Stroup et al., 2000).

[8] QUOROM: QUality Of Reporting Of Meta-analysis (Moher et al., 1999), replaced by PRISMA in 2009.

thread in the history of research synthesis is the impact these methods and the structures that support them do or ought to have on science practice. This is clearest in the context of publication guidelines. For example, one goal of the recent revisions to the *American Psychological Association* research reporting guidelines was to accommodate secondary analyses of aggregate findings documented in research reports (APA Publications & Communications Board Working Group, 2008). It has been suggested that wide-spread use of evidence hierarchies that identify meta-analyses and randomized control trials as the "highest" level of evidence (based on internal validity) influence citation patterns directly and through influence on article submission guidelines (Dijkers, 2009). Finally, Clarke, Chalmers, and others have repeatedly called for guidelines necessitating pre- and post-study systematic reviews to assess the contributions of each study (Chalmers & Altman, 1999; Clarke, 2004; Clarke, Alderson & Chalmers, 2002; Clarke & Chalmers, 1998; Clarke, Hopewell, & Chalmers, 2007, 2010).

Research synthesis is framed as having been developed in response to the failings of traditional literature reviews, and in some cases, rather than as an extension of them (c.f., Dickersin & Chalmers, 2010; Dijkers, 2009; Garfield, 1987; Mulrow, 1987). At least three themes recur in discussions of the emergence of systematic approaches to reviewing literature: (1) Pressures associated with increasing numbers of primary research publications (Chalmers, Hedges & Cooper, 2002; Glass, McGaw & Smith, 1981); (2) the roles of reputation and prestige (or "experience and expertise," Huth, 2009) versus more egalitarian or "fair" evaluations of research findings; and (3) episodic and systemic failures to achieve unbiased estimates of consensus, including for the purpose of communicating "the state of science" to inform policy and practice decisions (Chalmers, Hedges & Cooper, 2002; Glass, McGaw & Smith, 1981; Light & Pillemer, 1984; Light & Smith, 1971; Schulze, 2004).

A number of influential works were published in the 1980s (e.g., Hedges & Olkin, 1985; Rosenthal, 1984; "Statistics in Medicine," 1987; Yusuf, Peto, Lewis, Collins, & Sleight, 1985). Jointly, these publications contributed to the stature of quantitative research synthesis among statisticians (Chalmers, Hedges, & Cooper, 2002). Interest in use of research synthesis for policy decisions continued during the 1980s as well. In 1982, the Office of Technology Assessment (OTA) published a report that discussed the potential uses of meta-analysis and systematic reviews in assessments of health technologies. In 1983, the National Institute of Education published a collection of commissioned essays that explored the potential of secondary research studies to contribute to knowledge in education research, policy, and practice (Ward & Reed, 1983). A notable difference between Ward and Reed (1983) and the 1982 OTA publication is the stronger emphasis on the implications of diverse epistemologies and approaches to research in the context of integrative syntheses of primary studies and also a more integrated discussion of meta-analysis and research synthesis in education. Issues related to divergent research orientations would become important to the diffusion of research synthesis in other fields such as nursing and complementary and alternative medicine (Boyle, 2012).

Through the 1970s, 1980s and early 1990s, important developments occurred in the medical and health sciences that culminated in what was to become known as the evidence-based practice (EBP) movement. Archibald ("Archie") Cochrane is recognized for providing a vision for EBP inseparable from the methods used in medical research, first with his emphasis on RCTs,[9] and second, on systematic review of RCT findings[10] (Alvarez-Dardet & Ruiz, 1993; Chalmers, 2006). Just prior to the establishment of the Cochrane Collaboration, and the declaration of the evidence-based practice (and later, policy) movement (Evidence-Based Medicine Working Group, 1992), publications from two important high-profile lines of research were released, the *Effective Care in Pregnancy and Childbirth* (*ECPC*)[11] project (Fox, 2011; Mosteller, 1993) and a study on treatments for myocardial infarction (Antman, Lau, Kupelnick, Mosteller, & Chalmers, 1992). *ECPC* effectively advocated for and demonstrated the benefit of a systematic approach to review. The *ECPC* project, which was led by Iain Chalmers at Oxford, resulted in the two volume work, *Effective Care in Pregnancy and Childbirth* (1989), which contained "syntheses provided by scores of meta-analyses of randomized and quasi-randomized trials…" (Mosteller, 1993 p. 524); a companion guide to practice recommendations, and the Oxford Data Base of Perinatal Trials. In the myocardial infarction study, the authors were able to demonstrate the need for research syntheses through a comparison of textbook advice on treatment for myocardial infarction with results from systematic research syntheses (Chalmers et al., 2002). This research showed that "valid advice on some lifesaving treatments had been delayed for more than a decade, and other forms of care had been promoted long after they had been shown to be harmful"

[9] Cochrane, A. L. (1972). *Effectiveness and efficiency: Random reflections on health services.* London: Nuffield Provincial Hospitals Trust. Note: Cochrane also explicitly recognized that the RCT approach was not universally suitable for research.

[10] Cochrane, A. L. (1979). 1931-1971: a critical review with particular reference to the medical profession. In: *Medicines for the year 2000* (pp. 1-11). London: Office of Health Economics.

[11] Chalmers, I., Enkin, M., & Keirse, M. J. (1989). *Effective care in pregnancy and childbirth*. Oxford: Oxford Medical Publications.

(Chalmers et al., p. 21), with the implication that, for some patients, the cost of not performing clear and valid syntheses was premature death.

EBP catalyzed the diffusion of research synthesis methods. As observed by Lee, Bausell, and Berman (2001), the rapid increase in use of research synthesis in most medical and health sciences is readily apparent from a simple review of search results retrieved by queries for meta-analyses and systematic reviews in databases such as *PubMed* and the *Web of Science*. The high visibility and apparent success of EBP[12] fostered the development of evidence-based movements in other practice disciplines, including nursing, social work, and librarianship (Trinder & Reynolds, 2000). More than two decades later, it appears that the message of EBP still engenders initiatives in a widening spectrum of fields.

Publications that introduced research synthesis to wider audiences began to appear more frequently beginning in the 1990s. These included Lipsey and Wilson's (1993) critical assessment of over 300 quantitative syntheses on the efficacy of psychological, educational, and behavioral treatments; and Cooper and Hedges's (1994) *Handbook of Research Synthesis. Meta-Ethnography* by Noblit and Hare (1988) is generally recognized as the work that translated the concept of synthetic research methods to an approach congruent with an interpretive perspective.

Despite the apparent success of early studies, reports of research synthesis studies were not

[12] The "apparent success" of evidence-based medicine refers especially to the intersection of EBM research and research funding, policy, and interests of health insurers; as well as adherence to EBM principles by *segments* of researchers, which started from researchers associated with clinical epidemiology. Pope (2003) notes internal (within the world of research) and external power struggles rose with EBM approaches. Use of EBM knowledge in everyday medical work has met more resistance, in part due to tension related to the type of evidence EBM produces – findings with high internal (rather than external) validity at the group (rather than individual) level; but also because the "art" of medical practice is delegitimized.

immediately recognized as important research contributions on par with primary research. In 2002, Chalmers, Hedges, and Cooper described the acceptance of research synthesis in academia as follows:

> Over recent decades, research synthesis has been widely seen within academia as second class, scientifically derivative work, unworthy of mention in reports and documents intended to confirm the scientific credentials of individuals and institutions. Indeed, systematic reviews are sometimes characterized as "parasitic recycling" of the work of those engaged in the real business of science... (pp. 21-22)

Recent studies suggest that this is no longer the case in at least some medical and health science fields (Bastian, Glasziou & Chalmers, 2010; Dijkers, 2009). Acceptance and use of research synthesis in other fields appears to vary greatly, though may be greater in practice-oriented fields due to the association between research synthesis and EBP (Trinder & Reynolds, 2000) and the efforts of influential individuals and highly visible boundary organizations[13] (Cash, 2001; Guston, 1999,2001) that have been pivotal to the evidence-based movement. Other factors that may contribute to the growing number of studies that use research synthesis include the perception that syntheses can integrate relatively large or diverse bodies of knowledge; the identification of approaches that can be used to synthesize research across and within groups of studies aligned with different philosophical perspectives; and publications that examine or promote the potential of research synthesis methods within various disciplinary contexts (e.g., Dyba, Kitchenham, & Jorgensen, 2005 in software engineering; Okoli & Schabram, 2010, in information systems; Osenberg, Sarnelle, & Goldberg, 1999, in ecology; Rousseau, Manning, & Denyer, 2008 in management and organization science).

[13] Such boundary organizations include the Cochrane and Campbell Collaborations and the EPPI-Centre in the UK and health science programs in Australia, Canada, and more recently, the United States (Fox, 2011).

Functions of reviews and research syntheses

Generally, research synthesis is regarded as a relatively new form and method for literature review. Noguchi (2006) suggests that review articles serve as bridges between different audiences.[14] This metaphor is especially relevant in the case of reviews and research syntheses since they may be used to integrate previously unconnected lines of research (Leitch, 1958); aggregate and summarize prior findings (Leitch, 1958; Cooper, 1994; Major & Savin-Baden, 2010); translate ideas across disciplinary boundaries (Altman & Goodman, 1994; Noguchi, 2006), across language barriers (Gordon & Santman, 1981), between generalists and specialists (Cooper, 1986; Noguchi, 2006), across time (Price, 1963), into interdisciplinary contexts (Dijkers, 2009) and for new comers to a field (Luck, 1981).[15] Garfield, who often wrote about reviews and their functions, emphasized the role of reviews in literature discovery: "…every time an author makes a reference he is in effect indexing that work from his point of view. This is especially true of review articles…" (Garfield, 1955, p. 470).

It is important to consider how use of research synthesis may be contributing to changes in how reviews are written and used more broadly. While it has long been recognized that reviews serve many purposes, it is possible that the development of research synthesis, in effect, represents the emergence of the codification of different types of reviews and their associated functions – at least in some fields that have made extensive use of research synthesis. Discussion in research synthesis

[14] The bridge metaphor is conceptually similar to that of boundary objects (Star & Griesemer, 1989), though perhaps more specific with respect to how bridging documents are used: One would expect fewer differences in how a bridging document is used by different audiences compared to how a boundary document is used by different communities – based on the description of boundary objects Star and Griesemer (1989).

[15] Luck was central to the establishment of the Annual Reviews publishing organization.

methods texts (Card, 2012; Cooper, Hedges, & Valentine, 2009; Petticrew & Roberts, 2006; Sandelowski & Barroso, 2007) and on the roles and uses of traditional literature reviews and research syntheses (e.g., Dijkers, 2009; Hammersley, 2002; Sherman, 2009; Squires, 1989), suggests that this process, though underway in the medical and health sciences, has yet to stabilize. In these fields, this may be especially true in relation to reestablishing the legitimacy of some functions of traditional literature reviews. In other fields, it is less clear whether the distinctions between different types of research synthesis and reviews will be seen as helpful to achieving the goals of research and of research as it relates to practice and policy.

Recent citation analyses in several health and medical science fields seem to support the notion of different functions for different types of research syntheses and reviews. Though past research has shown that review articles tend to be more highly cited than other types of articles (Aksnes, 2003; Ketcham & Crawford, 2007; Moed & van Leeuwen, 1995; Moed, van Leeuwen, & Reedijk, 1996; Peters & van Raan, 1994), studies of health/medical literature indicate that systematic reviews (including meta-analyses) (Bhandari, et al., 2004; Montori, et al., 2003), and meta-analyses (Patsopoulos, et al., 2005) are more highly cited than other types of review. While this may be a reflection of (a) publishing recommendations for authors made available by journals or (b) beliefs about evidence hierarchies, differences do seem to exist.

Relationship between research synthesis methods and the diffusion and integration of research

Literature reviews research syntheses may serve different functions within science fields. One of the primary intentions of authors who write reviews (Cooper, 1988) and research synthesis (Cooper, Hedges, & Valentine, 2009) is to integrate ideas and findings of primary research studies. Integration is the process of bringing together a relatively disperse set of ideas and findings. In some ways, this can be viewed as analogous to other practices that bring together diffuse ideas, such as collaboration and interdisciplinary research. This observation is in accord with that of Rafols and Meyer (2010) as it relates to interdisciplinarity and integration; and Liu, Rafols and Rousseau (2012) on the relationship between diffusion and integration. Accordingly, in order to indicate the extent to which diffuse ideas are integrated in a review or synthesis, it seems appropriate to draw on measures designed to assess interdisciplinarity and outcomes of collaboration.

Diffusion of Innovations

Research in the tradition of the diffusion of innovations is focused on how innovations, which may be ideas, technologies, methods, convention, behaviors, or other definable entities, are communicated and spread from person to person across social systems over time. The diffusion paradigm is generally broadly construed, and may consider the spread of innovations across populations, in social networks, or at more granular levels such as across specific boundaries. As might be expected given the broad range of levels of interest, researchers affiliated with a range of disciplines engage in diffusion research. Rogers (2003) traces the emergence of diffusion research to Tarde's 1903 book, *The Laws of Imitation*, though many recognize the work of Ryan and Gross (1943) on the adoption of hybrid corn among Iowa farmers as the beginning of contemporary diffusion research. Following the work of Ryan and Gross, diffusion research itself was widely adopted in a number of fields, including rural sociology and epidemiology during the 1940s and 1950s. Greenhalgh, Robert, Bate, MacFarlane, and Kyriakidou (2005) credit the rapid diffusion of diffusion research to post-World War II beliefs in technology as a means to solve problems. Reviews of diffusion research by Rogers and

Greenhalgh and colleagues (Greenhalgh, Robert, Bate, et al., 2005; Greenhalgh, Robert, Macfarlane, et al., 2005) suggest that diffusion research may have been a case of 'multiple discovery' (Merton, 1996), which were brought together under the umbrella of the diffusion of innovations by Katz and Rogers in the 1960s (Rogers, 2003; Ruttan, 1996). Though Chatman, in 1986, wrote that diffusion research was "relatively new to the field of library and information science" (p. 377), by 2006, Case (2007) noted that the "diffusion paradigm" was one of the more prevalent frames in ILS research.

Examples of topics in studies of scientific fields from ILS and cognate fields that draw on the diffusion of innovations include communication practices among scientists (Crane, 1969; Garvey & Griffith, 1971), the development of research fields (Estabrooks et al., 2008; Valente & Rogers, 1995), use of research methods (Tonta & Darvish, 2010), resources (Chen, 2004; Shachak, 2006), and the spread of technologies and ideas in the science system (Chen & Hicks, 2004; Leydesdorff & Rafols, 2011a,2011b; Tonta & Darvish, 2010). In addition to these studies that explicitly draw on diffusion, it is possible to interpret many studies from ILS and cognate fields that focus on the spread of ideas and change within populations over time within the framework of diffusion. Such studies are especially prevalent in research that focuses on change represented in the scientific literature.

In document-centric work that focuses on the diffusion of ideas across populations, inferences about the relationship between people and ideas may be made based on observations of changes in how ideas are represented in documents. For example, McCain (2011) studied obliteration by incorporation (Garfield, 1975; Merton, 1988) in the context of the Nash Equilibrium. In this study, overall trends in the presence or absence of a reference for the Nash Equilibrium concept varied over time and by field, though an overall trend towards omitting a reference for the concept was not observed. Hilgartner (1990) examined changes in how a broad estimate of the relationship between diet/nutrition and cancer presented in the highly publicized review *Causes of Cancer*[16] was represented in popular, scientific, and professional media. Across these contexts, there was the tendency to simplify the estimate such that it was represented as more certain and precise than was indicated in the original report. Littell (2008a) observed similar patterns in how results of a trial intervention were reported in reviews. Small (1978) discusses the use of highly cited Chemistry articles to symbolize concepts by the group of authors who cite them, a process that may emerge through convergence on meaning after an article is referenced many times (Elkiss et al., 2008) – or may result from other related factors or features of the articles studied.

Defining diffusion

Rogers (2003) defines diffusion as "the process in which an innovation is communicated through certain channels over time among members of a social system" (p. 5). The four main elements of interest to classic diffusion researchers are, as indicated in the above definition: (1) the innovation; (2) communication (over certain channels); (3) time (and diffusion decisions and processes); and (4) individuals in a social system. In diffusion studies, researchers typically investigate a subset of these elements. Another way to frame diffusion research is through the specification of dimensions of difference in relation to social, cognitive (or psychological), spatial, temporal, cultural-institutional, and organizational space (Boschma, 2005; see, e.g., Leydesdorff & Rafols, 2011c for an application of this approach in information science). This frame may be especially valuable to studies concerned

[16] Doll, R. & Peto, R. (1981). The causes of cancer: Quantitative estimates of avoidable risks of cancer in the United States today. *Journal of the National Cancer Institute, 66*(6), 1192-1308.

with the diffusion of innovations across populations. The discussion below draws on a combination of these frames of reference.

Innovations

Rogers (2003) identifies six innovation attributes that contribute to increased rates of adoption: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, (5) observability, and (6) reinvention potential. According to Rogers (1995, in Rogers, 2003), the first five of these attributes account for 49% to 87% of the variance in rates of adoption. Of these, relative advantage, compatibility, reinvention potential, and by extension, complexity are most central to my interests.

Relative advantage

Relative advantage is the degree to which an innovation is perceived as better than the idea it supersedes. The ultimate relative advantage of an innovation is the potentially complex set of attributes that relate to the relative costs and benefits of adoption and use of an innovation. Relative advantage may be considered according to the extent to which an innovation is (a) perceived as better than its precursor; and (b) perceived as useful for a given purpose (Moore & Benbasat, 1991). Additionally, an innovation may be considered better because it is perceived to be more economic or efficient or because it is believed to contribute positively to social image or prestige (Strang & Soule, 1998; Yuan & Woodman, 2010). Low initial investment requirements and immediacy of rewards may further contribute to the likelihood of adoption.

As an innovation, research synthesis has received mixed reviews with respect to its relative advantages over traditional literature reviews. Proponents generally emphasize the relative advantages of the outcomes of research synthesis: findings are believed to be more objective, transparent, and representative of the work of a field related to a stated problem or question (e.g., Mulrow, 1994). Other advantages include that researchers are directed to focus on what researchers actually did – through close engagement with the findings of research – rather than what researchers say they did, as one might if focusing on conclusions or discussions (Cooper & Rosenthal, 1980). Potential advantages include the ability to account for publication bias (Ferguson & Brannick, 2011; Rothstein, Sutton, & Borenstein, 2005), and providing a framework for study inclusion criteria. The latter may be especially important for interdisciplinary reviews (White, 1996). Distinct disadvantages generally accorded to research synthesis include the time and resources necessary to conduct them and the length of time required to establish confidence in findings through the accumulation of studies and their subsequent analysis (Kissin, 2010). Syntheses that include meta-analyses are often perceived as technically complex and therefore challenging for both readers and researchers.

Compatibility, complexity, and reinvention potential

Compatibility, complexity, and reinvention potential comprise three closely related characteristics of innovations. Compatibility is the degree to which an innovation is perceived as being consistent with existing values, norms, beliefs, past experiences, and perceived needs of potential adopters (Rogers, 2003). Complexity, the degree to which an innovation is perceived as difficult to understand and use (Rogers, 2003), may be considered on multiple dimensions, including (a) cohesiveness or divisibility, (b) the heterogeneity and number of users or groups of users involved in adoption; (c) the sophistication or level of intellectual difficulty associated with the innovation; and (d) radicalness, or the extent of change or difference introduced by an innovation (Pelz, 1985). The extent to which the components of an innovation are cohesive, or how easily they are separated may influence how completely an innovation is adopted, or the extent to which it is changed during the implementation process (Pelz, 1985). Denis, Hébert, Langley, Lozeau, and Trottier (2002) argue innovations are complex packages composed of an irreducible hard core of essential elements plus multiple layers of technologies and knowledge. The boundaries of the innovation are fuzzy, and feature a 'soft periphery' of supporting structures and systems at the interface between the innovation and its use context. In a given context, the essential elements of the innovation are kept intact, and others translated (Latour & Woolgar, 1986) and edited (Shalin & Wedlin, 2008) to fit the needs of the use context. Carlile (2004) differentiates between transfer, translation, and transformation based on the degree of difference, dependence, and novelty associated with an innovation as it crosses a boundary from one use context to another. These concepts related to how an innovation or idea is changed present a different perspective of reinvention, which Rogers (2003) defines as change or modification by a user in the process of adoption and implementation; or the degree to which an individual's use of a new idea departs from the core or main version of an innovation (i.e., "fidelity"). The term "adaptation" may also be used in studies that emphasize the heuristic process of negotiating and distributing changes between the use context and the innovation. Ansari, Fiss, and Zajac (2010) suggest technical, cultural, and political factors influence the adaptation of practice in organizational settings.

Communication

Communication is the second element of diffusion emphasized by Rogers (2003). Researchers may look at the content, channels, and other attributes of communication that are thought to be of importance in a particular diffusion process. Communication may be considered in terms of mass media versus interpersonal communication, or communications that are external or internal to a social group (for an overview of mathematical diffusion models focused on internal and external communication, see, e.g., Sultan, Farley, & Lehmann, 1990). On another level, the affordances of different modes of communication might be considered (Schramm, 1973). From a strong informational perspective, communication could be interpreted as an individual's attendance to, acquisition, and interpretation of any of diverse types of information within an environment (e.g., Brookes, 1980; Yu, 2011).

In studies of science, it is common to distinguish between formal and informal communications; and between communication and collaboration networks. Informal structures can be thought of in terms of interpersonal communication networks. Formal communications, however, are generally operationalized in terms of citation patterns. It should be noted, however, that references are generally made for a variety of reasons (e.g., Bornmann & Daniel, 2008; White & Wang, 1997), and should therefore be considered rather coarse indications of relationships. Additionally, scientists interested in the same topic may approach the topic from a different perspective, or be associated with different disciplines, and may not cite each other's work.

Genuis (2005) suggests that a publication can be considered a vehicle for the formation of weak ties between scientists; and others (e.g., Tonta & Darvish, 2010) have considered co-authorships signs of relatively strong ties. While it is common practice to discuss relationships – or ties – between individuals categorically as strong or weak, this dichotomous characterization is a simplification of continua of observed states. In some cases, the strength of a tie is represented using weighted edges in a network, which may provide a more descriptive assessment of the frequency or importance of communication and information exchange. The position of a paper within the network of citations may also be associated with the reception of ideas presented in the paper.

Diffusion of ideas over multiple dimensions of distance: Diffusion across populations

Degrees of distance between individuals moderate the accessibility and effectiveness of communication. Broadly, differences along distance dimensions can be collapsed into the concepts of homogeneity and heterogeneity, both of which are integral to a given diffusion process. To an extent, homogeneity ensures effective communication (Rogers, 2003; Weenig, 1993), but heterogeneity or distance is important to the introduction of ideas (Granovetter, 1973,1983), to overcome deficit thinking (Medin, Bennis, & Chandler, 2010), and is necessary for the development of novel combinations of ideas (e.g., Swanson, 1986; Upham, Rosenkopf, & Ungar, 2010). Ideas of individuals who bridge heterogeneous groups may be especially well received (Burt, 2004). At a more granular level, distance may be defined based on a number of interrelated (Trope & Liberman, 2010) dimensions, including spatial, cultural, organizational, social, cognitive or psychological, and temporal dimensions.

Spatial distance

Spatial distances, often discussed in terms of geographical distances, have been found to be an important factor related to the rate and extent of diffusion (Frenken, Hardeman, & Hoekman, 2009). Spatial proximity based on immediate (e.g., Cronin, 2008; Cronin & Shaw, 2007; Hillier & Penn, 1991), local (e.g., Jaffe, Trajtenberg, & Henderson, 1993), national (e.g., Börner, Penumarthy, Meiss, & Ke, 2006), and international (e.g., Leydesdorff & Rafols, 2011c) scales moderates the diffusion of ideas. In some cases, the effects of spatial distance appear to be diminishing (e.g., with respect to collaboration relationships (Jones, Wuchty, & Uzzi, 2008; Yan & Sugimoto, 2011).

Cultural distance and institutions

Cultural distances, defined here as including institutional distances (the inverse of Boschma, 2005, who included cultural distances in institutional distances), relate to political geographies (Lancho Barrantes, Guerrero Bote, Rodríguez, & de Moya Anegón, 2012), language (Liu, 1997), trends in use of research published in different languages (Manten, 1970), political (or power) differences (Bourdieu, 1988; Evans, 2005; Frickel & Gross, 2005; Leahey, 2002); and also behavioral norms that may compel compliance or engender assimilation based on cultural- (e.g., Wouters, 1999) and role-based identification (March, 1999). An example of the latter might include the assumption of different authorial roles, which leads to variations in writing and referencing practices (White & Wang, 1997).

Organizational distance and organizations

It can be useful to conceptualize science fields as loosely coordinated organizing structures; or as consisting of actors with multiple organizational affiliations (Chubin, 1976) such as memberships or affiliations with publishing bodies, professional associations, employing institutions, funding bodies, practice constituencies, and so on. The extent to which these organizational units are formalized varies. It may be helpful to consider organizations as structures that at least to an extent, persist such that they may be recognized as units independent of specific individuals. Using this definition, organizations may or may not be legally defined as such, but are at least recognized by members and non-members as cohesive bodies with defined functions and modes of operation. The notion of organizational distance can be conceptualized as distances between organizational units, which may be indicated categorically or through measures of other distances centered on the organization.

DiMaggio and Powell (1983) argued that diffusion often occurs through mimesis, with organizations adopting new ideas based on observations of prior adoption decisions of others with whom they identify or seek to emulate. This may be referred to as a contagion effect. Processes related to mimicry can be understood as either non-rational bases of decision-making, or decisions based on a different logic of rationalization. Abrahamson (1991) noted that in the business environment, adoption of management innovations does not necessarily reflect the efficacy of the adopted approach. It is possible for innovations that would be effective to fail; and for innovations that are not especially effective to be widely adopted. Abrahamson suggests that these behaviors can be explained based on mimicry ("fads") and also through limits on available options imposed by third parties ("fashions"). Though contagion effects and rational decisions made based on the "goodness" or suitability of an innovation to a context are often presented as contrasting mechanisms through which adoption occurs, in at least some cases, these may work in concert as innovations diffuse (Strang & Macy, 2001).

Social distance

Social distance is most often operationalized in terms of social structure or networks. Social relationships might be considered in terms of acquaintanceships, friendships, advice networks, and so on. In studies of science, measures may include reports of social proximity and relationships based on co-author and contribution relations (e.g., Cronin, Shaw, & Barre, 2004; Pepe, 2011). Pepe (2011) found that there is a strong overlap between author collaborations and acquaintanceships. Boschma (2005) emphasizes social embeddedness, which underscores the interrelated nature of spatial (Collins, 1974;

Duguid, 2005; Leahey, 2006; Polanyi, 1966), cultural (Emirbayer & Goodwin, 1994; Pachucki & Breiger, 2010), and social distance dimensions.

Cognitive distance

Conceptually, it is possible to distinguish between social relationships and cognitive interest-based affiliations in a social network. Topical focus is a type of intellectual affiliation, or alignment with a research field; and collaboration a working group-based social affiliation. Individuals who are connected via collaboration-based affiliations may or may not have the same intellectual interests. The extent to which they do is likely related to the extent of role differentiation and specialization in a collaborative group. Cognitive similarity is often assessed using measures of conceptual similarity, deduced, for example by co-occurrence of terms or sets of terms in documents (Callon, Courtial, Turner, & Bauin, 1983; He, 1999).

Interrelationship of social distance and referencing behaviors

The relationship between social relationships and referencing behaviors evident via citation analysis is somewhat unclear. White, Wellman, and Nazer (2004) found that referencing behaviors and social relationships differed in an analysis of an interdisciplinary group of scholars; while a study of referencing patterns associated with three information scientists offers some evidence of an association between social relationships and reference behaviors, strongest at a dichotomous level (having met someone versus not having met someone, (Johnson & Oppenheim, 2007). A study of bibliometricians found subtle positive correlations between social closeness and positive assessments of an author, work quality and publication venue; and negative correlations with low assessments of work quality, contradictory perspective, and use of old methods (Case & Miller, 2011). The extent and direction (i.e., whether positive assessments of work lead authors to seek out social ties, or whether social ties lead to increased rates of citation) of the association between social closeness and referencing behaviors is unclear (Case & Miller, 2011).

Temporal distance

Temporal distance is a primary interest in diffusion studies. Many early diffusion studies were performed with the intention of learning how to increase the speed of adoption of innovations (Rogers, 2003). Time may also be observed in terms of lags in the diffusion process, from awareness of (or exposure to) an innovation to adoption or rejection. Temporal distance also has a unique role in the context of document-based studies. Recorded communications are preserved over time, which extends the life of messages encoded in documents, though interpretations and use (Larivière, Archambault, & Gingras, 2008) of these messages may vary over time, and other factors.

Preservation of access to recorded information over time is, of course a central function of libraries, archives, and other types of repositories (e.g., Furman & Stern, 2011); and in fact, one that may be viewed as rising in importance compared to functions of these organizations in bridging access over spatial distances (Neavill, 1984). In this capacity, information service organizations function as boundary organizations (Cash, 2001; Furman & Stern, 2011; Guston, 1999,2001). Boundary organizations facilitate disclosure and access (Murray & O'Mahony, 2007) to information across distances, dimensions, and scale (Cash, 2001; Cash et al., 2006), and thereby contribute to the coordination of individual and group interactions with information resources, enabling use, and also contributions to knowledge production (Cash, et al., 2006; Furman & Stern, 2011) and accumulation (Murray & O'Mahony, 2007).

Innovation decisions

Rogers (2003) identifies five stages in the innovation-decision process that an individual may go through from the time s/he becomes aware of an innovation to eventual adoption or rejection: (1) knowledge; (2) persuasion; (3) decision; (4) implementation; and (5) confirmation. Additionally, a sixth step (6) discontinuance may be observed after an innovation has been adopted. The innovation-decision process model may be more appropriate to adoption of simple innovations by individuals and does not neatly transfer to other contexts such as with complex innovations and organizations. Based on cumulative evidence from a number of studies, Greenhalgh, Robert, Bate, *et al.* (2005) contend that innovation adoption, at least in organizational settings, should not be thought of as a linear process, but as a process of assimilation that consists of 'key observations' (e.g., initiation, development, and implementation or termination) that are not necessarily sequential, coordinated across the organization, or unidirectional. There may be triggers that propel or stall sets of decisions and action sub-processes. In the case of science, intellectual turning points (Chen, 2004; Kuhn, 1970) are triggers that propel research in new directions. Sherman (2009) draws on historical cases (e.g., James Lind's scurvy research) to suggest that research syntheses may be used to aggregate and preserve accumulated research knowledge for use, such that integrated findings are available once the social context is amenable to the application of this knowledge. While it is likely that in some cases, social, technological, and other types of change undermine this potential function of syntheses, Sherman's observations suggest research syntheses may support nonlinear innovation.

Consequences of innovation diffusion

Consequences of innovations are considered to be the changes that occur to an individual or a social system as a result of the adoption or rejection of an innovation (Rogers, 2003; Wejnert, 2002). Consequences may be the result of the complex and often unpredictable interactions between innovations and individuals embedded in a social and cultural context. Consequences can be framed in terms of effects within an innovation-diffusion process, for example, the consequences of additional adoptions of an innovation on other innovation adoption decisions; or in terms of how the adoption of an innovation affects use of other innovations or changes other aspects of interacting systems. Concepts related to the former include information cascades, tipping points, critical mass, the Matthew effect (Merton, 1968). In the context of research synthesis, displacement of use of traditional literature reviews or differentiation of functions and roles based on different genres of review may be a consequence of diffusion.

Epidemiological analogies for the spread of ideas

Goffman and Newill's (1964) application of an epidemic model to the spread of ideas is sometimes categorized as belonging to the larger body of diffusion research (Glänzel, 2003; Greenhalgh, Robert, Bate, et al., 2005) and sometimes as an independent set of ideas (Tabah, 1999). Goffman and Newill (1964) argued that ideas might be likened to infectious agents that are harbored in infected hosts, and therefore amenable to analysis using compartmental epidemiological S-I-R (susceptible – infected – removal) type models (see, e.g., Diekmann & Heesterbeek, 2000). Though Goffman and Newill proposed that their approach might be applicable in diverse circumstances (e.g., the spread of ideas generally, social problems, accidents, etc.), the discussion here is limited to the spread of ideas in science communities, which was the main focus of their paper. In the proposed analogy, infected hosts (authors) harbor ideas (the infectious material), which are transmitted via vectors, such as journal articles. As others in the specified population are exposed to the idea, some would be susceptible, and after a period of latency, might become infectious agents themselves. Others would be resistant to the virulent idea. Goffman and Newill refer to these as "removals". Of special interest to Goffman and Newill is the spread of the idea over time, and the ability to describe, predict, and promote (via information retrieval systems) epidemics. Epidemics, in this case, were thought to be a positive outcome for ideas. Recent applications of epidemic models to information diffusion include Bettencourt, Kaiser, Kaur, Castillo-Chavez, and Wojick (2008); Gurley and Johnson (2011); and Kiss, et al. (2010). In recent years, epidemiologic models have increased in complexity (Colizza, Barthelemy, Barrat, & Vespignani, 2007). Parameters to estimate the impact of heterogeneity in populations and across subpopulations, as well as to estimate behavioral responses (Funk, Salathe, & Jansen, 2010) are becoming more frequent (c.f., Ferguson, 2007).

Import and export of ideas: An economic analogy

Cronin and Davenport (1989) and Cronin and Pearson (1990) applied the idea of import and export from economics to characterize the extent of independence and dependence of a discipline on – or from – other disciplines. The authors argue that disciplinary robustness is reflected in the ratio of imports to exports, such that disciplines that import more ideas than they export are more dependent, and therefore more vulnerable. Disciplines that export more than they import, on the other hand, are characterized as more independent and robust. The import-export analogy has been used to describe disciplinary relationships in a number of studies, which have used authors (e.g., Cronin & Davenport, 1989; Cronin & Pearson, 1990) or journal sets (e.g., Cronin & Meho, 2008; Sugimoto, Pratt, & Hauser, 2008) as the basis of data selection and journal titles as the basis of disciplinary classification.

The import-export analogy emphasizes the importance of communication among disciplines, and therefore whether ideas spread across field boundaries. A ratio of intra-disciplinary citations to citation imports would seem to more closely reflect the idea of autonomy, which has been stressed as important to the establishment of disciplines (Bourdieu, 1988; Whitley, 2000). The export of ideas might indirectly be related to autonomy if, for example, the export of ideas contributes to disciplinary prestige and therefore has an impact on the ability of members of a discipline to secure resources. Cronin and Meho (2008) caution that interpretation of import-export ratios is not straight forward, and that the context of a field should be considered. Other interpretations of the importance of the export of ideas have included centrality with respect to a topical area (Grover, Ayyagari, Gokhale, Lim, & Coffey, 2006) and impact or influence of one discipline on another (Sugimoto, et al., 2008).

The import-export analogy could be expanded to develop a greater understanding of the division of labor within science. The notion of complementarity (Bonaccorsi, 2010) between fields suggests that the types of research contributions one field makes to another – for example, whether it exports instrumental, technical, theoretical, or other work, and how the importing and exporting fields benefit from this interaction is potentially an important consideration (Strathman, 1992). This type of influence would not be captured by a between-fields citation analysis alone, but work by Grover *et al.* (2006) and Strathman (1992) demonstrate that content analysis can contribute to such an understanding.

Scientific and Intellectual Movements (SIMs Theory)

Social movements in the context of science have been tied to diffusion theory by Scientific /

Intellectual Movements (SIMs) theory (Frickel & Grosse, 2005). SIMs are "collective efforts to pursue research programs or projects for thought in the face of resistance from others in the scientific or intellectual community" (Frickel & Gross, 2005, p. 207). SIMs theory seeks to explain the emergence of new forms of knowledge production. Such knowledge production is seen as contentious, political, and dependent on the availability of resources and collective action. Participation of high-status intellectual leaders, structural conditions that provide access to key resources, and access to micro-mobilization contexts may facilitate SIMs. Success is dependent on the ability of participants to frame ideas "in ways that resonate with the concerns of those who inhabit an intellectual field or fields" (p. 207). The theory focuses on the ephemeral process of emergence and early stages of diffusion.

The SIMs theory is notable in that unlike Bourdieu (1998) and Collins (1974) who emphasized the need for scientists to seek recognition over intellectual interests, Frickel and Gross (2005) identify intellectual interests as the primary motivation for early proponents to engage in the development of a SIM. Strategic interests may also play a part, but at least in some cases, reward seeking does not sufficiently motivate a scientist to align with an uncertain idea given the risks. Similarly, though research is characterized as socially contingent (Barnes, 1974; Bloor, 1991), SIMs theory explicitly recognizes the importance of intellectual content.

SIMs enriches diffusion concepts in the context of science through emphasis on the special context of science and knowledge production contexts; recognition of the agentive capacity of individuals and collectives; and through theoretical explanation of why observed patterns occur. In past research, Information and Library Science researchers have drawn on SIMs theory (e.g., Nolin & Åström, 2010). More broadly, SIMs theory has been used to explain how science communications may contribute to the dynamics of research fields (e.g., Meyer & Schroeder, 2009; Reinhardt, Hofer, Arenz, & Stucki, 2007; Vanderstraeten, 2011).

CHAPTER 3. STAGE I: DIFFUSION OF RESEARCH SYNTHESIS METHODS

The primary goal of the first stage of this study was to identify and describe when and to what extent research synthesis methods (RSM) have been used in and across science fields. Research at this stage was guided by the first research question:

RQ1: When, and to what extent has research synthesis diffused across fields of science?

A secondary goal of the first research stage is to inform selection of fields for study at a more granular level through examination of factors related to the extent and nature of research synthesis use within fields. These factors include:

- the extent to which resources are dedicated to literature review;
- the extent to which a field engages with EBP;
- the diversity of research synthesis methods used; and
- whether a field is more "pure" or "applied" in nature.

Definitions

Science fields are dynamic culture-bound socio-cognitive spaces (Whitley, 2000) held together by cohesive forces reflected in values, norms, beliefs, and practices (Bourdieu, 1988,2004). Multiple, overlapping field boundaries can be identified at different scales based on field interactions and attributes, such as those associated with collaboration and competition for resources, publication, and job markets; institutionalized training units (Chubin, 1976); and communications (Hyland, 2004; Swales, 2004).

In order to operationalize the concept of science fields, it is helpful to consider that research synthesis, like traditional literature review, may have multiple functions and may be written for a variety of audiences, including generalists and specialists, practitioners, students, policy makers, and the general public (Bruce, 1994; Cooper, 1988; Grant & Booth, 2009; Khoo, Na, & Jaidka, 2011; Noguchi, 2006; White, 1992). Based on these observations and the quantity of data required for this study, two category systems developed for Thomson's *Web of Science / Knowledge* (*WOS*) products were used to operationalize science fields. The broader Research Areas (SU) were used to aggregate data for the majority of analyses. For analysis of the diversity of fields that have engaged with research synthesis over time, the narrower *Web of Science* Categories (WC) were used in order to make use of existing tools and data sets.

The *Science and Social Science Citation Indexes* (*S/SCI*) *Web of Science* Categories (WC) divide science into overlapping categories based on journal title. The classifications are indicated in individual publication records in the *S/SCI*, and in the *Journal Citation Reports* (*JCR*). The WCs have been used extensively in bibliometric research, and provide access to socially meaningful divisions amenable to larger scale representations (e.g., Rafols, Porter, & Leydesdorff, 2010).

The newer Research Area classification system appears to draw substantially from the *Web of Science* Categories. There are just under two-thirds as many Research Areas as *Web of Science* Categories, and therefore data visualization and description requires fewer elements, though there is some loss of granularity. Appendix A presents a comparison of the two systems. In some cases, it was helpful to aggregate Research Areas into larger 'field groups,' which was done in consultation with Thomson-Reuters *Essential Science Indicators* and Research Area support information available via the Thomson Reuters website.

Research synthesis methods are research methods in which primary research findings are analyzed in a transparent and, generally, systematic manner, with the goal of generating new knowledge or interpretations. This study focuses on document-based research synthesis methods (c.f., Sidlauskas et al., 2010). A number of terms are used to indicate research synthesis methods "sub-types". Systematic review, integrative research review, qualitative research synthesis (Major & Savin-Baden, 2010); meta-ethnography (Noblit & Hare, 1988); systematic research synthesis (Gough, 2004); best evidence synthesis (BES) (Slavin, 1995); and realist synthesis (Pawson, 2006) are examples of sub-types of research synthesis. In the literature, "meta-analysis" has often been used to denote the composite process of a research synthesis. Conceptually, I define meta-analysis more narrowly as the statistical methods used to combine quantitative data across studies, an analytic technique that may be used within a research synthesis. This usage follows the original definition of meta-analysis proposed by Glass (1976).

Research synthesis was operationalized via a set of query phrases (Appendix B) and seed publications (Appendix C) used to search the *Science* and *Social Science Citation Indexes* (*S/SCI*). The query phrases were used to search the topic index, which includes title, abstract, author keywords, and "Keywords Plus™"[17] fields. The cited reference search feature in the *Web of Science* was used to search for records of publications that reference the selected seed publications. Appendix D provides details on the development of the search strategies. Search results identified with the keyword and

[17] "Keywords plus™" are keywords identified through text processing of the titles of referenced publications (Garfield & Sher, 1993).

cited reference search strategies were examined empirically to understand the relative effectiveness of the strategies within and across science fields.

Diffusion, in the tradition of the diffusion of innovations, is focused on how innovations, which may be ideas, technologies, methods, conventions, behaviors, or other definable concepts, are communicated and spread from person to person across social systems over time (Rogers, 2003). In some respects, diffusion can be viewed as the inverse of integration. Innovations diffuse along cognitive, organizational, social, institutional, and geographical dimensions (Boschma, 2005).

Diffusion is described by identifying when and to what extent science fields have used research synthesis using visual and quantitative techniques. Two measures describe when research synthesis methods (RSM) engagement began; and two the extent of research synthesis methods engagement:

1. When RSM engagement began
    a. Year of earliest RSM publication within each Research Area[18]
    b. Year in which continuous RSM publication began in a field (i.e., at least one RSM publication appeared in each subsequent year).
2. Extent of RSM engagement
    a. Total number of RSM-related publications
    b. Proportion of RSM-related publications to all publications from (1972) to 2011.

Additionally, the diversity of fields that engaged with RSM over time was examined. Diversity

[18] In order to minimize the influence of early false positives, including from cross-classification, for the "first" publication to be counted, one additional publication needed to be published within two years of the first. If this was not the case, the first publication year for which this is true was counted.

was operationalized using three measures described by Rafols and Meyer (2010). These measures depict three aspects of diversity: variety, balance, and similarity (Stirling, 2007). Variety refers to the number of science fields (WC's); balance, the distribution of publications across fields; and similarity, the extent to which fields are cognitively similar. Accordingly, counts of the number of fields were used to indicate variety; Shannon evenness was used to indicate balance, and a cosine-normalized citation index derived from the 2010 *Journal Citation Reports* (*JCR*) (Leydesdorff, Carley, & Rafols, 2013) was used to calculate average cognitive dissimilarity across the network. Time was aggregated into five-year periods. *Web of Science* Categories rather than Research Areas were used to distinguish fields in order to make use of existing analysis techniques (Chavarro, 2011; Rafols & Meyer, 2010).

Review publications critically assess prior research in a given area. Reviews vary in the extent to which they are comprehensive, explicitly or implicitly include expert opinion, and breadth and depth of coverage. Reviewed literature may be selected based on expert judgment, through sampling procedures, and systematic collection using defined search strategies (e.g., as suggested by Bates, 1992). Reviews include research syntheses such as systematic reviews and other types of reviews such as narrative reviews, historical reviews, and so on.

Publications with records that include "Review" in the *S/SCI* Document Type field are considered reviews. At this stage, no attempt was made to disambiguate reviews and research syntheses. Research syntheses may or may not be classified as reviews in *S/SCI*. In the *S/SCI*, publications are classified as the document type review "if they are either published in a review journal or include 100 or more references along with some indicator that the article is a review, such as the word "Review" or "overview" in the table of contents or in the article itself" (Thomson Reuters, 2009, p. 7). The definition operationalized by Thomson Reuters differs somewhat from others (e.g., MeSH) and as conceptualized by, for example, journal editors (Ketcham & Crawford, 2007), but seems to be generally in agreement with these discussions of review papers (Cooper, 1988; Ketcham & Crawford, 2007). If, in some fields, a great number of publications are categorized as document type 'Review' based only on the number of references, it might be more correct to interpret this measure as the extent to which the field engages with past research rather than a measure of the prevalence of reviews. The number of publications indexed in the *Web of Science* for each Research Field was used to normalize the review measure. Therefore, this measure reflects the proportion of publications indexed in the *SCI/SSCI* from 1972 to 2011 that are reviews.

The *evidence based practice and policy* (*EBP*) movement (Pope, 2003) is a scientific-intellectual movement (Frickel & Gross, 2005) with research, practice, political, social, and other dimensions, but which is primarily focused on mobilizing resources to translate and transform research-based knowledge to inform practice. Individuals who identify with the EBP scientific/intellectual movement often hold experimental research methods and research synthesis methods in high esteem.

EBP engagement is operationalized through a topic index search in *S/SCI* with the query phrase, "("evidence based") NOT ("evidence based on") NOT ("evidence based upon")". Results are limited to publication years 1992[19] through 2011. Experimentation and iterative scanning and comparison of search results suggests that this search phrase is on topic and relatively robust. With this search, the intention was to capture counts of publications across fields as evenly as possible since I am interested in the relative level of engagement with the evidence-based movement.

[19] The Evidence-Based Medicine Group (1992) effectively named this movement in a 1992 *JAMA* publication.

Prevalence of EBP within a field is measured by the quantity of publications returned as a proportion of all publications (1992-2011).

Diversity of research synthesis methods is conceptualized as engagement with a wide range of research synthesis methods within a field. Diverse forms of research synthesis include those that incorporate qualitative research, and also those that approach research synthesis from an interpretivist or realist stance.

Diversity of research synthesis methods within fields was operationalized with a subset of the searches used to identify research synthesis methods publications. Search strategies drew on a combination of seed publications and query terms associated with interpretive, qualitative, realist, and other variants of research synthesis. Keyword-based searches were performed on the topic index of the *S/SCI*, limited to the years 1976-2011. Records of publications that reference seed publications were taken directly from the subset of records identified in the RSM cited reference searches. Specific query terms associated with diverse approaches to RSM are indicated in Appendix B; and seed publications are identified in Table C1, Appendix C.

Pure and applied research fields: Scholars within a research field may view that field as more pure or applied based on its relationship to practical problems (Biglan, 1973a). Applied fields focus more on research that can be of more direct and immediate use outside of the research context. Prior studies that categorized science fields on Biglan's three-dimensional[20] taxonomy (Biglan, 1973b; Malaney, 1986; Stoecker, 1993) were compared with scope definitions in *Web of Science* support

[20] The other two dimensions of the taxonomy are hard versus soft, which indicates faculty perceptions of the degree of paradigm consensus in fields; and life or non-life systems, which indicates whether a field is concerned with living organisms.

resources to match fields previously studied with *S/SCI* categories. Once matched, findings on the pure-applied dimension of Biglan's scale were recorded at the categorical level (pure or applied).

Data collection

Bibliometric data were used as indicators of research field-level engagement with research synthesis methods (RSM), and, more coarsely, evidence-based practice (EBP), engagement with diverse forms of RSM, and relative prevalence of review publications by field and year. Data were collected from the *S/SCI* via the *Web of Science* platform in July and through August 3, 2012. The *Arts and Humanities Citation Index* (*A&HCI*) was not included because preliminary research indicated that methods of synthesis and terms used to describe these methods are different for most *A&HCI* fields. RSM engagement and diversity data consist of bibliographic records identified via a combination of keyword and cited reference search; EBP, review prevalence, and norming data were collected via the "Analyze" feature available via the *Web of Science / Web of Knowledge* platform (version 5). Data collected with the Analyze feature were collected by category and year, and across the indexes as needed.

Normalization data: Overall counts of publications by year and category were collected to calculate the relative proportions of research synthesis publications, EBP publications, and reviews. Diverse RSM publications were considered relative to the overall number of research synthesis publications. Normalization data was subsetted for each document set: field "Adoption Year" to 2011 for research synthesis engagement; 1972-2011 for reviews, and 1992-2011 for EBP. These date ranges correspond with those of the normalized data sets.

Data analysis

Data were organized by year of publication and *SCI/SSCI* Subject Category to determine, report, and present basic frequency data by year and fields. A variety of visualization techniques were used to enhance the description, including use of functional data analysis, and network overlay maps. Overlap analysis of items retrieved by query terms versus citing methods texts was performed to examine the effectiveness of each of these approaches overall and by field.

Descriptive functional data analysis (FDA) was used to describe the increase in use of research synthesis in fields over time. Functional data analysis is similar to discrete data analysis except that series of data points are transformed into functions, which are treated as data objects. FDA was chosen in order to visualize the rates of change in use of research synthesis methods over time, and also to calculate the first and second derivatives of the data objects. The first derivative represents the velocity of use of research synthesis over time; and the second derivative the acceleration in use of research synthesis over time. The analysis was performed following Ramsay and Silverman (2005) using the R package fda (Ramsay, Wickham, Graves, & Hooker, 2012): b-splines were fitted to normalized longitudinal RSM publication count data arranged by research field and year to create functional data objects. Counts of the total number of publications by Research Area and publication year were normalized based on the total number of documents by Research Area and year. The first and second derivatives of these functional objects were then identified, and each set of objects plotted.

The diversity of fields that engaged with research synthesis methods over time was examined using the variety, balance, and similarity measures previously discussed. Results over time are visualized with line graphs to illustrate the change in diversity over time and with overlay maps. The overlay maps were created in Pajek (Batagelj & Mrvar, 2012) following Rafols, Porter, and Leydesdorff (2010), and using the cosine similarity matrix previously used to measure the cognitive similarity of fields that engaged with research synthesis. This matrix is the basis of the network that connects category counts in the visualizations. The overlay maps are based on ten-year rather than five-year time slices in order to conserve space.

Descriptive statistical analyses and correlations were calculated using SPSS v. 20 (IBM Corp., 2011) and R v. 2.15.1 (R Core Team, 2012) using RStudio v. 0.97 (2009-2012). Spearman rank correlation statistics were selected to analyze correlations between ordinal data.

Results: Diffusion of research synthesis methods across science fields

The extent of engagement with research synthesis methods has increased following the development of contemporary forms of the methods in the 1970s in education and psychology. Beginning in the 1990s, a greater number of fields engaged with the methods. Prior to examining diffusion patterns in more depth, data collection and contributions of keyword versus cited reference search strategies are reviewed. Known issues with the consistency of the data source, the *Science* and *Social Science Citation Indexes* are considered in relation to search strategies and query results.

Query sets: Summary of results and comparison of research strategies

Plain text files downloaded from the *Web of Science* included 36,157 records of publications that cited the selected seed publications. These records were loaded into *Sci2* 1.0 (Sci2 Team, 2009) to parse and deduplicate the records. Sci2 uses the *Web of Science* accession number (UT field) as a unique identifier to distinguish records. Through this process, 22,899 unique records were identified.

Subsequently, the iPython interactive programing environment (Perez & Granger, 2007) python package PANDAS 0.7 (Pandas Development Team, 2012) and NumPy (Jones, Oliphant, & Peterson, 2001) were used to filter records to include only items published through the end of 2011, resulting in a total of 21,757 records. An example of the python scripts used in this and subsequent processes is included in Appendix E.

The 116,677 records retrieved with keyword queries were similarly parsed and deduplicated, resulting in 116,613 unique records. The 64 duplicate records may have been retrieved because of updates to the *S/SCI* databases during the data collection period. Keyword results set records were also filtered by publication year in PANDAS. As would be expected based on the original *Web of Science* search parameters, which limited results to those published through 2011, all records retrieved with keyword queries were found to be associated with items published through the end of 2011.

The two record sets, the citing reference query records and keyword query records, were then loaded into PANDAS. *Web of Science* accession numbers were used to calculate the intersection and union of the sets, the number of unique records in the union set, and the number of records uniquely identified by each search strategy. In the union set, there were 138,370 records, of which 123,881 were unique. The overlap of 14,489 between records retrieved with keyword and cited reference searches is about 12.418 percent of the keyword query set and 66.595 percent of the cited reference query records. Figure 1 shows the proportion of items retrieved over time with the cited reference search, the keyword search, and also the intersection (items retrieved by both search strategies) and union (items retrieved by either of the search strategies). Keyword search results were limited to those published between 1976 and 2011 to limit false positive results, and therefore no records were retrieved with the keyword search prior to 1976. Keyword search results prior to 1976 were excluded because the term "meta-analysis" was not coined until 1976, and it does not appear that other standard terms were used to describe research synthesis prior to this date based on historical accounts of the development of research synthesis (e.g., Glass, Smith, & McGraw, 1981). The first seed item used for the cited reference search was published in 1971, and therefore results prior to 1971 would not be expected. Table 2 summarizes the outcomes of search result set pre-processing.

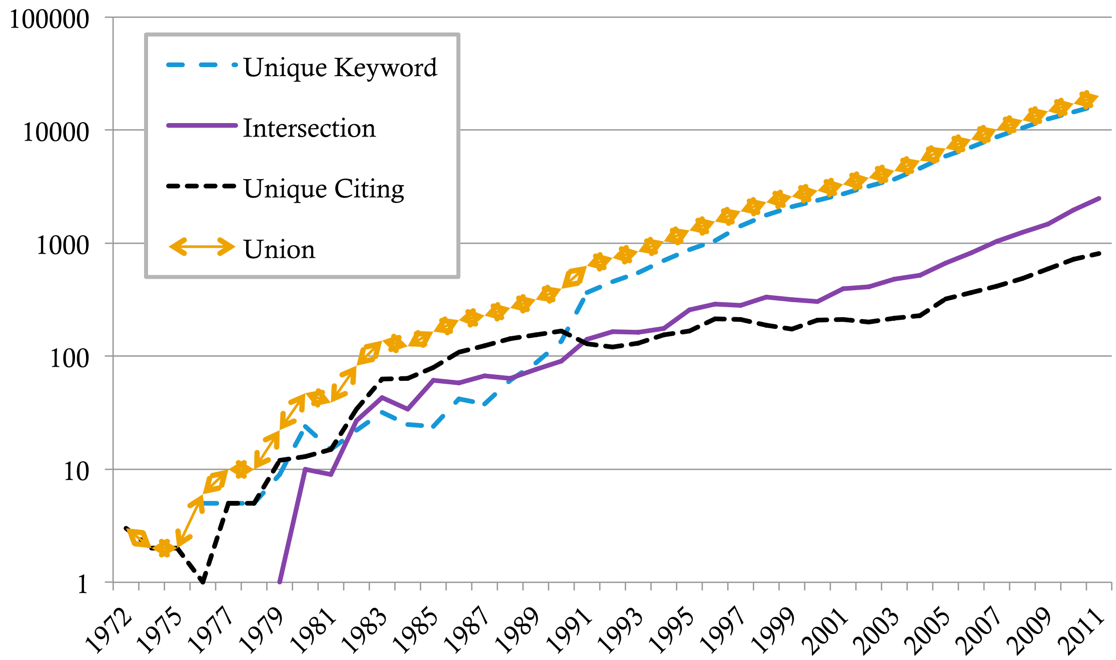


Figure 1. Unique records retrieved with keyword and citing reference queries, 1972-2011

Note: Log scale used on y-axis. The number of records retrieved with both query strategies (the intersection) is shown with in solid purple, and with either strategy (the union), a yellow arrow line.

Table 2. Search and pre-processing of result sets

Search Strategy	Keyword search	Cited reference search
First year possible/observed	1976/1976	1971/1972
Total records retrieved	116,677	36,157
Total records, de-duplicated	116,613	22,899
Total records published through 2011	116,613	21,757

While seed publications and keyword queries were identified based on a review of the literature and interactive scanning, the final search strategy used to identify publication records is a compromise between precision and recall. Selective inclusion of journals in the *S/SCI* necessarily limits the extent to which search results are comprehensive in light of the goal of this research. Two recently established journals devoted to research synthesis, *Research Synthesis Methods* and *Systematic Reviews*, were not indexed in the *S/SCI* at the time of data collection.[21] Some classic articles related to research synthesis are also excluded. For example, the *Educational Research Review*, a journal in which at least two seminal research synthesis articles were published in the 1970s (Glass, 1976; Smith & Glass, 1977), was not indexed in the *SSCI* until the 1990s. There were, however, a number of seminal research synthesis articles from these journals indexed in a manner similar to books indexed in the *S/SCI*, so it was possible to include these in the citing reference searches.

As indicated in Figure 1 and Tables F1 and F2 in Appendix F, an increase in records retrieved with keyword queries occurred between 1990 and 1991. Prior to the early 1990's, *S/SCI* records generally do not include abstracts, which is likely to contribute substantially to the difference in the number and proportion of items retrieved via keywords. The increase in cited reference query results would be expected to increase in part due to the increase in the number of citable items. Qualitatively, it appears that keyword and cited reference search strategies complemented each other.

The lack of obvious anomalies in a plot of the second derivative of the polynomic curve

[21] *Research Synthesis Methods* (http://onlinelibrary.wiley.com/journal/10.1002/%28ISSN%291759-2887) the journal of the Society for Research Synthesis Methodology, began publication in January 2010; and *Systematic Reviews* in February 2012. *Systematic Review* (http://www.systematicreviewsjournal.com/) articles would have fallen outside the collection scope for this study based on date of publication as well.

functions of the set of field-year publication count time series (Figure 2) provides further support for the complementary nature of the combination of the keyword and cited work search strategies. The second derivative of the field-year publication count function can be considered a representation of the *acceleration* in publication rate. Had there been a large jump in the number of records retrieved in the early 1990s when indexed abstracts first begin to appear, this graph would indicate a substantial acceleration in publication rate at that time.

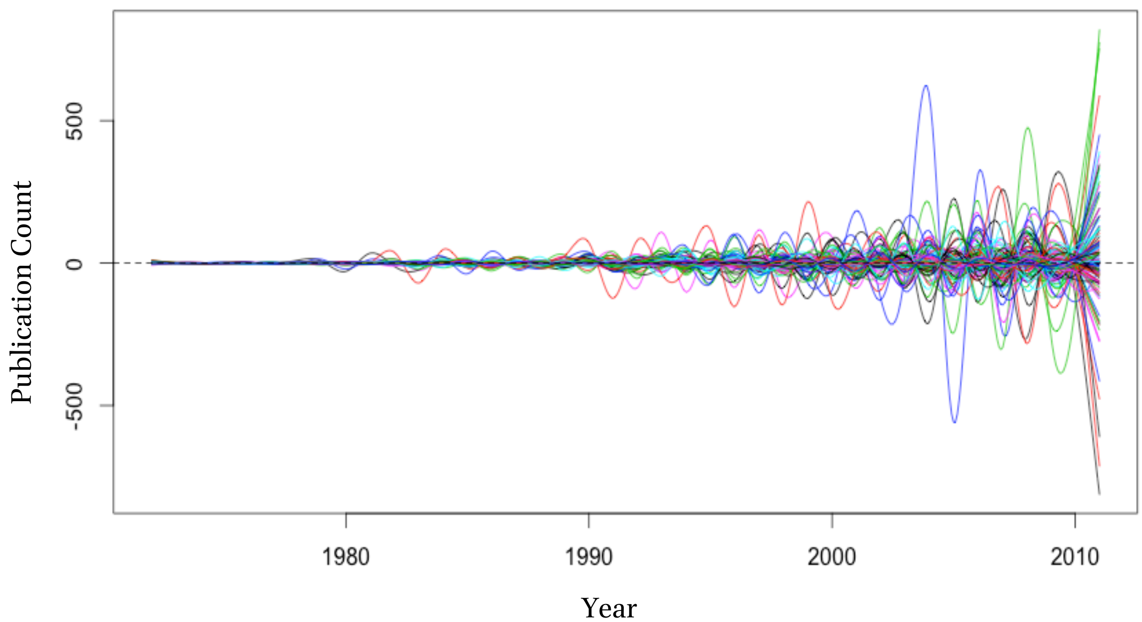
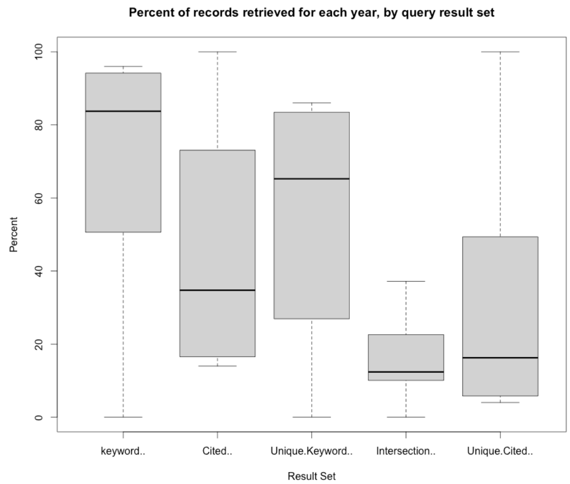


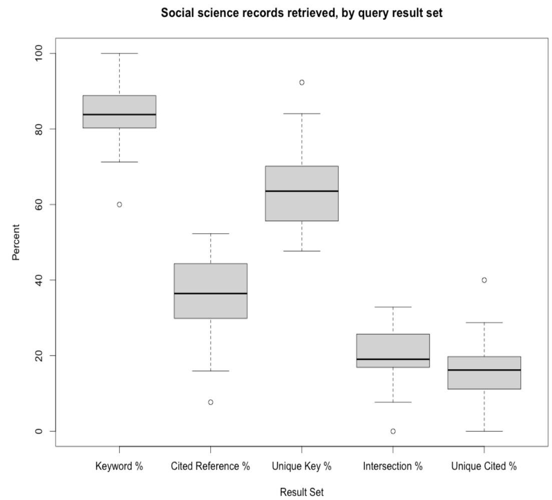
Figure 2. Spaghetti plot of the second derivative of the publication year-field counts

Note: The second derivative depicts 'acceleration' in publication counts over time.

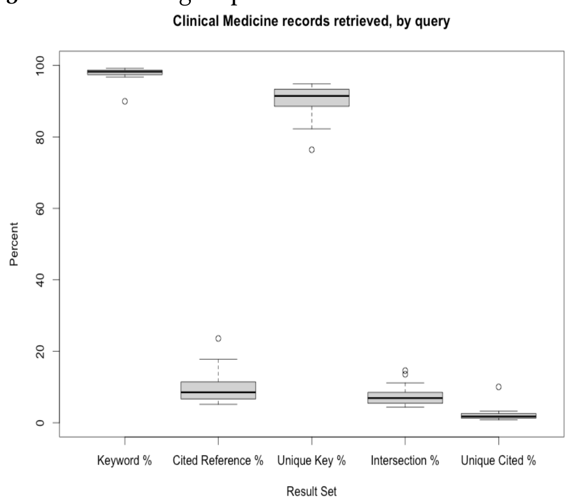
Comparison of the relative proportion of records retrieved via the two search strategies by the larger field group aggregates revealed differences in the apparent relative effectiveness of the search strategies across (Figure 3) and within (Table G1, Appendix G) field groups. Keyword queries resulted in a greater proportion of results in Clinical Medicine and Other Health & Medical Sciences. Citation searching yielded a relatively high proportion of results in the Social Sciences generally, as well as some Life Science and Technology fields. Fields in the Technology group appear to be most variable in terms of the relative proportions of results identified with keyword versus citing reference searches. Differences in the effectiveness of keyword queries versus cited reference queries likely result from a combination of factors. Four potentially important factors include (a) differences in referencing practices; (b) inclusion of the Keywords Plus™ field in the topic index of the *Web of Science*; (c) the keyword query terms and seed publications selected for this study; and (d) the extent to which fields produce and use their own methods publications. Subsequent stages of this study will, to an extent, provide information about differences in referencing practices as they relate to use of research synthesis methods for those fields that are studied in more depth. It would be possible to examine the extent to which terms included in the Keywords Plus™ field and not other fields contribute to the number of items retrieved by testing the queries on individual record fields. However, it would also be necessary to examine whether these items represent engagement with research synthesis to determine the extent to which inclusion of this field inflates RSM engagement counts. Preliminary searches and examination of results and extensive review of the literature were performed prior to finalizing the list of query terms and keyword publications in order to optimize the search strategy. The final factor, variation in the nature of research methods materials produced and used in fields is outside of the scope of this study. Again, subsequent stages of this research may provide some indirect evidence regarding this factor.



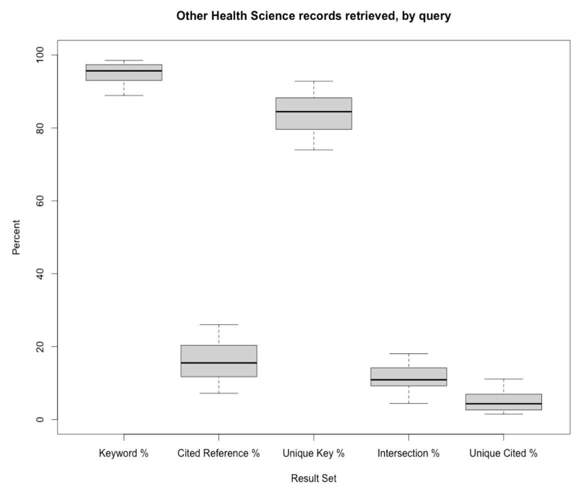
3a. Across field groups



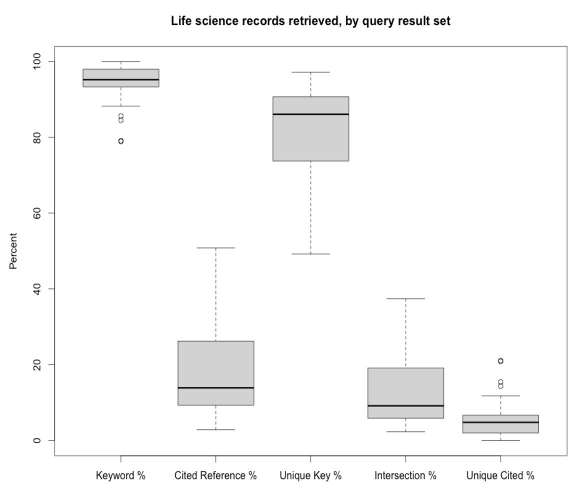
3b. Social sciences (N=24)



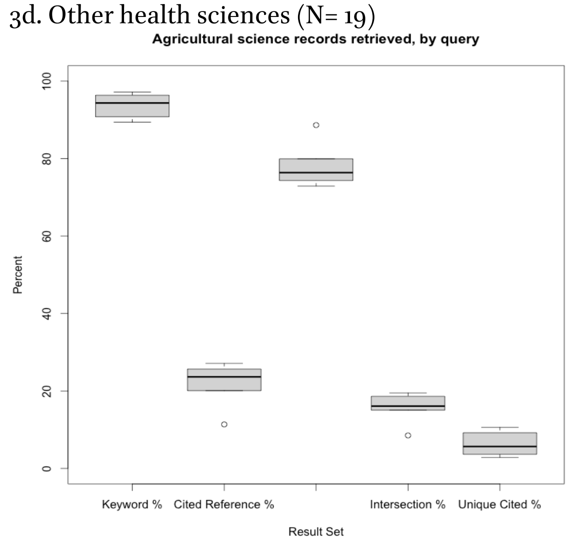
3c. Clinical medicine (N=24)



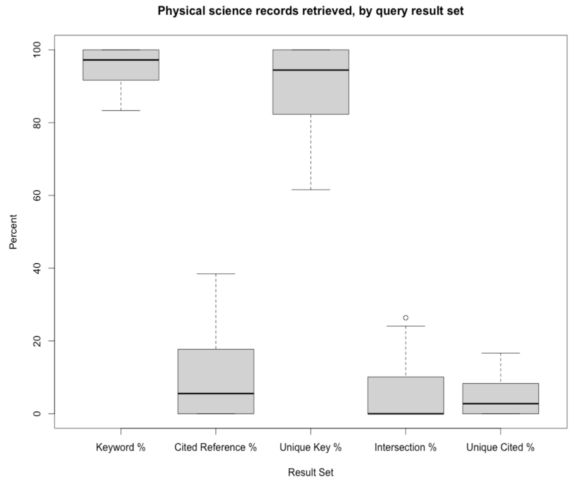
3d. Other health sciences (N= 19)



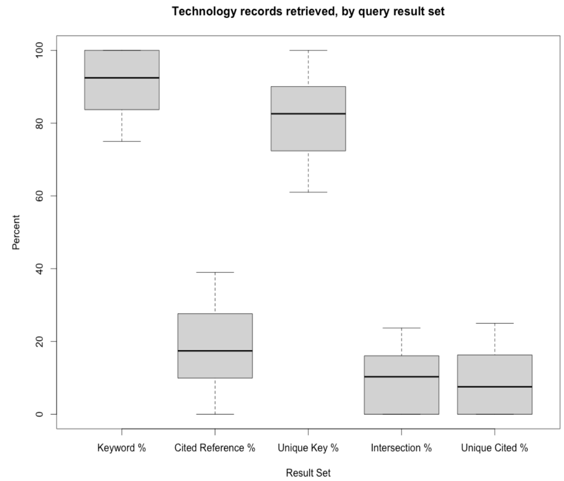
3e. Life sciences (N=25)



3f. Agricultural Sciences (N= 6)



3g. Physical Sciences (N=17)



3h. Technology (N=20)

Figure 3. Proportion of records retrieved by search strategies

Note: Figure 3a presents the percent of items retrieved by search strategy across field groups; and 3b-3h presents percent retrieved by each search strategy across research areas within in each field group. In 3b-3h, "N" is equal to the number of fields (*Web of Science* Research Areas, SC) in the larger field groups.

Diffusion of research synthesis methods

Across all years (1972-2011), 123,881 records that provide evidence of engagement with research synthesis were found using a combination of keyword queries and cited reference searching the *S/SCI*. The number of publications has increased over time and varies across research field. Detail on search results and a comparison of yield by search strategy is presented in Appendix A.

First years of research synthesis methods engagement

The first record of research synthesis methods in this dataset belongs to an Education/Education Research paper published in 1972. As of 2011, only the field of Microscopy included no research synthesis publications. Seven other fields (Crystallography, Mineralogy, Mining

Mineral Processing, Remote Sensing, Robotics, Telecommunications, and Thermodynamics) did not meet the "first year" criteria, which requires that, for the "first year" publication to be counted, one additional publication must have been published within two years after the initial publication. The intention of this requirement was to reduce the impact of false positives and noise in the data due to issues such as language use and *WOS* document cross-categorization. Of the eight fields that did not meet the criteria, four were in Technology (Microscopy, Remote Sensing, Robotics, and Telecommunications) and four in Physical Science and Math (Crystallography, Mineralogy, Mining Mineral Processing, and Thermodynamics). All fields in other field groups (Social Sciences, Clinical Medicine, Other Health Sciences, and Agriculture) met the first year criteria.

For those fields that met the first year criteria, the average first year was about 1990 (s.d. = 7.74 years), the median first year, 1989, and range 1972 to 2010. The distribution is positively skewed (0.607) and kurtosis is positive (0.108) (Figure 4).

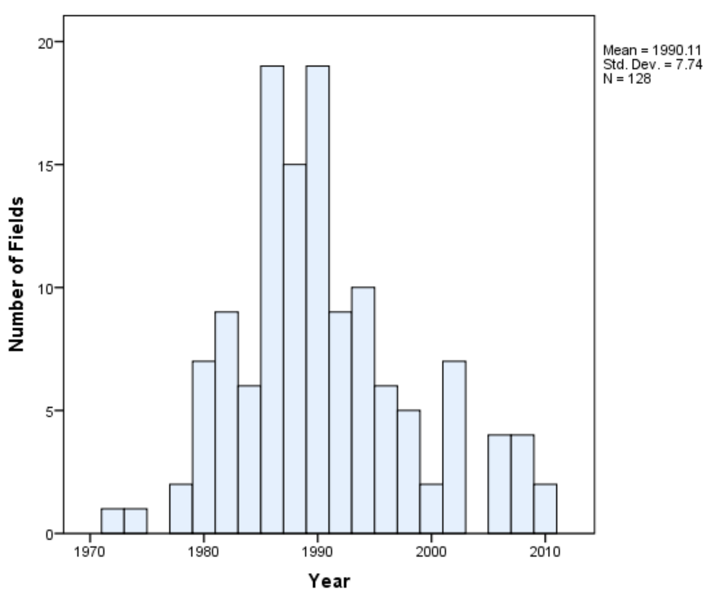


Figure 4. Year of first RSM publications across research fields.

First year distributions differ viewed from the perspective of field groups (Table 3 and Figure

5). The Social Sciences field group has the earliest first year of RSM publication based on the median (1985, mean = 1987.35), and also the greatest variation (s.d. = 10.46 years) and observations of both the earliest (1972) and latest (2010) years in the data set. First years of Clinical Medicine (mean = 1986.84, median = 1987) and Other Health and Medicine (mean = 1986.47, median = 1986) fields are earliest based on the mean. Clinical Medicine contains the least variation (s.d. = 3.01 years, range = 1980 to 1994).

Technology and Physical Science and Math fields that do not yet have a first year were treated as missing values. Nonetheless, these two fields, along with Agriculture, include the most recent first years of RSM publication (Technology: mean = 1994.71, s.d. = 7.92 years, median = 1994; Physical Sciences and Math: mean = 1997.46, s.d. = 8.18 years, median = 1996; Agriculture: mean = 1994.33, s.d. = 3.14, median = 1994.5).

Table 3. Year of First RSM Publication by Field Groups

Field Group	Field Ct	Missing	Mean	SD	Min	1st Qtr	Median	3rd Qtr	Max
All	136	8	1990.11	7.74	1972	1985	1989	1994	2010
Social Sciences	23	0	1987.35	10.46	1972	1981	1985	1994	2010
Health & Med	19	0	1986.47	6.41	1978	1980	1986	1989	2001
Clinical Med	25	0	1986.84	3.01	1980	1985	1987	1988	1994
Life Sciences	25	0	1990.72	4.65	1982	1989	1989	1992	2001
Phys Sci Math	17	4	1997.46	8.18	1982	1993	1996	2005	2008
Technology	21	4	1994.71	7.92	1982	1986	1994	2002	2006
Agriculture	6	0	1994.33	3.14	1990	1992	1994.5	1997	1998

Note. Only fields that had a “first year” were included in calculations.

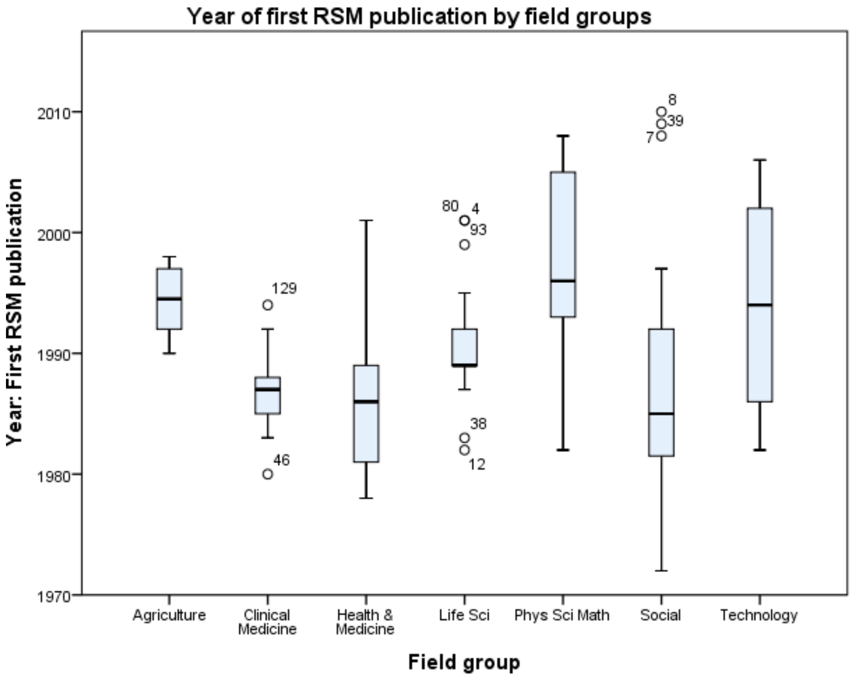


Figure 5. Year of first RSM publication by groups for fields with a "first year" publication.

Labeled data points: Clinical Medicine: 46 = General Internal Medicine, 129 = Tropical Medicine; Life Sciences: 12 = Behavioral Sciences, 38 = Environmental Sciences Ecology, 93 = Paleontology, 4 = Anatomy Morphology, 80 = Mycology; Social Sciences: 7 = Archaeology, 39 = Ethnic Studies, 8 = Area Studies. Note: label numbers were used to identify fields, and conserve space in the graph only.

Continuity of RSM engagement

In addition to the "first year", the year in which research synthesis publications began to appear without interruption is also recorded (first year continuous use). This measure, which is more exclusive, was developed in order to understand when RSM began to appear regularly, and to avoid inclusion of false positives, especially for normalization of the intensity of RSM engagement. One limitation of this measure is that it was assumed that once fields began to engage with research synthesis methods with some regularity, use of the methods would continue. While this is true generally, the field of International Relations appears to be an exception.

The distribution of the first year of continuous RSM publication across all fields is slightly less skewed (0.407) and with a kurtosis of -0.434. As expected, measures of central tendency are slightly later (mean = 1992.31, s.d. = 8.01, median = 1990). Observed values range from 1975 to 2010. Figure 6 presents the distribution of first years of continuous use across fields, and Table 3 summary statistics for all fields as well as field groups. In this study, the first year of continuous use has been used as an indicator of when a field adopted RSM.

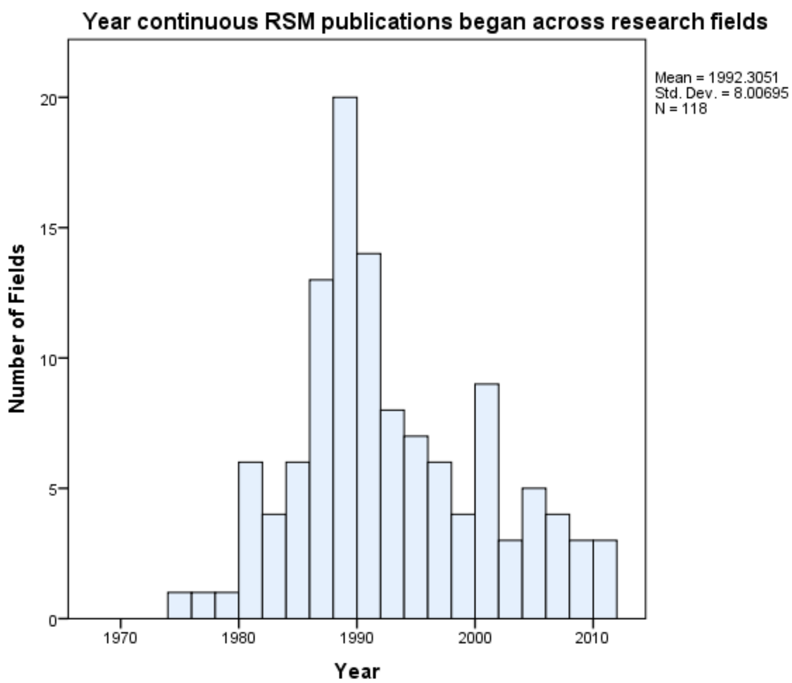


Figure 6. First year of continuous RSM publication across research fields ranges 1975-2010

Fields that may have begun continuous use in 2011 are excluded based on measure criteria. See Figure 8 below for an overview of when specific fields adopted RSM.

Again, Education and Education Research holds the earliest position: at least one RS work was published each year from 1975 through the present in this field. Two other social sciences, Psychology (1976) and Business and Economics (1979) follow shortly after. In the early eighties, several other fields, including the first in the health sciences (Geriatrics and Gerontology; Rehabilitation; and Sports Sciences, all in 1980), and the general social science category (Social Sciences Other Topics, 1980) began to engage regularly with research synthesis methods. Similar to the first years of RSM publications above, while the social science fields were the earliest to use research synthesis, the social sciences are also the most variable in terms of when continuous use of RSM began. Field groups with the least variability include clinical medicine, the relatively small agriculture set (N = six fields), and the life sciences (Table 4 and Figure 7). Researchers engaged with research synthesis later in the Physical Sciences and Math and Technology field groups.

Table 4. Year continuous RSM publication began by field groups

Field Group	Field Ct	Miss	Mean	SD	Min	1st Qtr	Median	3rd Qtr	Max
All	136	18	1992.31	8.01	1975	1987	1990	1998	2010
Social Sciences	23	2	1990.05	10.35	1975	1982	1988	2000	2010
Other Health & Med	19	0	1988.26	7.5	1980	1982	1988	1990	2008
Clinical Medicine	25	0	1988.44	2.72	1983	1986	1989	1990	1994
Phys Sci Math	17	7	2000	7.62	1985	2000	2001	2004	2010
Technology	21	9	1997.75	9.1	1985	1989.5	1997.5	2006	2010
Life Sciences	25	0	1994.76	5.6	1986	1991	1994	1998	2006
Agriculture	6	0	1995.17	3.06	1990	1993	1996.5	1997	1998

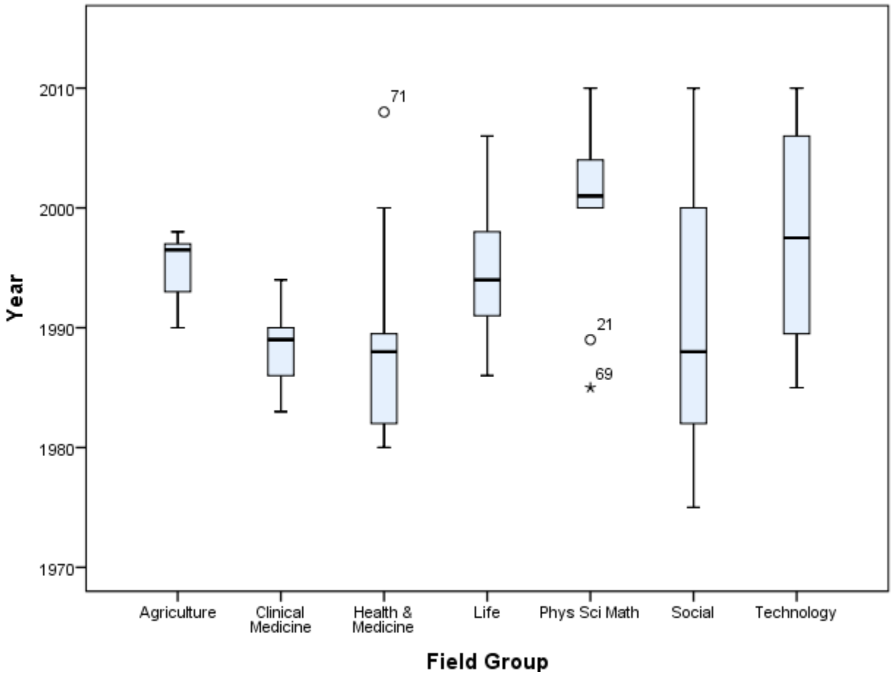


Figure 7. Year continuous RSM publication began by field groups.

Numbered data points: Other Health and Medicine: 71 = Medical Ethics; Physical Sciences and Math: 69 = Mathematics, 21 = Chemistry.

In addition to fields in the Technology and Physical Sciences and Math field groups, RSM publications did not appear regularly in two fields in the Social Sciences, Archaeology and International Relations. Though a string of RSM publications were observed from 2008 to 2010 in International Relations, and sporadically as early as 1994, the observed counts met the "first year" but not the continuous RSM publication criteria. Based on these observations, the first year of continuous RSM publication was assigned "NA" for this field. Table 3 and Figures 6 and 7 summarize the first year of continuous research synthesis publications overall and by research field groups. Figure 8 illustrates when continuous use of research synthesis began by field and within fields groups.

Figure 8. Adoption curve: when continuous RSM publications began by fields and field groups

Note: Within time slices for each field group, fields are arranged in descending time order.

Extent of research synthesis engagement

The number of research synthesis methods publications retrieved by field ranges from 0 publications in Microscopy to 15,521 publications in General Internal Medicine (Psychology is a close second at 15,044). Generally, the Clinical Medicine field group has the greatest number of RSM publications. The top twenty fields ranked by the number of RSM publications (2,204 to 15,521 publications per field, Table 5) includes thirteen Clinical Medicine fields; three Other Health and Medicine fields, three Social Sciences and one Life Science.

In contrast, the twenty fields with the fewest number of RSM publications includes nine fields from the Physical Sciences & Math group (Crystallography, Mining Mineral Processing, Mineralogy, Thermodynamics, Polymer Science, Geochemistry Geophysics, Electrochemistry, Optics, and Astronomy Astrophysics); nine from Technology (Microscopy, Remote Sensing, Robotics, Telecommunications, Imaging Science Photo Technology, Mechanics, Spectroscopy, Metallurgy Metallurgical Engineering, and Automation Control Systems); and two from Social Sciences (Archaeology and Area Studies). Information Science Library Science (ISLS) ranks 64th based on the number of publications, and 75th normalized over the number of documents published.

Table 5. Research fields with the greatest number of RSM publications

Rank RSM	Field	Group	RSM Ct	Rank prop	RS began	Size rank
1	Gen Int Med	CM	15521	14	1984	6
2	Psych	SS	15044	12	1976	9
3	Card Syst Cardiol	CM	9502	22	1986	12
4	Neurosci Neur	CM	9016	40	1983	5
5	Psychiatry	HMO	8434	7	1981	27
6	Pub Env Occ Hlth	HMO	7875	8	1982	29
7	Onc	CM	7077	26	1986	18
8	Surgery	CM	6452	20	1986	13
9	Pharma Pharmacy	CM	5793	42	1985	8
10	Gastroent Hepa	CM	5339	20	1987	30
11	Business Econ	SS	4451	43	1979	18
12	Hlth Care Sci Serv	HMO	3970	4	1988	69
13	Ob Gyn	CM	3902	13	1988	48
14	Endocr Metab	CM	3336	35	1990	24
15	Pediatrics	CM	2735	37	1986	33
16	Hemat	CM	2631	50	1989	21
17	Urol Nephr	CM	2440	32	1990	45
18	Educ, Educ Res	SS	2431	39	1975	44
19	Resp Syst	CM	2320	24	1989	59
20	Env Sci Ecol	LS	2204	64	1986	15

Note. "Rank RSM" is number of RSM publications in a field compared to other fields. General Internal Medicine, ranked "1", has the greatest number of RSM publications. "RSM Ct" is the number of RSM publications. "Group" refers to field groups. Field groups abbreviations are: CM = Clinical Medicine, SS = Social Sciences, HMO = Health & Medical Sciences, LS = Life Sciences. "Rank Prop" is based on the proportional number of research synthesis publications, normalized over all publications. "RS began" is the year continuous RSM use began. Size rank indicates the overall size of the field based on the number of documents in the Research Area, 1972-2011.

Across all fields, the mean number of publications is 1,295.06 (s.d. = 2,530) and median, 342.5. The distribution is positively skewed (3.519) and with a kurtosis of 14.327. Figure 9 presents the distribution of counts by fields on a log scale, and Table 6 summary statistics across all fields and by field groups.

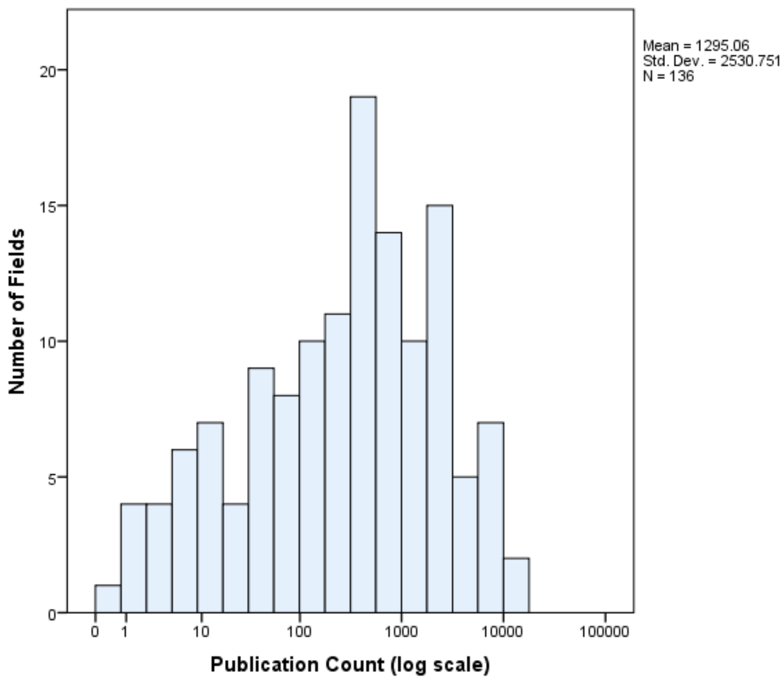


Figure 9. Count of RSM publications across fields

When viewed from the perspective of field groups, Clinical Medicine fields include the greatest number of RSM publications (mean = 3,616.3, s.d. = 3,637.8, median = 2,380), followed by Other Health and Medicine (mean = 2,101.7, s.d. = 222.1, median = 1,772) and Social Sciences (mean = 2,530.75, s.d. = 2,530.75, median = 342.5). The Life Sciences and Agriculture fall in the middle, and have less variation than the Social Sciences. Technology and Physical Science Math fields have the fewest number of research synthesis publications.

Table 6. Number of research synthesis publications

Field Group	Mean	SD	Min	1st Qtr	Median	3rd Qtr	Max
All	**1295.1**	**2530.8**	**0**	**53.3**	**342.5**	**1279.8**	**15521**
Soc Sci	1133.4	2989.6	2	58.0	301.0	490.0	15044
Oth Hlth & Med	2101.7	2222.1	45	588.8	1772.0	2155.0	8434
Clinical Med	3616.3	3637.8	287	736.0	2380.0	5452.5	15521
Life Sci	550.4	567.1	19	167.0	359.0	688.0	2204
Agriculture	246.0	164.9	76	114.3	196.0	332.5	543
Tech	131.5	222.9	0	6.0	22.0	112.0	762
Phys Sci-Mth	108.5	270.8	1	4.0	12.0	68.0	1171

The number of research synthesis publications was normalized based on the total number of documents published in each field from the year continuous RSM publications began to appear (Table 7). This normalization accounts for field size and the length of time researchers have engaged with RSM. The normalized counts bring out the comparative similarity among the "Other Health and Medical Science" fields; and diversity in Clinical Medicine. The Social and Life Sciences engaged with RSM to a lesser extent. Variation in the Social Sciences is much lower compared to measures based on raw counts.

Table 7. RSM Publications per 10,000 publications from the year of continuous RSM use

Field Group	Mean	SD	Min	1st Qtr	Median	3rd Qtr	Max
All	**52.1**	**63.6**	**0**	**7.3**	**23.3**	**77.6**	**313.4**
Soc Sci	56.4	51.3	5.4	19.2	34.1	76.2	225.8
Oth Hlth & Med	126.5	80.7	11.8	55.9	124.1	165.2	302.5
Clinical Med	82.9	146.5	22.2	58.4	78.6	112.2	146.5
Life Sci	42.1	61.4	6.0	14.2	22.3	51.7	313.4
Agriculture	14.6	4.8	8.1	11.2	14.1	17.7	22.0
Tech	5.2	5.8	0	1.1	3.4	6.9	15.5
Phys Sci-Mth	4.2	5.4	0	0	1.1	5.5	21.4

Count data normalized based on the number of publications published between 1972 and 2011 in each field were scaled to identify the number of RSM publications per 10,000 publications overall and then transformed to create functional objects and construct spaghetti plots to illustrate the relative growth patterns across fields. The functions present a complex but dynamic view of increasing engagement with research synthesis over time. In Figure 10, the functional data plot, the slopes and shapes of the publication rate functions depict a range of growth trajectories, from steeply increasing to long gentle slopes. Also note the dense matt in the right corner, which includes fields that have only recently begun to show a modicum of interest in research synthesis methods.

Dramatic differences are evident in the plot of the first derivative of the functional slopes (Figure 11). The first derivative corresponds with research synthesis engagement as a function of the "velocity" of publication over time. It would be necessary to examine fields in more detail to determine whether or to what extent the pronounced fluctuations in velocity are an artifact of the data set. The data do suggest that engagement with research synthesis has fluctuated to differing extents across fields. It is possible that some fields are more affected by "fads" and "fashions" in research practices (Abrahamson, 1991; Baskerville & Myers, 2009), which may be induced externally (fashions), such as by funding agencies, or internally (fads) as a result of group dynamics. There is also the possibility that in addition to overall trends in research, there may be a periodicity in publication trends; or that in addition to increasing engagement overall, events such as conferences, special issues, or controversies may trigger increased engagements for limited periods.

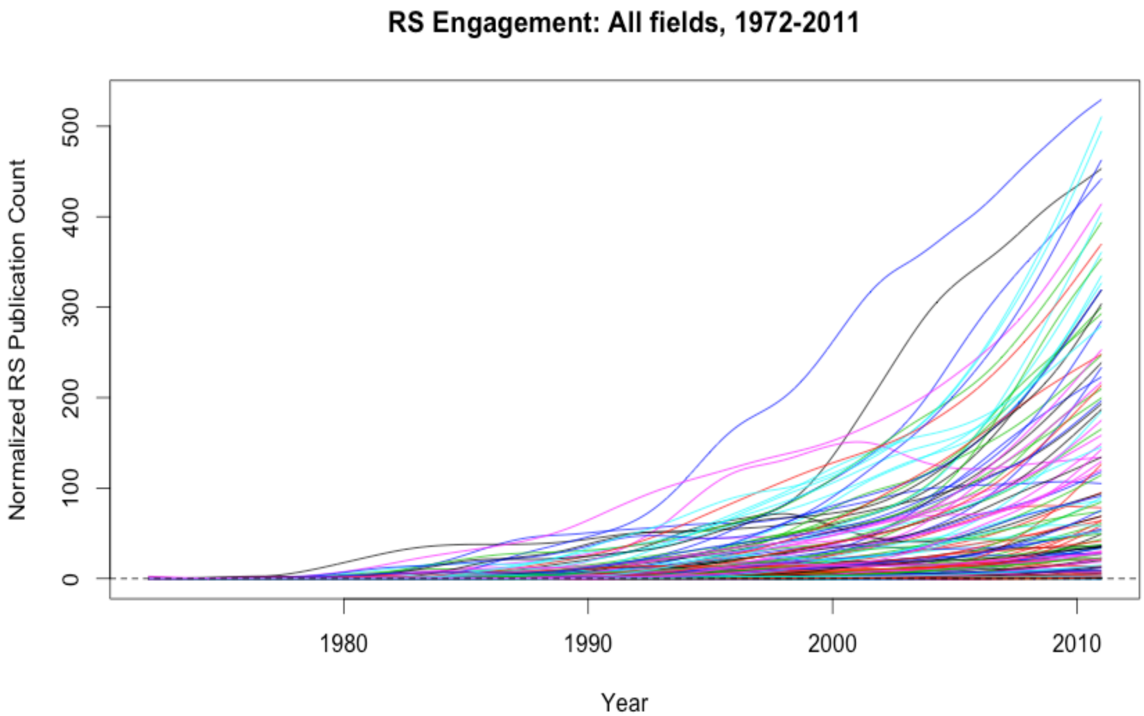


Figure 10. Rate of research synthesis publication differs across science fields

Note: Normalized publication count is expressed in the number of publications per 10,000.

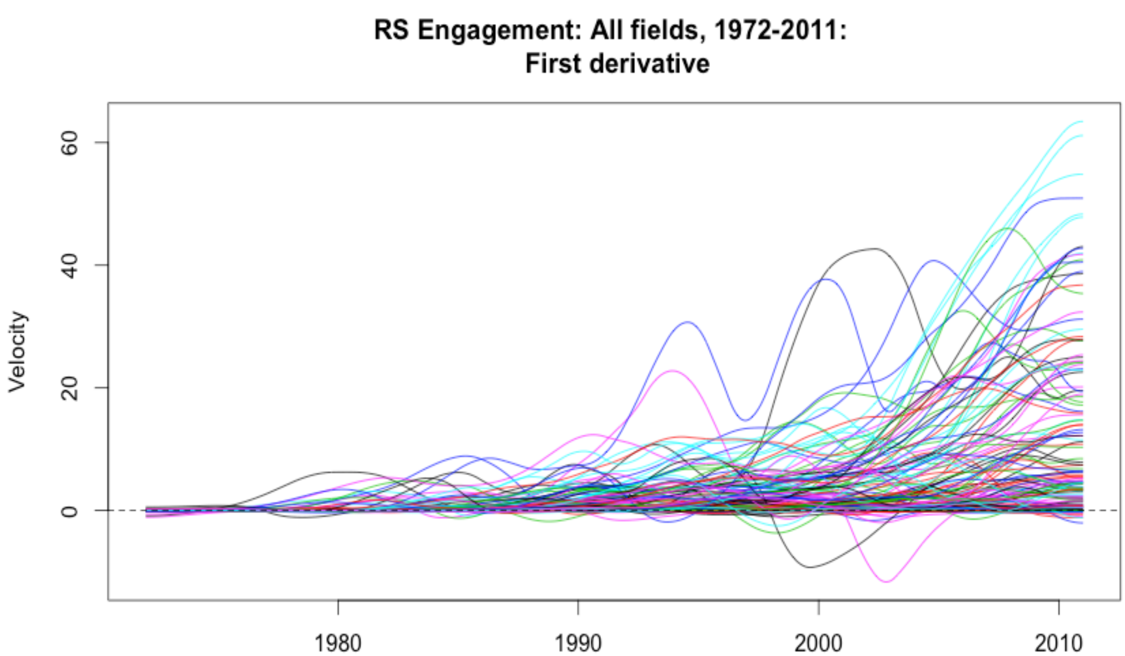


Figure 11. Velocity of research synthesis publications in science fields

Diffusion over time: Diversity of fields that engage with RSM

Another important aspect of diffusion is the diversity of fields that engage with an innovation. As indicated in Table 8, the variety and cognitive dissimilarity of fields that have engaged with research synthesis over time has increased, though at fluctuating rates. As the number of categories has neared the maximum, 223 WCs, the rate at which variety has increased has slowed. The largest increase occurred in the first half of the 1990s, which corresponds with other evidence and with the rise of the evidence-based practice and policy movements. Figure 12 depicts the number of fields, category nodes, that have engaged with research synthesis methods over time. Dissimilarity also increased over time, which indicates that the set of fields that have engaged with research synthesis methods has become increasingly diverse cognitively based on overall citation patterns across science. The increase in dissimilarity is evident in the overlay maps (Figure 12): more cognitively dissimilar fields are spatially distant and connected by fewer links in the maps.

Table 8. Diversity of science fields engaged with RSM over time.

Time period	**Variety**	**Shannon Evenness (Balance)**		**Dissimilarity**
		Count data	Normalized	
1972-1976	16	0.976	0.867	0.873
1977-1981	54	0.801	0.806	0.856
1982-1986	84	0.782	0.795	0.872
1987-1991	131	0.818	0.805	0.890
1992-1996	170	0.820	0.828	0.904
1997-2001	189	0.806	0.845	0.906
2002-2006	203	0.792	0.855	0.911
2007-2011	211	0.789	0.867	0.911

Note. The three aspects of diversity, based on representations of engagement with research synthesis at the field level, are variety, balance (Shannon evenness), and (cognitive) dissimilarity.

Shannon evenness was used to measure balance, the proportional distribution of RSM publications in WCs. Both raw count data and normalized count data were used to calculate balance. Balance, based on raw count data indicates that there is an increasing difference in the proportions of research synthesis publications across fields: though the number of fields that engage with research synthesis at all has increased (variety), the number of publications in each field has grown increasingly disparate. The normalized count data, compared to the raw count data, depicts greater balance across fields: When the size of a field is taken into account, the proportion of research synthesis publications to all publications in fields where it occurs is more even. In part, the greater evenness may be explained by the smaller variance associated with normalization. This view adds another dimension to diversity, however, because the range in the size of fields that engage with RSM and the increasing numbers of publications produced by some large fields in later years in a sense skews field-level comparisons.

In addition to the magnitude of difference in balance, the trends differ when balance is calculated with raw versus normalized count data, especially in view of the last two time periods (2001-2006 and 2007-2011), when balance in the proportional engagement of fields increases though balance decreases based on the number of publications. The maps in Figure 12 are based on absolute counts of RSM publications. In these maps, the proportional size of nodes indicates balance.

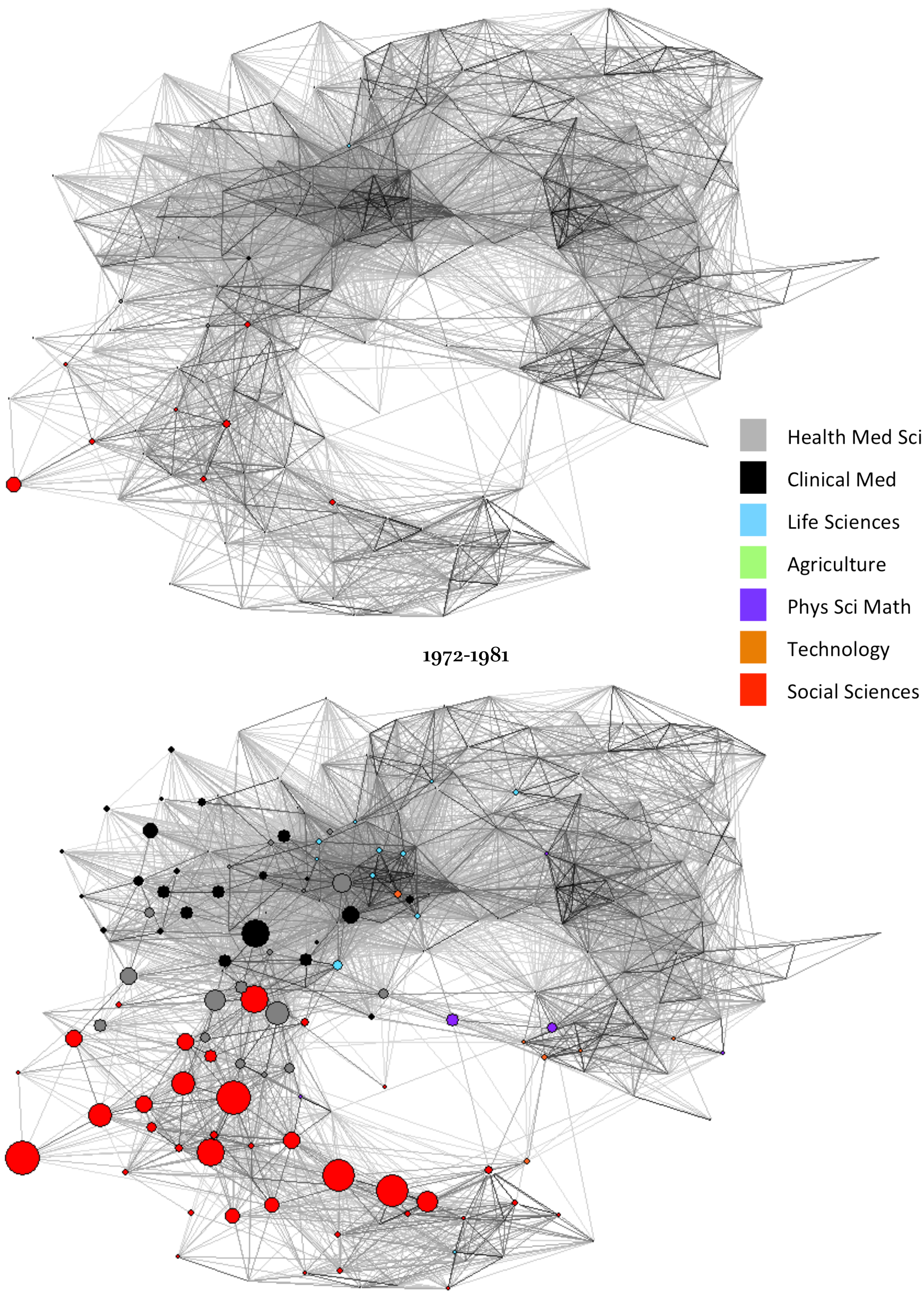


Figure 12a. RSM diffusion projected on a science citation map, 1972-1991

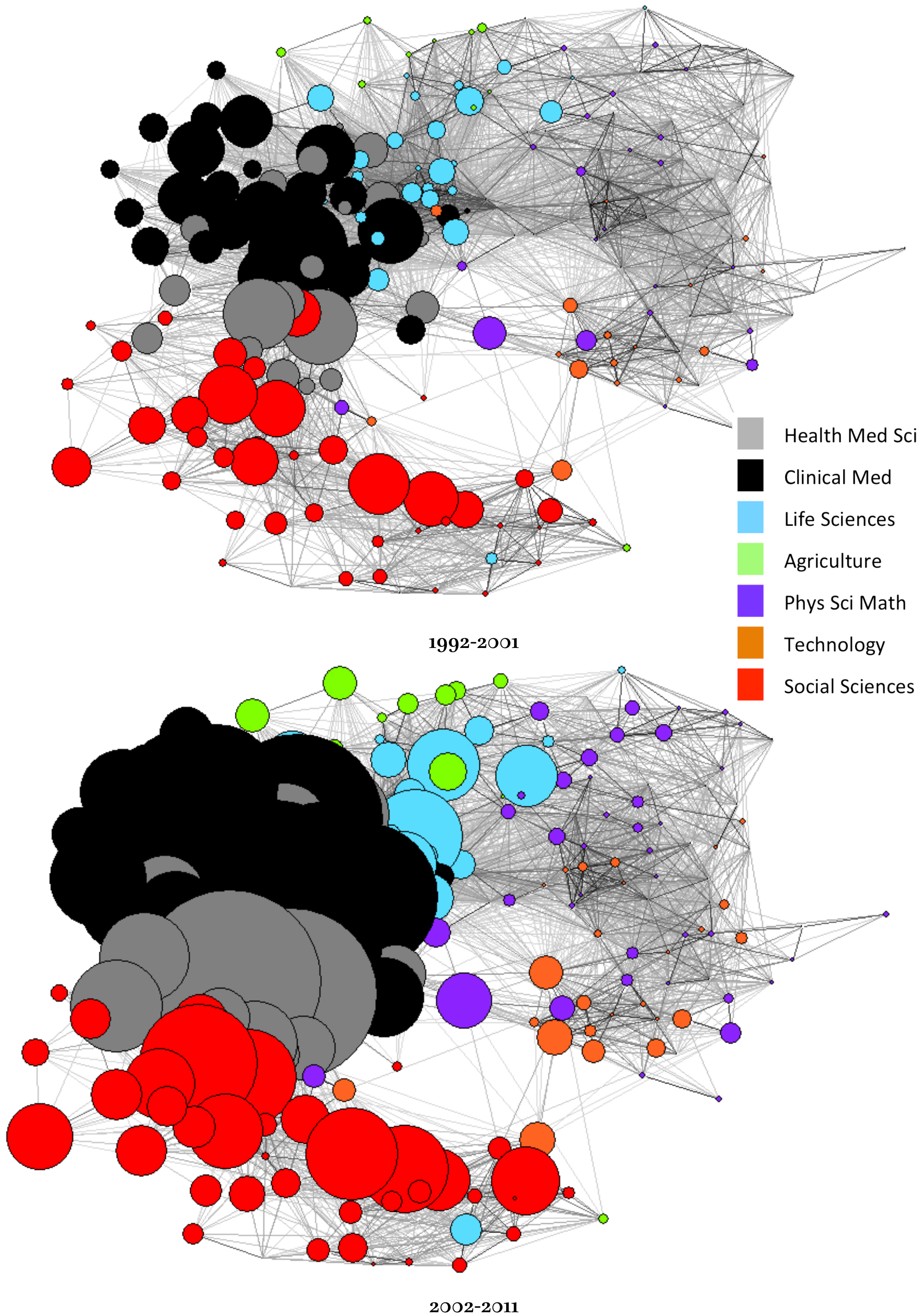


Figure 12b. RSM diffusion projected on a science citation map, 1992-2011

Characteristics associated with research synthesis methods diffusion

The secondary goal of this research stage was to inform selection of fields for closer examination in subsequent phases of this study. Four factors were selected for closer examination: the proportion of reviews in research fields; the extent to which authors have engaged with evidence-based practice and policy (EBP); the extent of interest in diverse approaches to research synthesis; and whether a field is more pure or applied. Bivariate Spearman's rho (ρ) correlation (one tailed) was performed to examine associations between these factors and measures of the extent and history of engagement with research synthesis and size of research fields (Table 9). Correlations were analyzed with Spearman's rank correlation coefficient because it is an appropriate nonparametric measure of association for variables measured on at least an ordinal scale.

While sixteen of twenty-one correlations were significant, only associations between three variables were strongly correlated. Strong correlations were observed in all bivariate analyses between (a) the number of years RSM have been used in a field, (b) the proportion of RSM publications compared to all publications within fields, and (c) the extent of engagement with EBP.

The relationship between the number of years RSM publications were produced and the proportion of RSM publications ($\rho = 0.706$, $p < 0.001$) is not surprising given that it takes time for publications on any topic to accumulate, but also suggests continuity of engagement with the methods. The strong correlations between EBP and both the proportion of RSM publications ($\rho = 0.893$, $p < 0.001$, see Figure 13) and the number of years RSM use ($\rho = 0.712$, $p < 0.001$) underscore the historical relationship between EBP and RSM.

Table 9. Bivariate Spearman's rho (ρ) correlations

Measure		RSM /all pubs N=136	Yrs RSM used N=136	Field size N=136	Reviews /all pubs N=136	EBP /all pubs N=136	Diverse /all RS N=135	Biglan class N=67
RSM /all pubs	Rho (ρ)		.706	-.060	**.403**	**.893**	.072	**.279**
	Sig.		0.000	0.244	0.000	0.000	0.203	0.011
Yrs RSM used	Rho (ρ)	.706		.385	.289	**.712**	.166	**.331**
	Sig.	0.000		0.000	0.000	0.000	0.027	0.003
Field size	Rho (ρ)	-.060	.385		.187	-.055	-.164	.091
	Sig.	0.244	0.000		0.015	0.264	0.029	0.231
Reviews /all pubs	Rho (ρ)	.403	.289	.187		.351	-.258	-.213
	Sig.	0.000	0.000	0.015		0.000	0.001	0.042
EBP /all pubs	Rho (ρ)	.893	.712	-.055	.351		.144	**.424**
	Sig.	0.000	0.000	0.264	0.000		0.048	0.000
Diverse /all RS	Rho (ρ)	.072	.166	-.164	-.258	.144		0.048
	Sig.	0.203	0.027	0.029	0.001	0.048		0.351
Biglan Class	Rho (ρ)	.279	.331	.091	-.213	.424	0.048	
	Sig.	0.011	0.003	0.231	0.042	0.000	0.351	

Note. Diffusion characteristic correlations are in the upper left quadrant; additional characteristics in the lower right, and between variables in these groups, the upper right and lower left. "RSM/all pubs," the proportion of RSM publications, was calculated from the year continuous RSM use began to 2011. "Yrs RSM used" is the number of years of continuous RSM use. "Field Size" is the number of publications, 1992-2011. "Reviews/all pubs" is the proportion of reviews to all documents, 1972 to 2011. "EBP/all pubs" is the proportion of EBP to all documents, 1992 to 2011. "Diverse/all RS" is the proportion of diverse RSM to all RSM. "Biglan Class" was treated at the ordinal level, with 1="Pure", 2="Mixed", and 3="Applied." "Mixed" fields were identified as both pure and applied in prior studies.

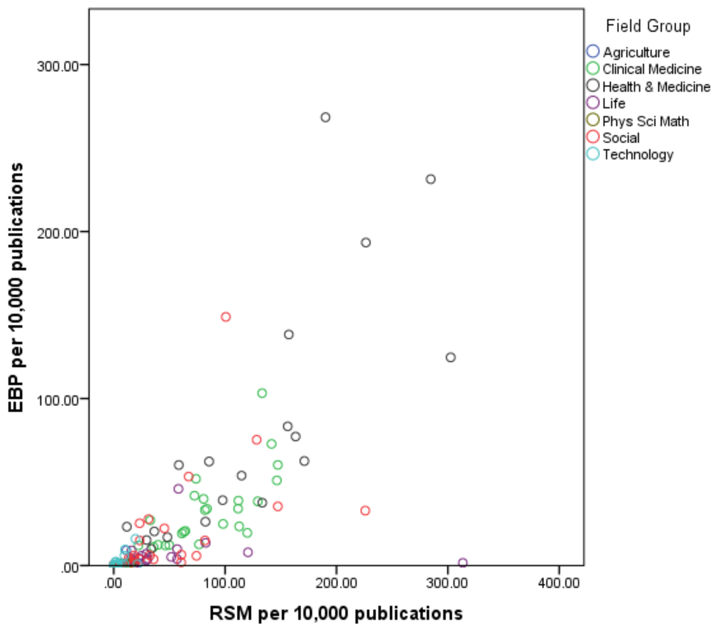


Figure 13. Relationship between proportions of EBP- and RSM-related publications

Note: EBP proportions include publications from 1992 to 2011, and RSM from 1972-2011. All proportions are per 10,000 documents.

Correlations between diffusion variables and the additional characteristics were generally small to moderate. Moderate correlations were observed between the proportion of reviews and proportion of RSM ($\rho = 0.403$, $p < 0.0001$); and between Biglan class and years of RSM use ($\rho = 0.331$, $p = 0.003$). Within the group of additional characteristics selected for examination, the strongest correlations were observed between the proportion of EBP and Biglan class ($\rho = 0.424$, $p < 0.001$), and reviews and EBP ($\rho = 0.351$, $p < 0.001$). Small negative correlations were observed between the proportion of reviews and diverse RSM ($\rho = -0.258$, $p < 0.001$), and Biglan class ($\rho = -0.213$, $p = 0.042$).

EBP engagement

The extent to which a field engages with evidence-based practice and policy may be an indicator of a greater interest in research synthesis methods, especially as these methods might be used to translate and transform research-based knowledge to inform professional practices. A number of prolific high-profile researchers (e.g., Sandelowski, Cooper, Glass, and Light) have worked at the nexus of research synthesis methods and EBP. The quintessential effort in this area comes from medicine and the health sciences: the Cochrane Collaboration.

Given that the EBP measure used in this study is relatively coarse, it is possible that the relationship between EBP and RSM is underestimated. At an anecdotal level, evidence of interest in using RSM to inform practice and policy decisions predates known usage of the phrase "evidence-based practice" by at least twenty years. For example, Light and Smith (1971) quote then-Senator Walter Mondale's address to the American Educational Research Association (AERA) as a motivating example of the need for the "cluster approach,… a means of combining the data of studies from which conflicting conclusions have been drawn" (p. (1)). Mondale, discussing the relationship between research and school integration policy states:

> What I have not learned is what we should do about these problems. I had hoped to find research to support or to conclusively oppose my belief that quality integrated education is the most promising approach. But I have found very little conclusive evidence. For every study, statistical or theoretical, that contains a proposed solution or recommendation, there is always another, equally well documented, challenging the assumptions or conclusions of the first. No one seems to agree with anyone else's approach. But more distressing: no one seems to know what works. As a result I must confess, I stand with my colleagues confused and often disheartened (Mondale, in Light & Smith, 1971, p. (2)).

While the strategy used to collect EBP data was not appropriate for collecting early EBP-like publications, it is also possible that recent publications have been missed. For example, there is some evidence that in some contexts, "evidence-based" phrases may be used less frequently as other phrases such as "research-informed practice" or the more broad and encompassing "translation science” become more prevalent. Hjørland (2011), for example, argues that “research-based practice” is preferable to EBP because it “is open to more fruitful epistemologies and provides a broader understanding of evidence” (p. 1301).

The level of engagement with EBP varies across and within fields (Figure 14). Fields in the Health & Medical Sciences group have engaged with EBP to the greatest extent. Fields in Clinical Medicine and Social Science, and a few other fields have also engaged with EBP to an extent. The relatively high proportion of EBP publications identified in some fields, such as Computer Science; and relative lack of EBP in others, such as the Veterinary Sciences is surprising. It would be necessary to collect more evidence to understand the relationship between EBP and these fields.

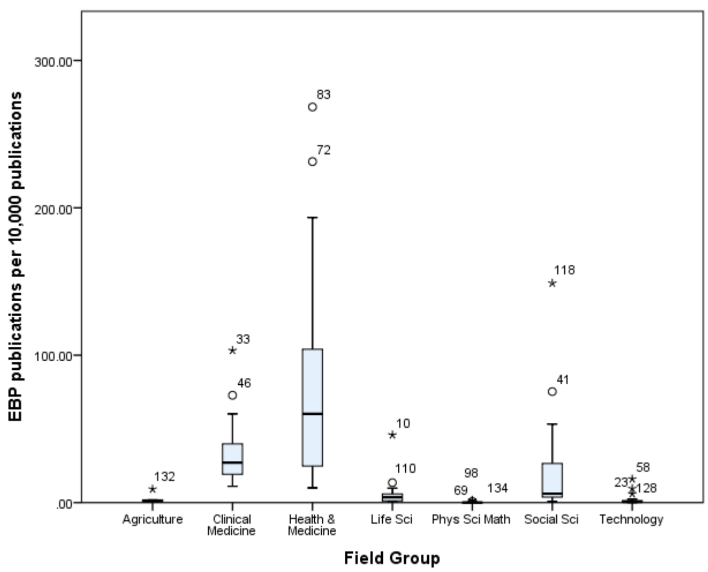


Figure 14. Number of EBP publications per 10,000 publications

Note: Numbers, used to label fields, not indicate quantities, identify: Agriculture: 132 = Veterinary Sciences; Clinical Medicine: 33 = Emergency Medicine, 46 = General Internal Medicine; Health & Medical Sciences: 72 = Medical Informatics, 83 = Nursing; Life Sciences: 10 = Audiology, Speech Language Pathology, 110 = Reproductive biology; Physical Sciences & Math: 69 = Mathematics, 98 =

Physical Geography, 134 = Water Resources; Social Sciences: 118 = Social Work, 41 = Family Studies; Technology: 23 = Computer Science, 58 = Information Science Library Science, 128 = Transportation.

Reviews: Resources dedicated to past research

Traditional literature reviews are one way that researchers bring past research to bear on contemporary problems. Researchers in fields that devote a greater proportion of resources to reviews may be interested in novel approaches to research integration. Conversely, if traditional review practices are viewed as a good fit for the field, researchers may be more reticent to adopt novel approaches, especially those as resource-intensive as systematic research synthesis methods. Low levels of review could also be better predictors of adoption of research synthesis methods in either direction. For example, some researchers might devote few resources to review activities because approaches of traditional reviews are seen as unhelpful – though past research is viewed as relevant. More likely, low levels of review in a field may indicate that researchers in a field do not value formal integration of past research compared to alternative initiatives.

Review prevalence: exploration and findings.

There has been a great deal of variation in the number of review papers published across fields and within fields over time. Figure 15 presents longitudinal count data for each field, normalized by annual counts of total publications. By field groups, there appears to be a general upward trend in the proportion of reviews – with the possible exception of the Social Sciences in recent years. The recent decrease in the proportion of reviews in a number of Social Science fields begins in 2010 after relative highs from around 2000 and just before through about 2009. Whether this reflects a change in publication practices, a change in the citation indexes, or something else is unclear.

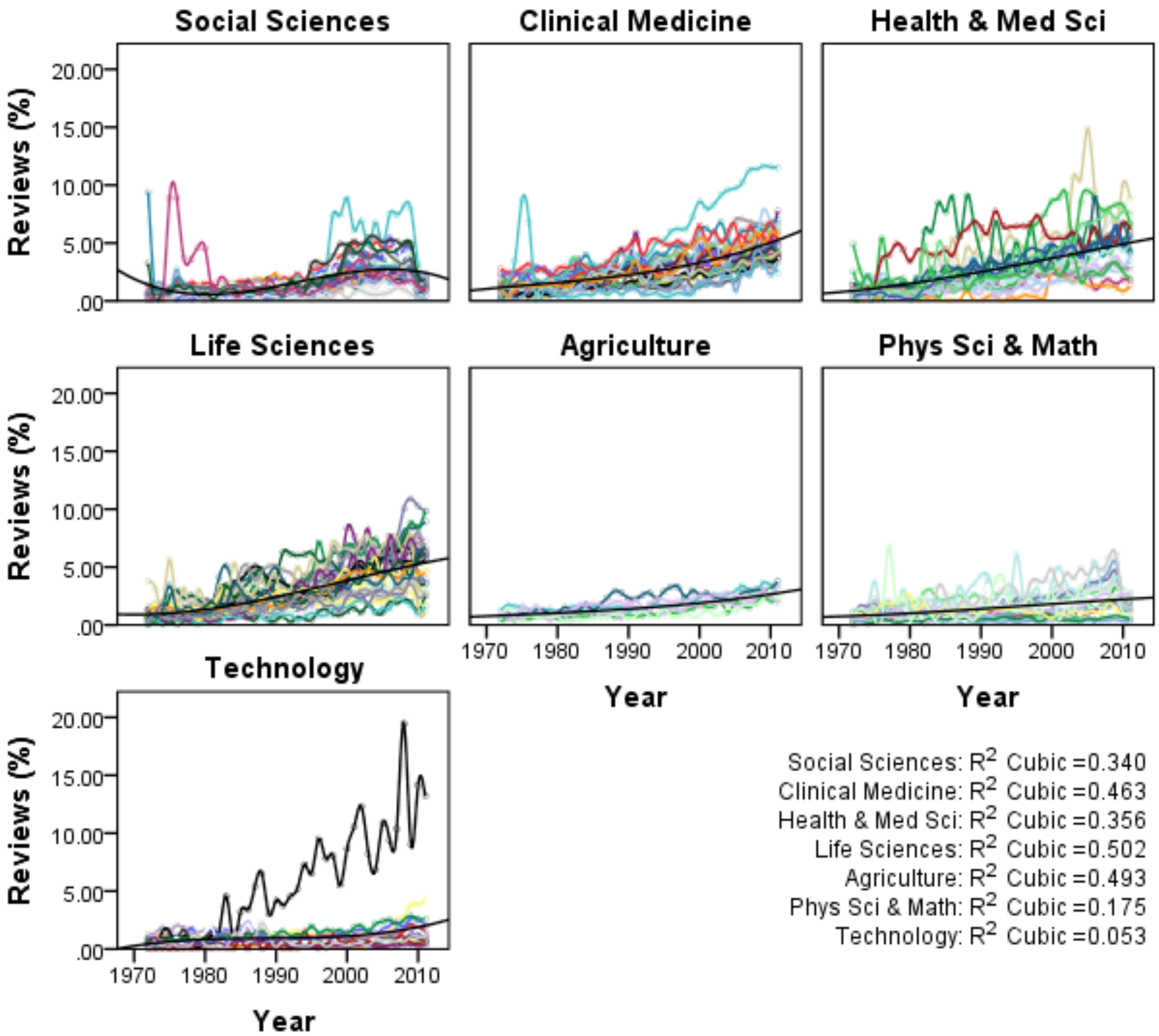


Figure 15. Proportion of reviews by field and field group

Note: Cubic interpolation lines were fit to each group to bring out field group-level trends. Proportion of review papers are expressed as a percent of documents of all types.

Field-level observations

Microscopy, a Technology field, had the greatest proportion of reviews in the Technology field group, and also the highest proportion of reviews for a single annual period (19.49%, in 2008). This observation is interesting not only because of the great number of Microscopy reviews in recent years, but also because Microscopy was the one field for which no RSM publications were found. The pronounced year-on-year differences in Microscopy may be related to size. Based on total number of publications (1972-2011), only 12 of 136 fields were smaller. A high proportion of reviews were also observed in Pharmacy and Pharmacology, a Clinical Medicine field, beginning in the early 1990s; and Anthropology, a Social Science, in the mid- to late 1990s.

With the exception of the Social Science fields "Mathematical Methods in the Social Sciences," and "Social Issues," and Forestry in Agriculture, only the Physical Sciences & Math and Technology groups include fields with an average proportion of reviews of less than one percent across all years (1972-2011). The average annual proportion of reviews for fourteen of twenty-one technology fields was less than one percent, and the average for six more was between one and two percent. In this field group, only Microscopy had a substantial average annual proportion of reviews, approximately 5.79%. The average annual percent of reviews in Information Science Library Science was just over one percent (1.03%). Physical Sciences & Math devoted a slightly larger proportion of resources to reviews. The average annual proportion of reviews was less than one percent for five of eighteen fields, and between one and two percent for eight others. Only five were greater than two percent. Within this group, Telecommunications had the highest average annual proportion of reviews (3.94%).

Correlations with diffusion and field characteristics

Review prevalence was moderately correlated with RSM engagement ($\rho = 0.403$, $p < 0.001$, see Figure 16) and EBP engagement ($\rho=0.351$, $p < 0.001$), but only modestly correlated with other factors, including years of RSM use ($\rho = 0.289$, $p < 0.001$), field size ($\rho = 0.187$, $p = 0.015$), proportion of Diverse RSM ($\rho = -0.258$, $p = 0.001$), and Biglan Class ($\rho = -0.213$, $p = 0.042$). These associations suggest that the relationship between reviewing practices and RSM engagement is not direct. Given the changes in the proportion of reviews over time within fields, it is also possible that measurement of reviews en masse from 1972 through 2011 has masked the relationship between reviews, RSM engagement, and other associated factors. The negative correlations between Biglan Class and EBP suggest that it may be beneficial to look more closely at the association between review prevalence and RSM in the context of more pure fields and also those that engage with EBP.

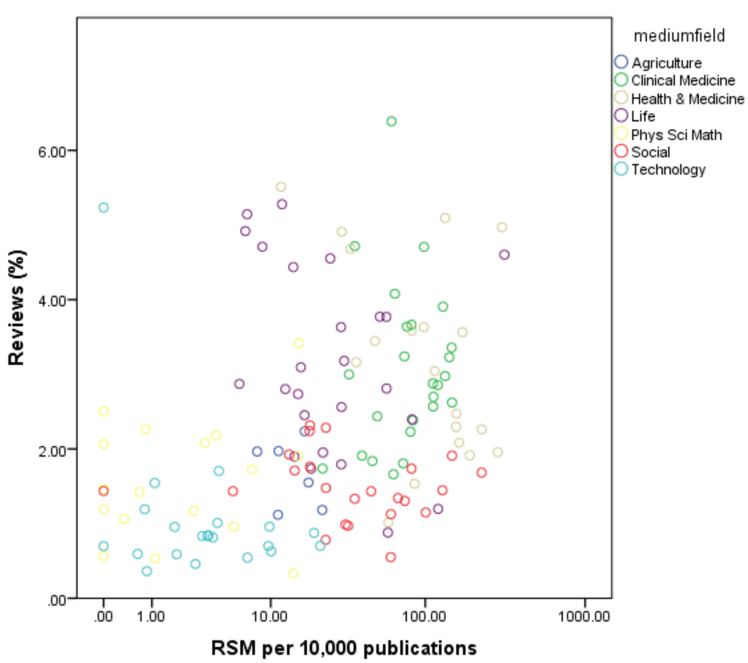


Figure 16. Scatter plot of review prevalence and engagement with RSM

Note: RSM engagement was plotted on a log scale.

Diversity of research synthesis methods

Diverse approaches to research synthesis could influence whether and to what extent researchers in a field adopt the methods. A diverse form could be imported from another field, or developed by researchers in the field. If the field was receptive to the diverse, adapted form of RSM, this might facilitate adoption of RSM. Though this is possible, data collected in the first stage of this study suggests that engagement with diverse forms of research synthesis was negligible in most fields during the time studied. Only 3,136 instances of a diverse RSM publication were found, and five or more 'diverse' publications were discovered in just over half the fields (76 of 136). Table 10 lists fields in which at least three percent of RSM publications were considered diverse.

Table 10. Diverse Research Synthesis Methods

Prop. Rank	Count Rank	Field	RSM pub counts Diverse	RSM pub counts All	RSM pub prop Diverse	RSM pub prop All	Years of RSM
1	52	Geography	11	58	18.966	0.232	8
2	25	Public Administration	30	219	13.699	0.233	21
3	72	Energy Fuels	5	37	13.514	0.142	6
4	64	Urban Studies	7	53	13.208	1.117	12
5	18	Sociology	40	329	12.158	0.183	30
6	50	Operations Res Mgmt Sci	12	112	10.714	0.041	18
7	16	Biomedical Social Sciences	47	466	10.086	0.856	22
8	4	Nursing	204	2,148	9.497	1.901	30
9	11	Computer Science	65	717	9.066	0.096	26
10	48	Transportation	13	152	8.553	0.568	18
11	20	Information Sci Library Sci	34	408	8.333	1.465	21
12	40	Linguistics	17	209	8.134	0.312	23
13	9	Social Sciences Other Topics	92	1,152	7.986	0.455	32
14	41	Math Methods: Social Sci	17	216	7.870	0.725	22
15	6	Education Educ Research	172	2,431	7.075	0.673	37
16	53	Social Issues	11	160	6.875	0.145	22
17	22	Social Work	33	490	6.735	0.836	28
18	37	Evolutionary Biology	18	313	5.751	1.333	18
19	27	Government Law	27	488	5.533	0.133	25
20	3	Health Care Sci Services	217	3,970	5.466	2.264	24
21	15	Mathematics	53	1,171	4.526	0.142	27
22	8	Environmental Sci Ecology	94	2,204	4.265	0.294	26
23	17	Medical Informatics	45	1,070	4.206	2.846	26
24	56	Biodiversity Conservation	10	238	4.202	0.825	16
25	24	Engineering	32	762	4.199	0.034	24
26	51	Science Tech Other Topics	12	305	3.934	0.018	27
27	38	Family Studies	18	532	3.383	1.283	25
28	2	Public Env Occ Health	264	7,875	3.352	1.633	30
29	29	Mathematical Comp Bio	23	688	3.343	1.205	22
30	54	Zoology	11	359	3.064	0.112	22

Fields that included more than one hundred diverse RSM publications were: Psychology (302 publications), Public Environmental and Occupational Health (264 publications), Health Care Sciences Services (217 publications), Nursing (204 publications), General Internal Medicine (189 publications), Education and Education Research (172 publications), and Business Economics (105 publications).

In the Spearman's rho (ρ) correlation analyses, the proportion of Diverse RSM was found to correlate with the number of years of RSM use ($\rho = 0.166$, $p = 0.027$), field size ($\rho = -0.164$, $p = 0.029$), proportion of reviews ($\rho = -0.258$, $p = 0.001$), and EBP engagement ($\rho = 0.144$, $p= 0.048$). The magnitudes of the correlations were modest, and no association was found between the proportion of Diverse RSM and the overall proportion of RSM.

These preliminary findings may be influenced by how diverse RSM were defined and the search strategy used to identify diverse forms of research synthesis. Conceptually, diverse forms of research synthesis were defined based on the overall process of synthesis. As a result, incremental introductions of novelty that contribute to the development of diverse approaches were excluded. Second, only records that either cited a seed publication or retrieved through a keyword judged to be diverse were categorized as diverse. While these terms and seed publications might be appropriate for some fields, they may not be applicable more widely. It is also possible that diverse forms of research synthesis draw on the more traditional and widely used terms. For example, in Evolutionary biology, the development of phylogenetic meta-analysis was important. Whether this should qualify as a diverse form of RSM would need to be examined. This example is intended to suggest that the search strategy used made assumptions about the language researchers would use to describe methods.

Other possibilities include that Diverse RSM contribute indirectly to diffusion of RSM overall, or that it is only important in niche communities.

Biglan Classifications

Data from prior studies consulted to classify fields as more pure or applied were matched with only sixty-seven of the one hundred thirty-six fields. Thirty-two fields were identified as applied, thirty-three as pure, and two, which were classified differently across studies, as "Mixed." Though, as Biglan (1973a) emphasizes, the pure-applied dimension is continuous and fields fall at different locations, the data indicate there was an association between Biglan class and other variables.

Moderate correlations were observed between Biglan class and EBP engagement ($\rho = 0.424$, $p < 0.001$) and years of RSM use ($\rho = 0.331$, $p = 0.003$). More modest correlations were found between Biglan class and RSM engagement ($\rho = 0.279$, $p = 0.011$) and review prevalence ($\rho = -0.213$, $p = 0.042$). The association between Biglan class and EBP supports the idea that EBP is more relevant to more applied fields. As previously noted, the association between Biglan class and both years of RSM use and RSM engagement are likely explained in part by the historical relationship between the EBP movement and diffusion of RSM. The negative association between Biglan class and review prevalence suggests that more pure fields are likely to devote more resources to review activities. In literature related to research synthesis (e.g., Cooper & Hedges, 1994; Light & Smith, 1971) it has been suggested that RSM are important because they can contribute to the cumulative nature of research-based knowledge. It would be interesting to learn whether the nature of fields, pure or applied, moderates the relationship between review prevalence and RSM engagement; and also whether researchers in more pure fields cite the accumulation of knowledge as a reason RSM should be used.

It should be noted that though, technically, it was appropriate to use Spearman's rank correlation statistics as an indicator of association with Biglan class data since data were ordered to indicate whether a field was less applied (i.e., more "pure") to more applied in nature. However, there were only three levels. A more fine-grained understanding of the relationship between Biglan class and other dimensions of research fields in the context of research synthesis could be obtained with data that (a) represents where fields occur on the continuum between "pure" and "applied" at more fine-grained levels; (b) are indexed by date or time period of collection; (c) include judgments from researchers across fields more broadly; and (d) include judgments for a greater number of research fields.

Transition from Stage I to Stages II and III

The transition from Stage I to Stages II and II involved selection of fields for examination and transition from *Web of Science* categories to science fields in order to support contextualized field-level interpretations of data. A discussion of these components of the transition phase follows.

Selection of fields for more in-depth examination

Stage I observations, considered in light of my professional and educational background and factors associated with study feasibility, informed selection of fields to examine in Stages II and III. From the Life Sciences field group, Evolutionary Biology and Conservation Biology were selected; and from the Social Sciences field group, Social Work and Women's Studies. One field, the "meta-discipline" (Bates, 1999) Information and Library Science (ILS), was selected in advance. Selection of ILS offered the opportunity to investigate how ILS intersects with diffusion of research synthesis methods internally and in relation to other fields.

Field selection criteria

In order to select fields, a summary data table that included data on each factor examined in Stage I was consulted. First, to ensure project feasibility, fields with more than 1000 or less than 150 research synthesis-related publications were eliminated. The remaining 46 candidate fields were then examined. Within this set of fields, two overarching subject categories, "Science Technology Other Topics" and "Life Sciences Biomedicine Other Topics"; fields with low incident rates of research synthesis-related publications; and Clinical Medicine fields, which have been relatively well studied, were eliminated. Additionally, "Integrative & Complementary Medicine", which Boyle (2012) examined in a study that complements this project, was eliminated.

The remaining 32 candidate fields included 3 fields from the Agriculture field group, 4 from Health and Medical Sciences, 13 from Life Sciences, 11 from Social Sciences, and 1 from Technology. These fields were examined to identify sets that would be diverse yet complementary. Criteria considered include the extent of engagement with research synthesis methods, when a field began to engage with the methods, whether a field was considered more "pure" or "applied", the level of engagement with evidence-based practice, the extent of engagement with past research, and overall field size. Preference was also given to fields associated with field groups that have received less attention with respect to research synthesis. This preference was cautionary in that I wanted to limit the potential for overlap with prior or on-going studies; and forward-looking since data or results from complementary studies might one day be synthesized with those of this study. For analytical purposes, fields that included essentially the same content across *Web of Science* Categories and Subject Areas were also preferred.

Unique field characteristics and accessibility of fields to me as a researcher were also considered. For example, Stage I results suggested that Women's Studies researchers engaged with research synthesis methods to a considerable extent, though with relatively few publications using 'diverse' forms of research synthesis. This was surprising given that Women's Studies research is generally considered to favor qualitative, interpretive, or critical approaches. Therefore, Women's Studies was selected in part because this field seemed to present an anomaly. Information Science Library Science was selected in advance because I consider it my 'home' field; and Evolutionary Biology was selected in part because of my Research Assistantship at the National Evolutionary Synthesis Center (NESCent), my undergraduate training in botany, and basic work experience in botany and ecology. The latter two experiences also influenced selection of Biodiversity / Conservation. Finally, in my studies in Information and Library Science, I have become familiar with some research and theory in the Social Sciences, which makes these fields more accessible to me.

It is necessary to be cautious about retrospective discussion of personal factors that influenced field selection – even though these personal factors were considered prospectively. More specifically, I might have selected other fields based on other experiences. For example, in addition to botany, I took classes and worked in horticulture; and, in my Information and Library Science training, work experience, and literature review for this study, I have been exposed to research and literature resources associated with the health sciences. I might have drawn on these experiences to support selection of fields from Agriculture or the Health and Medical Sciences. Fields that I seriously considered but did not select include: Veterinary Sciences from the Agriculture field group; Biomedical Social Sciences and Substance Abuse from the Health and Medical Sciences field group;

Criminology/Penology, Linguistics, Mathematical Methods in Social Sciences, Public Administration, and Sociology from the Social Sciences field Group; and Transportation from the Technology field group.

Summary of Stage I observations for selected fields

The selected fields from the Life and Social Sciences field groups, Evolutionary Biology, Biodiversity / Conservation, Social Work, and Women's Studies complement each other based on relationships with larger field groups identified in this study; and in that two are generally considered more applied and two more pure in orientation (Figure 17). ISLS complements the selected fields as a 'meta-discipline' that is concerned with the informational characteristics of the selected fields.

	Pure	Applied
Life Sciences	Evolutionary Biology	Biodiversity/ Conservation
Social Sciences	Women's Studies	Social Work

Figure 17. Complementary characteristics of selected fields

Biglan studies categorized Evolutionary Biology as a more pure science. Though Social Work is generally thought of as an applied field, prior Biglan Studies resulted in a "Mixed" pure/applied categorization. Prior Biglan studies did not examine Biodiversity/Conservation (or Conservation Biology), ISLS, or Women's Studies. Generally, Conservation Biology and ISLS are thought of as more applied, and Women's Studies may be thought of as 'mixed' or more pure. The selected fields also differ in the proportion of field resources devoted to reviews: The two life sciences have engaged more with past research, as gauged by the number and proportion of reviews identified based on the *Web of Science* 'Document Type' field. Lower levels of engagement with past research were observed in Social Work and ISLS, and almost none in Women's Studies (Table 11).

Table 11. Macro-level overview of field characteristics

	Evolutionary Biology	**Biodiversity Conservation**	**Social Work**	**Women's Studies**	**Info Science Library Sci.**
Field Group	Life Sciences	Life Sciences	Social Sciences	Social Sciences	Technology
Year use of research synthesis methods began					
1st Year	1990	1994	1982	1985	1985
Continuous Year	1994	1996	1984	1987	1991
RSM proportions (*Number of RSM-related documents per 10,000 documents overall*)					
First Year	33.725	54.158	78.658	66.909	17.426
Continuous Year	313.387	56.953	100.641	81.873	19.477
Evidence-based practice prevalence					
EBP Count	14	45	552	50	320
EBP per 10,000	1.58	9.85	148.89	15.00	16.01
Review prevalence					
Reviews (%)	4.762	5.686	1.326	0.120	0.882
Diverse forms of research synthesis methods					
Diverse Count	18	10	33	7	34
Diverse RSM/ All RSM (%)	5.75	4.20	6.73	2.33	8.33
Pure versus applied science: Biglan measure					
Biglan	P	n/a	Mid	n/a	n/a

Engagement with research synthesis varied across the selected fields during the time period examined– the number of documents associated with RSM ranged from less than twenty (ISLS) to over 300 (Evolutionary Biology) per 10,000 publications. The Life Science fields were later adopters of RSM: first use and continuous use began in the 1990s for both fields. The Social Science fields adopted RSM in the 1980s. EBP has been very important in the field of Social Work, and to a much lesser extent in Women's Studies, Information Science Library Science, and the Life Science fields.

Translation: From *Web of Science* categories to science fields

In order to understand diffusion and use of research synthesis methods within science fields, it is necessary to develop an understanding of the historical development and context of research within each field. Therefore, fields have been interpreted in light of field descriptions identified by researchers in the literature and *Web of Science* category scope notes and journal title coverage. *Web of Science* category scope notes for the five selected fields are presented in Table 12 and journal titles as indicated in the 2012 *Journal Citation Reports*, downloaded in September 2013 are identified in Appendix H. The *Web of Science* Categories (WCs) and Research Areas (SUs) aggregated equivalently in fields analyzed in Stages II and III (Appendix A, Table A1).

Table 12. *Web of Science* Category scope notes for selected fields

***WOS* Category**	**Field interpretation**	***WOS* scope note**
Evolutionary Biology	Evolutionary Biology	…the molecular, natural selection, and population mechanisms of evolution; the evolution of species and related groups; the classification of organisms based on evolutionary relationships; and the biology and ecology of extinct organisms.
Biodiversity Conservation	Conservation Biology	…conservation management of species and ecosystems. Topics include conservation ecology, biological conservation, paleobiology, natural history and the natural sciences.
Women's Studies	Women's Studies	…interdisciplinary topics such as women and health, women's psychology, women and politics, as well as gender studies and feminism.
Social Work	Social Work	…homelessness, social casework, social services, social work education, public welfare, family counseling, child welfare and abuse, social work administration, social work with groups, and gerontological social work.
Information Science & Library Science	Information & Library Science (plus some Management Information Science, focus on ILS)	…a wide variety of topics, including bibliographic studies, cataloguing, categorization, database construction and maintenance, electronic libraries, information ethics, information processing and management, interlending, preservation, scientometrics, serials librarianship, and special libraries.

Summary: Stage I Results

Research synthesis methods have diffused broadly across science. Relatively modest engagement with the methods in the 1970s and 1980s was followed by expansion in both the extent of engagement and diversity of fields that engaged with the methods in the 1990s. Engagement with the methods continued to increase and spread to a greater diversity of fields through the first decade of the 2000s.

Measures of association between the extent of engagement with research synthesis methods within science fields indicate engagement with EBP ($\rho = 0.893$, $p < 0.001$) and the number of years a field has engaged with the methods ($\rho = 0.706$, $p < 0.001$) are strongly related. A relatively weak association between engagement with the methods and whether a field is more “pure” or “applied” in nature based on prior studies ($\rho = 0.279$, $p = 0.011$) presents an interesting contrast to the level of association with EBP. The difference in levels of association may in part be explained by a lack of engagement with the methods in technology-focused fields. However, limitations associated with the Biglan class data, which include the age of studies used to identify whether a field was more pure or applied and gaps in coverage of fields within studies, may have contributed to the difference in magnitudes of association between EBP and RSM engagement versus Biglan class and RSM engagement.

An association between the extent to which fields engage with past research and engagement with research synthesis methods was found, though the strength of that association was only moderate ($\rho = 0.403$, $p < 0.001$). To an extent, this finding supports commentary that suggests the methods are used to cope with vast quantities of research information in some fields.

Patterns observed in Stage I analyses informed selection of two Life Science fields, Evolutionary Biology and Conservation Biology, and two Social Science fields, Social Work and Women's Studies, for more in-depth analysis in Stages II and III. A fifth field, Information and Library Science, was selected in advance.

CHAPTER 4. STAGES II AND III: FIELD-LEVEL DIFFUSION CONTEXTS AND IMPACTS

The goal of the second stage of this research was to examine the diffusion of research synthesis methods at a more granular level in the contexts of five diverse fields: Conservation Biology, Evolutionary Biology, Social Work, Women's Studies, and Information and Library Science. The third stage focused on the impact of the methods in each field through a comparison of the use of research synthesis methods publications versus traditional literature reviews; and collaboration patterns associated with the production of research syntheses versus literature reviews. Findings across Stages II and III are presented together in the context of each field, and then discussed in a comparative context across fields. Data cleaning processes and coding reliability are discussed prior to field-level presentations. Research at Stage II was guided by the research questions:

RQ2.1. To what extent has research synthesis diffused within the selected fields?

RQ2.2. How do field contexts influence adoption and use of research synthesis?

RQ2.3. What trends emerge when adoption and use are examined across science fields?

In order to understand field engagement with research synthesis methods at a more granular level, the following attributes of research synthesis use and discussion were examined:

- How each field has engaged with research synthesis (e.g., use method, development of tools for those who perform research synthesis, modifications or development of novel methods or techniques, evaluations of use).
- Support for studies that use research synthesis methods (funding and establishment of

centers / institutions);

- The knowledge base that informs syntheses.
- Topical content of publications related to research synthesis

How each field has engaged with research synthesis, or modes of engagement was examined to determine the extent to which researchers in the field actually used the methods; and to identify publications that related to the methods in other important ways. For example, if researchers are motivated to use research synthesis but available methods are not compatible with research in the field, we would expect some members to contribute work to adapt the methods to the field. Similarly, since the availability of previous research and methods of primary study identification and selection are essential to conducting research syntheses, researchers might be expected to discuss literature resources. Given the example of the Cochrane Collaboration in the health and medical sciences, it is possible that organizational resources would be an important theme. Resource availability was also examined through review of reported funding sources. The knowledge base was examined as an indicator of the origin of resources that contribute to research synthesis publications; and topical content as an indicator of the content of research synthesis publications.

Across the research fields examined in Stages II and III, research practices have changed to an extent by virtue of the fact that some researchers in the fields use research synthesis methods. Stage III of this study is intended to examine shifts in how research is practiced as it relates to collaboration patterns and use of research synthesis studies.

Research synthesis is generally regarded as a relatively new form of review. Unlike traditional reviews, authors who perform a research synthesis follow a method and conduct the synthesis as a research study. In doing so, it is often necessary to incorporate judgments made by multiple researchers to assess study attributes such as relevance and whether a study meets study appraisal criteria. Therefore, if a field adopts research synthesis methods, it is possible that shifts in practice would be observed in terms of resources (number of authors) required to perform a research synthesis versus a review and greater use of research syntheses versus reviews. Therefore, whether collaboration patterns and use of research syntheses and traditional literature reviews differs was examined. Research at Stage III was guided by the research questions:

RQ 3.1: How do research syntheses and traditional literature reviews differ in terms of the number of collaborating authors?

RQ 3.2: How do research syntheses and traditional literature reviews differ in terms of the extent to which they are used by researchers?

RQ 3.3 What do findings of RQ3.1 and RQ3.2 reveal when compared across science fields?

Stage II: Data Collection

Research synthesis publications were examined across *Web of Science* categories for each field selected for more in-depth analysis at Stages II and III. *Web of Science* records collected during Stage I of this research comprised the primary data of analysis. *Web of Science* records were supplemented with material from full text versions of publications as noted in the analysis section. Novel data was generated through content analysis of publication metadata.

Coding

Since the publications in the data set were expected to relate to research synthesis in a number of ways, article titles, abstracts, and author keywords were analyzed to define their relationship with research synthesis. In addition to articles that implement research synthesis methods and those that comment on use of the method, articles that relate to research synthesis in other ways were also of interest. To the extent possible, metadata from *Web of Science* records corresponding with this information was used. In cases where no abstract was available in the *Web of Science* record, article full text was sought via the University of North Carolina Library Services. If an abstract was available through the libraries, it was added to the *Web of Science* records. For publications that did not have abstracts, the introduction was used. If publications did not have a clear introduction, full text of the item, minus article meta-data and references, was summarized using smmry.com, a text summarization web service, and the summary was included in lieu of an abstract. Preliminary testing indicated use of PDF files as a full text source had some limitations because repeated page headers (e.g., journal titles) were sometimes included in summaries. Therefore, in cases where another format, such as text or html, was available, the non-PDF format was used.

Coding categories were established to identify whether publications related to research synthesis methods directly, indirectly, not at all. For publications that related to research synthesis methods directly, how the item related to research synthesis was determined using a non-exclusive category system. Categories available included: (1) reports a research synthesis study; (2) develops research synthesis methods; (3) develops resources for research synthesis; (4) study or evaluation of research synthesis methods; (5) discusses research synthesis; (6) introduces research synthesis methods; and (7) relates to research synthesis in other ways (Table 13). Publications were assigned codes based on abstracts. In cases where additional information was needed to determine one or more categories, a question or note describing information needed to make a determination was recorded. Full texts of articles were then searched for the answer to the question, and the article was coded accordingly. Second coders were asked only to describe what information would be needed to code an article if it was not apparent from the title, abstract, and author keywords.

Table 13. Coding categories assigned to sample research synthesis publications

Code Category	Definition and description
No apparent relation (false positive)	No evidence that the publication directly relates to research synthesis
Secondary / weak relation only	Publication ONLY presents a weak, secondary, or tangential link to research synthesis: For example, secondary use of RSM products (e.g., for use in systems, or policy guideline development). Publications that focus on evidence based practice only, and not research synthesis coded as having a secondary or weak relationship to research synthesis.
Direct primary relation	Relates to research synthesis in one of the ways described below.
Reports RS Study	Reports research synthesis study, including as a demonstration
Develop RS Methods	Development of methods may refer to the development of new methods for research synthesis overall, or an incremental innovation in how research synthesis is performed. Development of a new way to perform any of the steps within a research synthesis study, including search, retrieval, assessing studies for relevance, study appraisal, judgment and extraction of relevant information, combination of results, summarization, dissemination/ public presentation and so on, would be considered development of RS methods.
Develop RS Resources	RSM resources development includes development of resources such as databases, software, study appraisal tools, and human skills specifically for use in subsequent research synthesis studies. Publications that review or evaluate resources for research synthesis studies coded in this category.
Study/evaluate RS Methods	Publication reports a study or evaluation of RSM use, methods, resources, and so on.
Discuss RS	Discussion may be about use of research synthesis methods, issues or opinions related to using research synthesis methods, and so on. The discussion may focus on research synthesis methods generally, or a specific research synthesis study or publication. Book reviews that discuss a publication related to research synthesis methods coded as "Discuss RS".
Introduce RSM	Introduces research synthesis methods to a field or community: The language in the abstract, title, and/or keywords suggests the publication is introducing research synthesis methods to a community.
Other	Paper directly related to research synthesis in a way other than those indicated by other coding categories. "Other" relationships briefly noted.

Reliability

To determine the extent to which coding was reliable, a field-stratified random sample of records was identified for coding by additional coders. Fields were randomly sampled to include at least 10% or forty items, whichever was greater (Table 14). Combined, the number of items to be coded exceeded the minimum of at least 10% or fifty items recommended by Lombard, Snyder-Duch and Campanella Bracken (2002). Items for coding by second coders were kept to a minimum because full text of items other than false positives was to be examined in subsequent stages of this research; and because of a lack of resources for coder compensation. One person was recruited to code the random sample of records for each field. When recruiting coders, preference was given to individuals with subject-area expertise, familiarity with research synthesis methods, or both. Inter-rater reliability is reported with percent agreement and Cohen's kappa for each coding category across fields.

Table 14. Publications for coding by multiple coders, by field

Field Name	Items identified in Stage I	Items for coding by multiple coders	
		Count	Percent
Evolutionary Biology	313	47	15.0
Conservation Biology	236	48	20.3
Social Work	490	49	10.0
Women's Studies	299	45	15.0
Information Science Library Science	406	41	10.0
All fields	1744	230	13.2

Descriptive publication data

In addition to content analysis, selected elements from *Web of Science* records associated with publications determined to have a relationship with research synthesis methods based on coding were analyzed to determine the publication years of records, journals of publications, and whether authors indicated financial support. Though financial support data is available in *Web of Science* records for a limited number of years (2008-2011 at the time this data was collected), it was examined as an indicator of resource availability.[22] Cited references were processed and visualized with bibliometric mapping to understand the knowledge base that informs research synthesis-related publications. Publication titles, abstracts, and keywords were processed and visualized using topic models to develop overviews of content related to research synthesis methods. Table 15 indicates fields from which data was extracted directly from *Web of Science* records for the analyses.

Table 15. Data extracted from *S/SCI* records without coder intermediation.

Element	***S/SCI* record field(s)**
Author	AU
Title	TI
Abstract	AB
Publication year	PY
Journal title	J9
Grant funded	FU, FX
Cited references	CR

Stage II: Data summarization, analysis, and visualization

Publication year, journal title, funding, and author data from *Web of Science* records were used to present tabulated results and trends. The Gini coefficient, a measure of balance (Stirling, 2007), is used to report proportional distribution of publications across *JCR* journal titles for each field. This measure was chosen because of its association with the Lorenz curve, an inverted version of which is used to visualize publication distributions. In the context of the Lorenz curve, the Gini coefficient

[22] More comprehensive funding data could be collected from publication acknowledgments, a step which would have required greater resources than those available for this study.

describes the area between a curve that describes the observed cumulative distribution (of publications) across units (journals) and a diagonal reference line (x (%) = y (%)) that describes what an equal distribution of resources across units would look like. Therefore, a Gini coefficient closer to zero describes a more even distribution of resources.

To communicate the content of publications related to research synthesis in each field, a thematic summary of publications that did not report research syntheses, but directly related to the methods in other ways, was performed based on the full text of publications. These publications provide insight into topics of concern related to the methods, and communication between authors surrounding the methods. Additionally, subjects – or topics of publications directly or indirectly related to research synthesis – were visualized with topic modeling.

Topic models

Topic models were developed to summarize RSM-related publications using a variational Bayes implementation of Latent Dirichlet Allocation (LDA) (Asuncion, Welling, Smyth, & Teh, 2009; Blei, Ng, & Jordan, 2003; Ramage & Rosen, 2011). Publications were represented by word co-occurrences in titles, author keywords, and abstracts using a 'bag of words' approach. Text preprocessing included removing labels from structured abstracts, applying the Porter stemmer, and identifying stop words and frequently occurring words. The number of topics selected was informed by perplexity scores for 5 to 30 topics (Ramage & Rosen, 2011), such that local perplexity minima were preferred. Topic labels for the four topic-oriented fields consist of word stems most frequently associated with each topic. Topic labels were assigned for Information and Library Science publications through examination of frequent topic words and documents for which more than eighty percent of the content was associated with the topic under consideration. If there were no documents meeting the eighty percent threshold corresponding to a given topic, the three publications with the highest proportion of content related to the given category were examined for common themes that corresponded with topic words. ILS was treated differently given my greater familiarity with research in the field. When interpreting topic maps in all fields, both topic words and documents primarily associated with the given topic were considered.

The document-topic matrix, which describes topic distributions across documents, was visualized in *Gephi* (Bastian, Heymann & Jacomy, 2009) as a bimodal network. Network partitions were identified by the Louvain algorithm (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008) and are represented by color. Topic nodes were sized in proportion to the sum of associated document proportions, and edge thresholds were applied to reduce visual complexity. Overall, this approach can be described as a quantitatively guided qualitative overview of publication content.

Bibliometric knowledge base maps

Publications referenced by research synthesis publications in each field were overlaid on a global map of science to identify the knowledge base contributing to research in each field. Cosine-normalized citation patterns across science reported in the 2010 *Journal Citation Reports* (*JCR*), aggregated by *Web of Science* categories, are the basis of the global science network (Rafols, Porter, & Leydesdorff, 2010). Citation patterns represent cognitive or socio-cognitive similarity between science fields, for which the categories are considered a proxy. The base map was visualized in *Pajek* (Batagelj & Mrvar, 2010) and overlaid with counts of references identified from the Cited Reference (CR) field of *Web of Science* records. In order to attribute references to *Web of Science* categories, the CR field was parsed to identify journals of publication. For each CR entry with a journal included in the *JCR,* the given entry was mapped to *Web of Science* categories to which the journal was assigned in the 2010 *JCR* using a journal title-category thesaurus, and the number of mappings counted. In the bibliometric knowledge base maps, nodes represent fields, and are sized in proportion to the number of references observed. Though the number and distribution of references varies widely across fields, equivalent size proportions were used across the five fields to facilitate cross-field comparisons. Shannon evenness and Rao-Stirling diversity (Stirling, 2007; Rafols & Meyer, 2010) describe the distribution of references across science fields. Shannon evenness is a ratio of Shannon entropy, which measures abundance and evenness of entities across categories, to the maximum entropy possible. Rao-Stirling diversity accounts for distribution across fields, and the degree to which fields differ. Difference between fields is estimated with the citation matrix used to construct the global map of science.

Stage III: Data Collection[23]

Stage III data was comprised of the *Web of Science* records identified in Stage II and *Web of Science* 'Review' records published between 2006 and 2008. At the inception of this research, it was planned to use *Web of Science* 'Document Type' fields to identify reviews. On download of records classified as Document Type 'Review', it became apparent that many records were not associated with review publications. A recent study of meta-analysis in psychology suggests similar findings (Barrios,

[23] Preliminary results from a repeatable approach to data collection using *Web of Science* and *Scopus* are included Appendix K. Data collected following this method tended to miss earlier items published by Springer, dropped a few titles due to differences in *Web of Science* and *Scopus* indexes, and dropped at least one volume of a title (*ARIST*, 2008) due to missing DOIs in *Web of Science*. Only two publications with malformed DOIs were noted, both in the *British Journal of Social Work* (due to substitution between an "l" and a "1").

Guilera, & Gomez-Benito, 2013). Rather than use a proxy believed to be extremely inaccurate, I made the decision to systematically categorize publications as research reviews, original research, other, or research syntheses (Table 16). In addition to the broad information provided by *Web of Science*, *Scopus* document classifications, publication headings, and researcher claims in publications were taken into account. Additionally, where needed, journal scope notes and author guidelines that specify the types of items published were consulted.

Table 16. Categories assigned to publications of document type "review"

Field	Review	Research Synthesis (in RS search)	Original Study or Other	Not available	Total
Evolutionary Biology*	146	16 (4)	231	10	403
Conservation Biology	121	48 (23**)	199	14	382
Social Work	45	41 (17)	50	0	136
Women's Studies	23	13 (3)	61	4	101
Information & Library Science	92	34 (21)	179	32	337
Total	**427**	**152 (68)**	**720**	**60**	**1359**

* 2007 only

**At least one study in the 'review' download and identified as a research synthesis should have been found with the initial search used in Stage I but was not: "meta-analysis" was included in the title of this study. The paper may have been added retrospectively.

Assignment to research reviews versus original research versus research synthesis versus 'other' types of publication incorporated triangulation: The *Web of Science* 'document type' set the outermost perimeter of publications to be examined, and the remaining sources refined this classification. *Scopus* document categorizations were examined, as were the title, full text, and supplement files.

Publications that reported methods that involved collection of novel data, including studies presented as content analyses of research, popular media, and other text documents were considered original research articles. Items tagged as "Book Reviews" on the publication site were categorized as "other". Only reviews of research were categorized as "research reviews". Other types of reviews, including reviews of policy, flora, fauna, and the geographic extent of species were categorized as either "Original Study" or "Other", depending on methods and data collection presentation. Social Science papers that focused on theory or model building, though often drawing extensively from literature review, were categorized as "Other". Journals typically identified towards the Management Information Science side of the Information Science Library Science category spectrum tended to publish theory papers. Publications were identified as a research synthesis if the paper presented a meta-analysis of findings or data across two or more publications; or if the author met four of seven criteria: Any of the six criteria specified by Cooper and Hedges (1994) and labeling or description of publication that is a close synonym of the search phrases used to define research synthesis in Stage I of this project (e.g., "synthesis of research").

DOI's, where available in *Web of Science* records, were used to search *Scopus* for corresponding records, which were then downloaded and matched to *Web of Science* records using the DOI fields. Book reviews and other forms of secondary works identified by *WOS* as reviews are not indexed by *Scopus*, and therefore it was easy to systematically verify assigned categorizations. Generally, while *Web of Science* tended to include a large number of items that are not reviews, *Scopus* tended to exclude items that were. For example, items indicated as a literature review in the title but not on the publisher's site were not identified as literature reviews in *Scopus*. Due to the need to access the text of documents, items which were not available from the University of North Carolina Libraries, Duke University Libraries, or otherwise accessible online were excluded; as were items written in languages other than English.

At the inception of this research, it was anticipated that comparison of reviews versus research syntheses would first be considered for one year, the most recent year for which five years of citation data was available (2008), and prior years would be examined only if a difference between reviews and syntheses was discovered. However, limiting analysis to one year generally would have included a small number of studies in the comparison. Therefore, three publication years (2006-2008) were included in comparisons for all fields except Evolutionary Biology. Data analysis, described below, was augmented to account for inclusion of multiple publication years.

Only one year (2007) of Evolutionary Biology publications was included because it was not feasible to categorize reviews for all three years. While 382, 136, 101, and 337 publications of document type "review" were published 2006-2008 in Conservation Biology, Social Work, Women's Studies, and Information and Library Science, respectively, 1226 Evolutionary Biology publications were identified. In addition to the number of publications, Evolutionary Biology publications were more likely to include supplements, which were necessary to review for methods details. Even with a modest estimate of fifteen minutes per item, it would have taken over 300 hours to categorize Evolutionary Biology "reviews" published 2006-2008.

Citation and collaboration data

Citation data records for publications categorized as research reviews or research synthesis were downloaded from *Web of Science* on 10 February 2014. All records were identified through *Web of Science* record identifier (UT) field searches to ensure the correct records were downloaded.

Variables

The dependent variables in this stage are the extent of use of research syntheses versus reviews; and the number of authors contributing to each type of publication. The number of citations that have accumulated five years after publication was used as an indicator of the extent of use. The independent variable was the type of publication (traditional literature review, or research synthesis).

Stage III: Data analysis

Number of collaborating authors and extent of use of publications were described and then tested. First, Wilcoxon rank sum tests were chosen to test for differences between publication types due to the non-normal distribution of data. Following this basic test for difference, the van Elteren (1960) test was applied using *SAS* software (SAS Institute, 2012) to account for differences in distributions across publication years. The van Elteren test is a non-parametric test for differences between two groups, controlling for another factor:

$$u = \sum_{j=1}^{m} \frac{w_j}{n_{1j} + n_{2j} + 1},$$

Where w_j is the Wilcoxon rank-sum statistic for testing the null hypothesis of no difference in the j^{th} year, and $n_{1j} + n_{2j}$ is the total number of papers in the j^{th} year across groups 1 (RS) and 2 (Reviews).

Data cleaning

Coding performed for Stage II analyses was used to clean data. Publications that, based on the abstract, titles, and author keywords, were apparently not related to research synthesis methods were not considered in Stage II and III analyses. Publications judged to have a secondary or weak relationship to research synthesis were retained for some analyses because though not directly related, these articles provide information about contexts of use.

Life science (Evolutionary Biology and Conservation Biology) publications retrieved with the search query were more likely to be related to research synthesis than were those of the social sciences (Social Work and Women's Studies) and Information and Library Science (Table 17 and Figure 18). Over eighty percent of the life science publications have a primary or secondary relationship with research synthesis, and the majority, a primary relationship. In the social sciences, about two-thirds of Social Work publications retrieved for this study, and just over a third of Women's Studies publications, are related to research synthesis methods. The proportion of items with a secondary relationship with research synthesis, while still small, is substantially larger than what was observed in the life sciences. Almost three-quarters of the items in the Information and Library Science set were judged to have a primary or secondary relationship to research synthesis. A larger proportion of ILS items were judged to have a secondary relationship with RSM (10.84% of the overall set retrieved, or 15.02% of items related to RSM at any level).

Table 17. Directness of relationship with research synthesis methods by field

	Evolutionary Biology		Biodiversity Conservation		Social Work		Women's Studies		Information Library Sci	
Relationship	Ct.	**Pct.**	Ct.	**Pct.**	Ct.	**Pct.**	Ct.	**Pct.**	Ct.	**Pct.**
Primary	244	**77.96**	189	80.08	284	**57.96**	95	**31.77**	249	**61.33**
Secondary	11	**3.51**	5	**2.12**	34	**6.94**	16	**5.35**	44	**10.84**
Primary or Secondary	255	**81.47**	194	**82.2**	318	**64.9**	111	**37.12**	293	**72.17**
No apparent	58	**18.53**	42	**17.8**	172	**35.1**	188	**62.88**	113	**27.83**
Total	313		236		490		299		406	

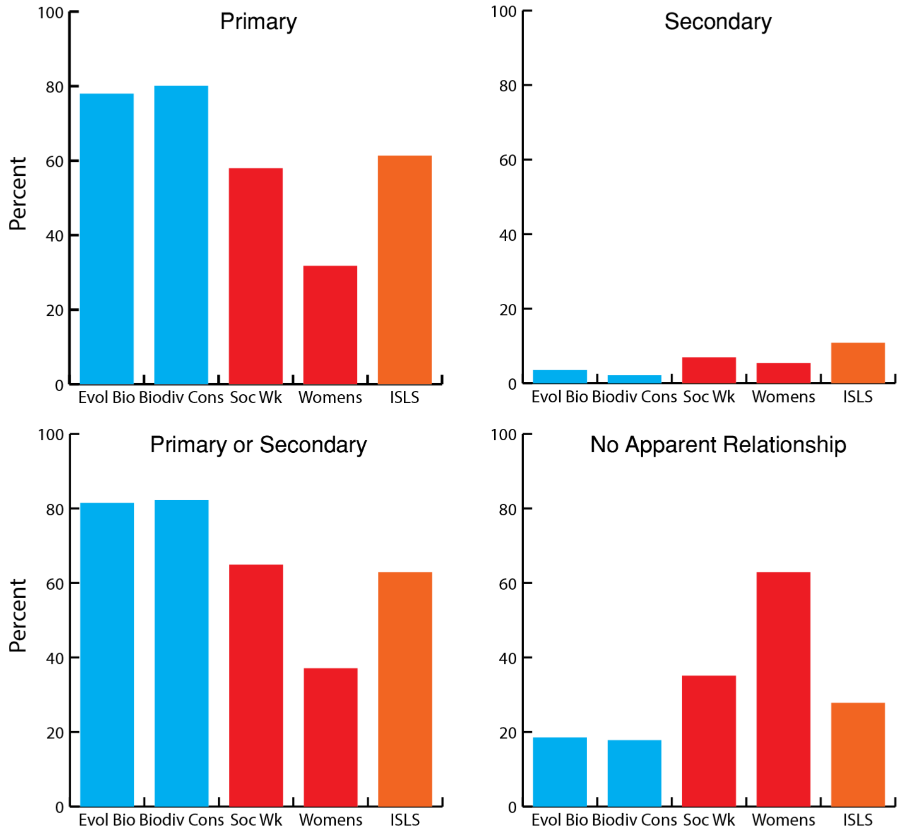


Figure 18. Primary, secondary, or no relationship with RSM: Percent of publications by field

These findings indicate that there was a high level of variance in the precision of the query used for this study. Recall that the search strategy was developed to maximize recall and ecological validity of findings at the macro-level. It should be noted that one reason Women's Studies was chosen for closer examination was because it was surprising to see Stage I results suggested a relatively high level of engagement with research synthesis in this field. One compromise in developing the search strategy was inclusion of the *S/SCI* Keywords Plus™ index, which includes keywords identified through algorithmic analysis of titles referenced by a given publication. As previously noted, since researchers in some fields are encouraged to identify whether a study is a research synthesis (e.g., a systematic review or meta-analysis) in the title of a publication there is the possibility that this increased recall of unrelated publications. Cited reference searching might have identified false positives, in part because papers may cite work for many reasons.

Reliability

Coder reliability measured with Cohen's kappa was found to range from very good to quite poor (Table 18). Agreement was good to very good on decisions about whether or not a publication was a false positive ("No apparent relation", $\kappa = 0.812$), those about whether the publication was directly related ($\kappa = 0.761$), and those about whether a publication reported a research synthesis study ($\kappa = 0.758$). Though the number of agreements and disagreements appear relatively favorable across other categories, Cohen's kappa values are low to very low. Even when all direct relations other than "reports a research synthesis" are combined, such that identification of any item is taken as a positive case and no items as a negative case, kappa value is only 0.439.

Hallgren (2012) notes that Cohen's kappa measures are generally unrepresentatively low when the distributions of observations fall under one category at a high rate compared to another category. Such a 'prevalence problem' may be an artifact of the coding system, the tendency of coders to assign one category rather than another, or because the category of interest occurs at a lower rate. In this study, the coding system was designed to capture events that were expected to be relatively rare (e.g., introductions to research synthesis methods) as well as those expected to occur relatively frequently (e.g., Reports of studies that use research synthesis methods). Given the aims of the coding scheme and the low number of items identified in several categories, it is likely that the prevalence problem influenced Cohen's kappa measures of inter-rater reliability. Further analysis should examine prevalence, and perform suitable analyses such as prevalence-adjusted kappa (Byrt, Bishop, & Carlin, 1993). Since differences between whether a publication is related to research synthesis, has a secondary relationship, or is not related at all implies a hierarchical relationship, ratings at this level might also be examined with a weighted approach.

Across all fields, Information and Library Science ratings were the least congruent. These ratings should be examined more closely. There was less follow-up with the ILS coder, but follow-up procedures did not change code decisions, but was merely a chance to discuss observations. It is possible that in some other way the coding process was different in this case. Other possibilities include that the heterogeneity of the field was greater and more difficult; that the multiple relations between ILS and research synthesis might have added a layer of complexity to coding; or the diversity of coders, both of whom are associated with the Information and Library Science field, though in different subfields, was too homogeneous. The latter factor might contribute to a "home-field disadvantage" (Medin, Bennis, & Chandler, 2010) due to more highly nuanced interpretations of content, and therefore less agreement on item categorizations.

Overall, based on reliability findings, analyses that rely on whether or not a publication is related to research synthesis can be interpreted with confidence, as can those that rely on ratings of whether a research synthesis is reported. Analyses that rely on other ratings, especially if additional steps are not taken to verify relationships, should be interpreted with caution.

Table 18. Inter-rater agreement

	Without ILS				With ILS			
Code Category	**Agree-ments**	**Disagree-ments**	**Percent Agreement**	**Cohen's Kappa**	**Agree-ments**	**Disagree-ments**	**Percent Agreement**	**Cohen's Kappa**
No apparent relation (false positive)	172	12	93.45	0.858	205	19	91.52	0.812
Secondary / weak relation only	174	10	94.57	0.416	210	14	93.75	0.429
Direct primary relation	166	18	90.22	0.798	198	26	88.39	0.761
Reports RS Study	167	17	90.76	0.815	197	27	87.95	0.758
Develop RS Methods	171	13	92.93	0.105	200	24	89.29	0.097
Develop RS Resources	173	11	94.02	0.236	207	17	92.41	0.222
Study/evaluate RS Methods	164	20	89.13	0.129	195	29	87.05	0.081
Discuss RS	157	27	85.33	0.345	187	37	83.48	0.319
Introduce RSM	175	9	95.11	0.159	215	9	95.98	0.163
Other	180	4	97.83	0.327	218	6	97.32	0.244
Primary: any other than Reports RS	154	30	83.70	0.512	178	46	79.46	0.439

Evolutionary Biology

Evolutionary thought is recognized as emerging with the work of Charles Darwin and publication of *The Origin of Species* in 1859, famously hastened by competing work of Alfred Russel Wallace. Until the Modern Evolutionary Synthesis of the 1930s and 1940s, "a wide-ranging consensus about the nature and dynamics of evolutionary change" (Gissis & Jablonka, 2011) did not exist: the Modern Synthesis solidified the impact of Darwin and the Darwinian Revolution through conceptual integration across paleontology, systematics, and genetics; and rejection of anti-Darwinian paradigms (Mayr, 1993, 1999; Mayr & Provine, 1980; Amundson, 1998). While geological data and observations has informed work by Darwin and others throughout the development of evolutionary biology, greater consideration of geological knowledge followed development of the theory of plate tectonics in the geological sciences and a process of integrating both theory and its implications into evolutionary thought (de Queiroz, 2014). In 2014, about fifty years after wide spread agreement on plate tectonics, explicit empirical integration of abiotic physical data remains a challenge to evolutionary biology research whether for lack of tools or due to competing interests. The field continues patterns of development, with new branches arising, sometimes diverging, relocating nearer distant fields. Through syntheses and departures, theory, resources, data, applications, insight, and tools co-influence directions and beliefs amidst the collegial milieu embedded in practices that unfold each day as researchers open lab doors, step into the field, and power on notebooks to investigate the "grand patterns and great processes of life" (Simpson, 1944) that are the core of Evolutionary Biology.

Funding for Evolutionary Biology research has benefitted from a combination of government and foundation support in the United States. In the early twentieth century, the Carnegie Institution, which invested in big science projects at the time, provided support for the Carnegie Station for Experimental Evolution at Cold Spring Harbor on Long Island, New York. In 1918, the Station was joined by a Eugenics Record Office to form the Carnegie Institution Department of Genetics, "whose research quality was as high in plant genetics as it was poor in human heredity" (Kevles, 1992, p.197). Following World War II, funding for biology research broadly, including evolutionary biology has increased, leading to an increase in specialization.

Data of evolutionary biology spans vast, if uncertain timescales; and diverse life forms scattered across the Earth. Data objects may undergo transformations and be subject to subsequent sampling. The broad conceptualization of synthesis (Sidlauskas et al., 2010) to include integration across concepts, methods, data, results, and research fields reflects the context of evolutionary biology research. This conceptualization is echoed in work supported by the NSF-sponsored National Evolutionary Synthesis Center (NESCent).

While some research supported by NESCent has focused on research synthesis methods, and meta-analysis in particular, including by researchers such as Mark Lajeunesse, Jessica Gurevitch, and Jason Hoekstra, a much broader spectrum of research is supported. Other efforts include those focused on development of information infrastructures and research methods and tools to bridge language barriers and synthesize phylogenetic trees; examination of controversial questions, and promotion of research across disciplines and specialties (National Evolutionary Synthesis Center, NESCent). A number of these initiatives also concern issues that have become central to methods-focused research synthesis, including transparency, repeatability, and open access to research and the tools used to conduct research. Additionally, evolutionary biology is generally permeable to Ecology research. The National Center for Ecological Analysis and Synthesis (NCEAS), also sponsored by the NSF, played a prominent role in the development and diffusion of meta-analysis in ecology (Cadotte, Mehrkens, & Menge, 2012), and methods texts suggest similarities between approaches to research synthesis methods in Ecology, Evolutionary Biology, and related biological fields, though specific emphases may differ (e.g., Koricheva, Gurevitch, & Mengersen, 2013).

Findings: Research synthesis in the context of Evolutionary Biology

Just over half (26) of all journal titles (47) listed in the Evolutionary Biology category in the 2012 *Journal Citation Report* (*JCR*) include at least one publication related to research synthesis (Table 19). Further analysis suggests the distribution approximates the 80/20 rule, with 82.0 percent of publications appearing in 21.3 percent of titles (Figure 19, Gini coefficient = 0.767). Journals that publish the greatest number of research synthesis publications are diverse, and include titles that publish across scales and focus on a variety of organism types. Review publications (e.g., *Trends in Ecology & Evolution, TREE*) and those devoted to study reports are represented.

Table 19. Evolutionary Biology journals with the most RSM-related publications

Journal	RS Count	Percent of RS	Cumulative pct.	Support (2008-2011 publications)*
American Naturalist	45	17.65	17.65	8 (13)
Proc. of the Royal Soc. B: Biol. Sci.	38	14.90	32.55	12 (16)
J. of Evolutionary Biology	34	13.33	45.88	13 (20)
Evolution	31	12.16	58.04	6 (12)
Trends in Ecol & Evol	14	5.49	63.53	2 (5)
Molecular Ecology	13	5.10	68.63	6 (9)
Amer. J. of Physic. Anthro	10	3.92	72.55	1 (5)
Biology Letters	9	3.53	76.08	3 (9)
BMC Evolutionary Biology	8	3.14	79.22	4 (8)
Evol. Ecology Research	7	2.75	81.96	1 (2)

* Number of associated papers, 2008-2001 with funding reported (and total journal publications, 2008-2011)

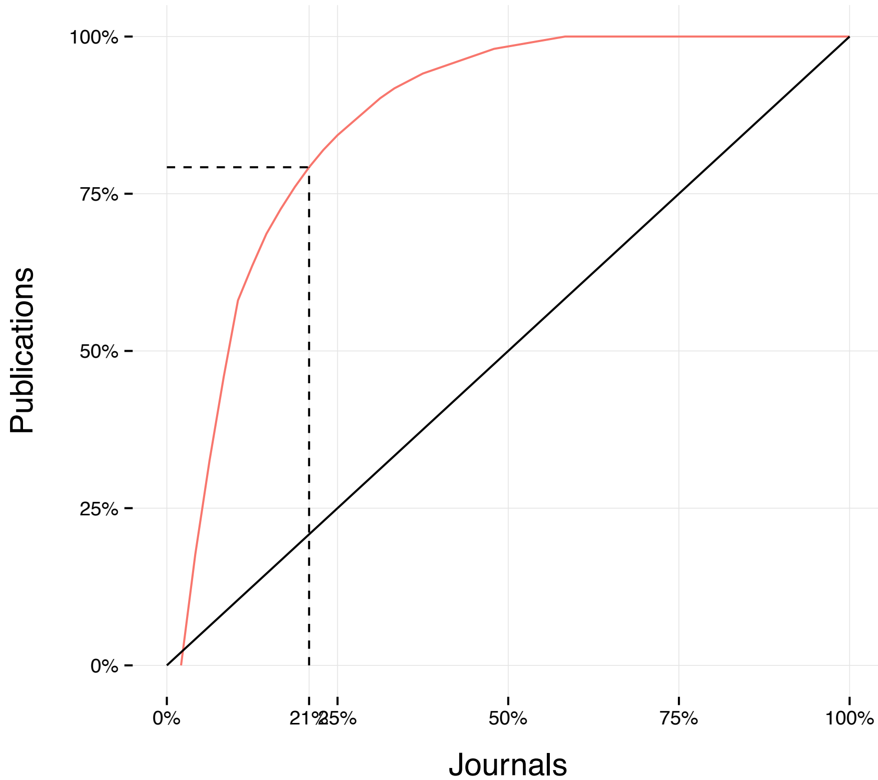


Figure 19. Evolutionary Biology: Distribution of publications across journals

Financial support: 2008 to 2011

Based on review of financial support data, available for papers published 2008-2011, there is at least some support for work related to research synthesis. Authors acknowledged at least one, but often multiple, sources of funding in sixty-six (61.68%) of 107 items published in this period. Table 18 identifies the number of publications that received financial support in journals where research synthesis was most common. Appendix I includes a full list of publication venues and years of publication of supported studies (Table I1), and funding organizations and years in which associated papers were published (Table I2).

Forty-seven of the sixty-six publications with funding reported a research synthesis but did not relate to research synthesis in other ways. One reported a research synthesis and discussed the methods. One reported a research synthesis, and studied and discussed research synthesis (*Journal of Evolutionary Biology*, 2011). One paper only discussed research synthesis methods (*Trends in Ecology & Evolution*, 2011). Three discussed and developed the methods (*American Naturalist*, 2009; *BMC Evolutionary Biology*, 2011, *Journal of Evolutionary Biology*, 2011). One paper reported a study of, discussed, and developed research synthesis methods (*Journal of Evolutionary Biology*, 2010). Two papers were judged to have a secondary relationship to research synthesis methods.

Knowledge base

The knowledge base of a set of papers is revealed through examination of referenced publications. The ecological sciences (darker green nodes in upper section of graph) broadly constitute the primary knowledge base of the set of 255 Evolutionary Biology papers with a primary or secondary relation to research synthesis (Figure 20). Other fields that are drawn on include the psychological and agricultural sciences. Overall, the reference network is fairly concentrated: 11,983 reference-category counts were attributed to 107 fields. Distribution across fields (Table 20) is relatively uneven (Shannon evenness = 0.606), though fields from which these publications draw are somewhat similar (Rao-Stirling diversity = 0.525).

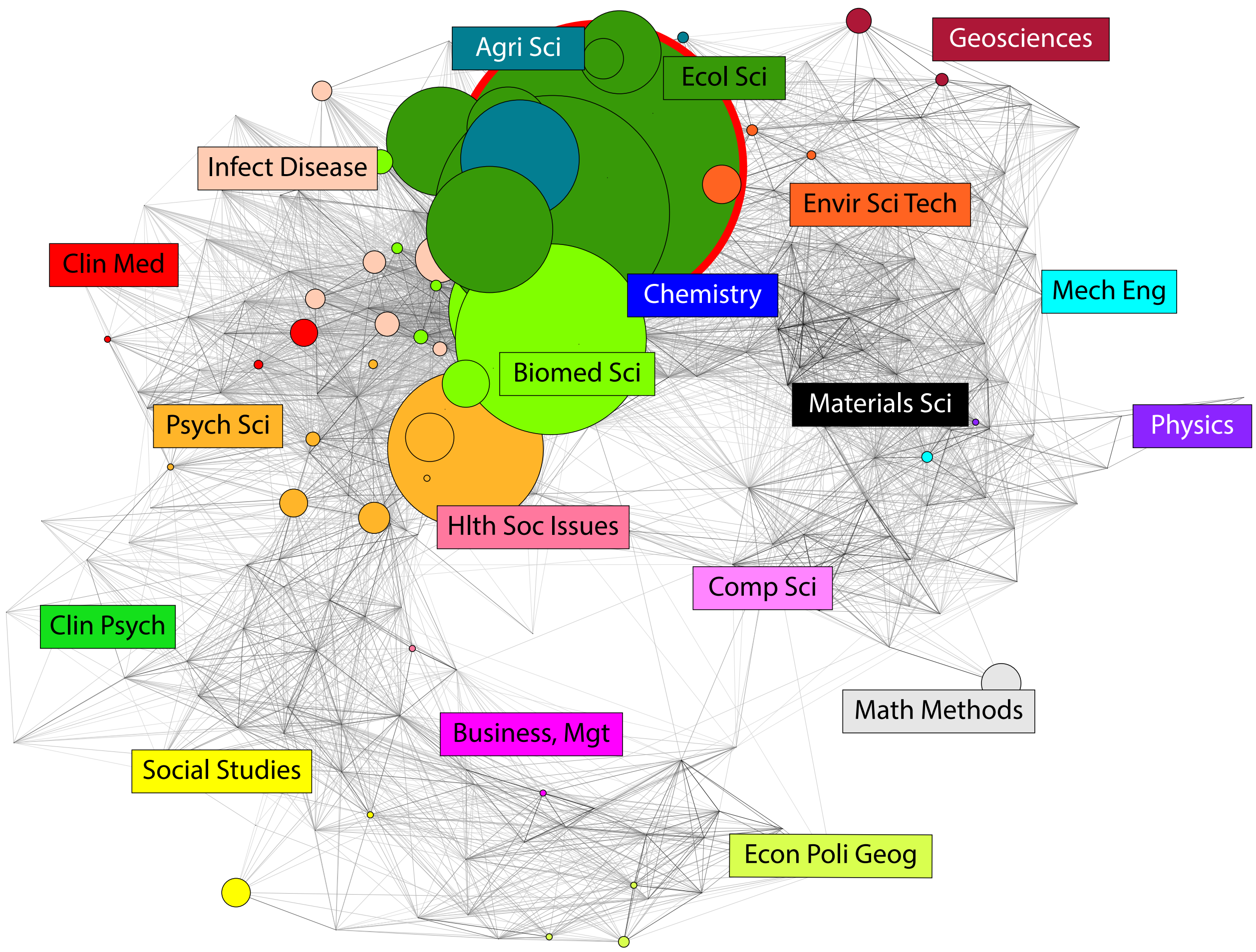


Figure 20. Evolutionary Biology: Knowledge base of RSM-related publications

Table 20. Evolutionary Biology: Diversity of fields referenced

Measure	Reference-Category count	Fields referenced	Shannon evenness	Rao-Stirling diversity
Value	11983	107	0.606	0.525

Modes of engagement

Since publication of the first study related to research synthesis in 1991 (Marchant & McGrew), almost three-fourths of all Evolutionary Biology papers related to research synthesis report a research synthesis study. Authors also frequently discuss research synthesis methods (18.03% of papers related to research synthesis). A number of papers (16, 6.56%) focus on development of methods, but fewer focus on resources or investigate the methods through research studies (Table 21, Figure 21).

Table 21. Modes of engagement with research synthesis in Evolutionary Biology

Mode	Reports	Methods	Resources	Study	Discuss	Introduce	Other
Count	181	16	3	8	44	3	33
Percent	74.18	6.56	1.23	3.28	18.03	1.23	13.52

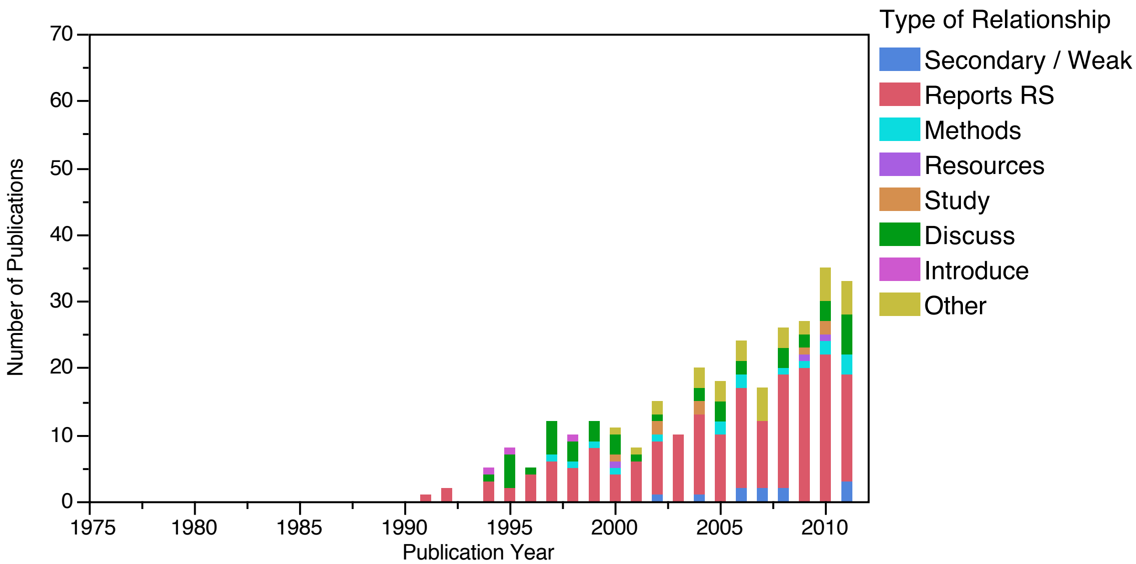


Figure 21. Evolutionary Biology: Number of publications, modes of engagement, by year

Introductions

Research synthesis was introduced in three different ways in three articles in the study set. The first, Gurevitch and Collins (1994) introduced the methods in the context of a discussion of field experiments. The second, Arnqvist and Wooster (1995), focused on research synthesis exclusively; and the third, van Zandt and Mopper (1998) provided detailed discussion of how the method was applied in the context of a study report. Across the papers, research synthesis is framed as “meta-analysis”, though the description of meta-analysis changes over time: First, Gurevitch and Collins identify meta-analysis as a set of statistical techniques. Second, Arnqvist and Wooster described it as a “statistical framework" (p. 236) and contrast quantitative meta-analytic reviews with narrative reviews; and third, Van Zandt and Mopper provide a detailed discussion of their multi-step application of the method, following the framework of Cooper and Hedges (1994), in the context of a study report. Though there was some use of research synthesis before the third introductory article[24], meta-analysis is identified as a technique "now becoming recognized in the fields of ecology and evolution" (van Zandt & Mopper, 1998, p. 595). All three publications highlight the social sciences, and Larry V. Hedges in particular, as important to the introduction of research synthesis in Ecology and Evolutionary Biology. Further, a clear line of communication is apparent in the collaborations between Hedges and Gurevitch. Though Gurevitch might be characterized as an ecologist more than an evolutionary biologist, the fields overlap and share some publication venues such as *Trends in Ecology & Evolution*. Some (e.g., Cadotte, Mehrkens, & Menge, 2012) have highlighted the centrality of synthesis centers such as NCEAS and NESCent in the development and use of meta-analysis in ecology and related fields. Additionally, locations of introductory articles (*TREE*, *American Naturalist*) suggest that researchers who work, publish, and communicate across ecology and evolution and the overlapping boundaries of the fields were important to the spread of research synthesis from ecology to evolution.

Methods

Methods development has focused almost exclusively on development and importation of meta-analytic techniques. Methods development focused on effect-size, such as in "factorial meta-

[24] Twenty-six publications directly related to research synthesis published prior to the third introduction by van Zandt and Mopper (1998) were identified in this study, including six in the *American Naturalist*, the journal in which van Zandt and Mopper was published.

analysis" (Gurevitch, Morrison, & Hedges, 2000), correlations (Fitzpatrick & Turelli, 2006) and weighted z-tests (Whitlock, 2005; Chen, 2011; Zaykin, 2011). Phylogenetic meta-analysis, or quantitatively accounting for the relatedness of species in a meta-analysis, has been a major focus (Hickerson, Stahl, & Lessios, 2006; Adams, 2008; Lajeunesse, 2009; Silvestro, Schnitzler, & Zizka, 2011). Genetics research was identified as a source from which methods to account for species similarities could be imported (Hadfield & Nakagawa, 2010). Accounting for the extent of difference is important because, as noted by Lajeunesse, Rosenberg, and Jennions (2013), the "apples and oranges problem" is literal in evolutionary biology and ecology.

Other papers introduced approaches to examine whether publication bias impacts a synthesis (Palmer, 1999; Rosenberg, 2005), whether study design features impact study findings and use of funnel plots to visualize and identify such occurrences (Palmer, 2002), and selection of effect size measures to support ecological inference (Osenberg, Sarnelle, & Cooper, 1997). One study (Dera, Eble, Neige, & David, 2008) presented a "meta-analytic" approach to synthesize theoretical morphological models.

The overlapping boundaries of biological science fields are reflected in discussion surrounding development of meta-analytic methods in Evolutionary Biology. For example, in 2008, Adams proposed an approach to meta-analysis that accounts for the degree to which evolutionary history is shared across taxa in synthesized studies; or, as Adams writes, "I derive a model for phylogenetic meta-analysis, so that data across studies may be summarized with evolutionary history explicitly incorporated" (p. 567). In 2010, Hadfield and Nakagawa moderate the contribution of Adams and others who contributed to the development of phylogenetic meta-analysis. The authors write, "Although many of the statistical techniques used in comparative biology were originally developed in quantitative genetics, subsequent development of comparative techniques has progressed in relative isolation. Consequently, many of the new and planned developments in comparative analysis already have well-tested solutions in quantitative genetics. In this paper, we take three recent publications that develop phylogenetic meta-analysis, either implicitly or explicitly, and show how they can be considered as quantitative genetic models. We highlight some of the difficulties with the proposed solutions, and demonstrate that standard quantitative genetic theory and software offer solutions" (p. 494).

Consequently, what Adams identified as an original contribution derived from combination of prior art, Hadfield and Nakagawa recognize as available from another field. Thus, priority claims may be constrained by mechanisms that isolate and bridge communities at different times. While this may negatively impact Adams's priority claim, potential benefits for comparative (evolutionary) biology include the ability to import theory and tools from a neighboring field to tailor implementation of meta-analysis to perceived needs – provided, as Hadfield and Nakagawa claim, the methods actually are equivalent, or better for the intended purposes. This potential highlights not only the overlapping nature of fields methodologically, but also the importance of cross-field communication, which, in biology broadly, has been characterized as increasingly difficult due to the pace of scientific activity and sizes of constituent communities (Soulé, 1985).

Resources

Two papers presented resources the authors suggested were related to meta-analysis. One, a report following a biologging conference, discussed developments in biologging instruments, data management, visualization, integration, and analysis (Rutz & Hayes, 2009). The second paper introduced PlutoF, a web service intermediary for access, retrieval, and deposit of datasets from the International Nucleotide Sequence Databases (INSD) and other resources (Abarenkov et al., 2010). The workbench provides annotation, sequence analysis, and other functions.

Studies and evaluations

Publication bias garnered the most attention in papers that studied or evaluated research synthesis. Palmer (2000) suggested selective publication of results is influenced by factors such as statistical significance of results, findings that are consistent with preferred hypotheses, consistency with theory, and editorial guidelines that emphasize originality and novelty. Suggested remedies included mechanisms to support publication of true rather than quasi-replication studies and increased use of funnel plots to graphically present publication bias. Building on research that indicates a tendency for the magnitude of effect sizes to decrease as publications on a topic accumulate, Leimu and Koricheva (2004) introduced cumulative meta-analysis as a method to assess fluctuations in these trends. Cassey, Ewen, Blackburn, and Möller (2004) examined the frequency with which effect sizes are reported and relationships between effect size reporting and publication bias. One study examined measurement practices in relation to findings (Palmer, 2002).

Discussions

Of the forty-three publications that discuss research synthesis, all but fourteen relate to the methods in multiple ways. Here, the focus is primarily on those that discuss research synthesis and related issues but do not relate to the methods in other ways. Of these fourteen publications, nine concern specific meta-analytic studies. A notable set in this group includes four "invited expert commentaries" (Houle, 1997; Leamy, 1997; Markow & Clarke, 1997; Whitlock & Fowler, 1997) solicited in response to a "Target Review", a meta-analysis of fluctuating asymmetry studies by Möller and Thornhill (1997). The editor's note that precedes the review and commentaries weakly describes the vitriolic tone of the invited commentaries: "Earlier I announced the plan to publish mini-reviews on controversial topics followed by invited expert commentaries… 'controversial' seems a weak description of the differences in opinion on this subject…" (Hoekstra, 1997). The current study identified four of seven invited commentaries and the target article, but missed the author's reply to commentaries. Borrell (2007) provides background and commentary on the Möller and Thornhill (1997) paper and commentaries solicitation.

Other discussion publications also comment on specific studies by Möller and others (Amos, 2009; Clarke, 1998; Templeton, 1996) and reply to comments (Falck, Bjornstad, & Stenseth, 1995; Möller & Cuervo, 2009). Comments and replies may identify flaws, include re-analysis of data, or present re-analysis of an augmented data set. In other papers, authors discuss areas that would benefit from greater use of meta-analytic approaches (Noor & Coyne, 2006; Prach & Walker, 2011), review publication bias issues (Möller & Jennions, 2001), and discuss the need for mechanisms to support study replications (Palmer, 2000).

In a letter in *TREE*, Kueffer and colleagues (2011) argued that the current publication system does not properly enable producers of primary research to receive credit for their work. Synthesis studies, including meta-analyses, are seen to contribute to problems with credit distribution because references to primary studies are often presented in materials not indexed by citation databases, such as supplementary material. Increasing development and use of large databases of primary study findings are another cause of concern in the context of credit distribution. Based on these observations, the authors advocate inclusion of meta-analyzed studies in locations that are indexed, inclusive co-authorship practices, and development of mechanisms to allocate credit for use of data deposited in databases.

Other relationships to research synthesis

The majority of publications (18) that related to research synthesis directly, but not in ways captured by the coding system used for this study used meta-analytic techniques within a study to compare magnitudes of effect across experimental conditions or effect sizes across different species. Other modes included use of meta-analyses to identify studies to use as data for meta-studies, and use of meta-analyses as a baseline to compare study results. One study was a review of findings of meta-analytic studies.

Topics related to research synthesis

Topics reveal methods-related attributes that are most salient in Evolutionary Biology, and lines of research prevalent in studies. Across the fifteen Evolutionary Biology topics, word stems associated with meta-analysis occurred more frequently than any other methods-related terms, including 'review', which occurred one type, and 'systemat', a stem for systematic, which did not occur at all (Table J1, Appendix J and Figure 22).

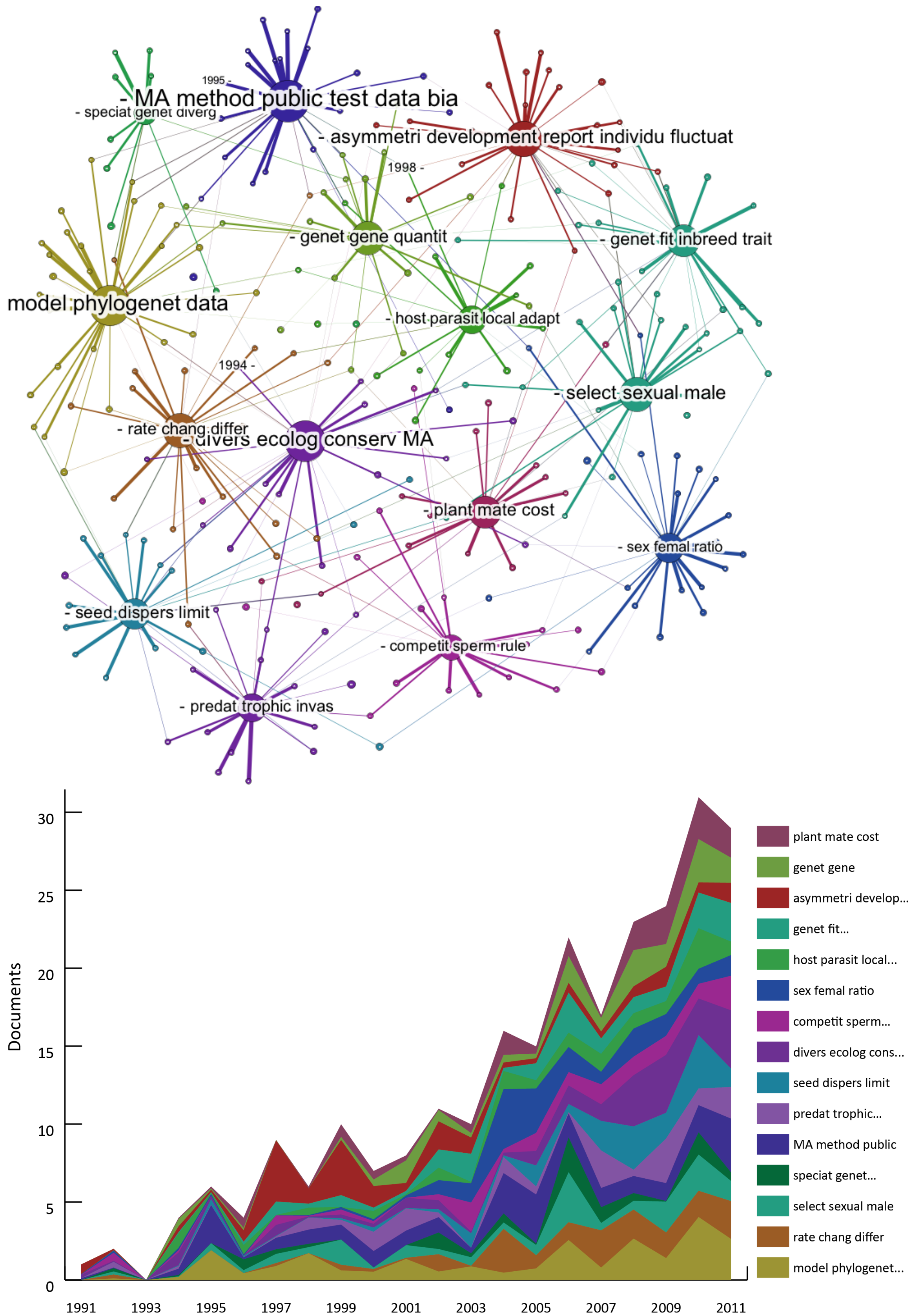


Figure 22. Topics associated with research synthesis in Evolutionary Biology

Examination of topics for lines of research revealed that fluctuating asymmetry ("asymmetri develop") was the focus of multiple early syntheses. Studies related to mate selection, sex allocation, and diversification rates were prevalent later (Figure 22). Controversies surrounding fluctuating asymmetry studies, which were most prevalent in 1997 in the study data, contributed to the proliferation of publications on the topic. It should be noted that the topic is controversial not only because of issues related to individual scientists, but also because of aspects of the phenomenon and how it is studied. Fluctuating asymmetry involves questions about bilateral symmetry and whether it is heritable. A part of this research relies on measures of small differences. For example, lengths of fingers on the left versus right hand in humans, or in length of tail feathers from each side in birds might be used to determine levels of symmetry. Symmetry measures might then be studied in combination with cross-generational genetic data.

Some topics are important to Ecology and Conservation Biology as well as Evolutionary Biology. Since journals such as *Trends in Evolution & Ecology, Evolutionary Ecology,* and *American Naturalist* span fields, this should be expected. Topics related to reproduction and mating may be important across the three fields. For example, topics related to mating and reproduction such as sex ratios ("sex femal ratio") have ecological importance with respect to communities and evolutionary implications with respect to survival of species over time. The same topic is important to Conservation Biology, especially in the context of breeding programs for rare or endangered species. Table J1 in Appendix J summarizes the most frequently occurring word stems in each of the fifteen Evolutionary Biology topics.

Prolific authors and their organisms in the context research synthesis publications

Due to the emphasis on phylogenetic heterogeneity and discussions of taxonomic bias in relation to research in Evolutionary Biology, an additional analysis was conducted to provide an overview of the types of organisms associated with research synthesis publications. Organisms are presented in the context of authors who study them and research topics with which those authors are associated.

Over six hundred authors contributed to papers related to research synthesis in the field (approximately 623[25]), though the majority (543) contributed to just one paper, and about 56 others, two. This suggests that in many cases, researchers in the field engage with research synthesis on specific occasions, but it is not their primary method of research. Thirteen people contributed to three studies, and ten to four or more. The most prolific authors in this data set (Table 22) studied a variety of topics and organisms, though topics such as fluctuating asymmetry, sexual selection, and related to the methods themselves are prevalent. Taxa studied by prolific authors align with more "popular" types of organisms, including birds, mammals, and two model organisms (*Drosophila melanogaster* and *Arabidopsis thaliana*). Concentration of research on more popular organisms reflects taxonomic biases observed in the field, potentially amplified by the need for a sufficient number of studies on a subject to conduct a research synthesis study.

[25] Author disambiguation steps included examination of full names where available, and initials. If necessary, full text of publications was examined to determine that two name forms did refer to the same or different individual(s). Further steps to disambiguate authors, such as connecting pre- and post-marriage names, were not performed.

Table 22. Most prolific authors, topics studied, and associated organisms

Author	Publications	Topics (frequent keywords)	Organisms
Möller AP	16	meta-analysis, developmental stability, fluctuating asymmetry, directional selection, mate choice, publication bias, sexual selection, viability, mean d(2)	Birds
Sheldon BC	9	sex allocation, sexual selection, population demography, multilocus heterozygosity, meta-analysis	Birds
Koricheva J	5	meta-analysis, publication bias, plant resistance, plant defense, cumulative meta-analysis	Plants
Jennions MD	5	Courtship calls, heterozygosity, sexual selection analysis, (meta-analysis, paradigms, publication bias)	Insects
West SA	5	Sex allocation, meta-analysis, local resource/mate competition, mean d(2), kin	Birds, mammals, cross-taxa
Nakagawa S	5	Meta-analysis, heterozygosity-fitness correlations, methods: comparative biology vs. genetics, size & gender x environment interactions, publication bias	Insects, Birds
Thornhill R	4	developmental stability, fluctuating asymmetry, sexual selection, meta-analysis	Birds, D. melanogaster
Coltman DW	4	Heterozygosity, fitness, mean d(2), (multivariate) meta-analysis, quantitative genetics, populations	Cross-taxa
Simmons LW	4	Polyandry, fertilizing/mating success, fluctuating asymmetry; paradigm shift; scientific revolutions	Insects
Van Buskirk J	4	phenotypic plasticity, population genetics, conservation biology, meta-analysis, genetic variance	*A. thaliana*, *D. melanogaster*, Amphibians
Gurevitch J*	3	meta-analysis; ecological experiments; statistical interaction; predation (including herbivory), competition	Plants, cross-taxa
Arnqvist G*	3	Meta-analysis, assortative mating	Insects

* Though only three papers were identified for each, Gurevitch and Arnqvist are included based on the prominence of their work to the diffusion of meta-analysis.

Impact: Shifts in practice

In the year analyzed, 2007, there were 143 reviews and 23 research syntheses, primarily meta-analyses, in Evolutionary Biology. The van Elteren test was not applied in analysis of Evolutionary Biology papers because only one year was examined. Based on the Wilcoxon rank sum test, there was no difference between collaboration or citation patterns associated with research syntheses versus reviews (Table 23).

The lack of difference between reviews and research syntheses may be a function of the number of studies evaluated or the year of publication. However, observations in the current study suggest research synthesis methods have been adopted in part, but that narrative research reviews are an important component of Evolutionary Biology literature. Notably, even so-called "narrative" reviews may be highly structured and contain features such as tables that summarize studies and results.

Table 23. Summary statistics: Impacts associated with use of research synthesis

		Authors	Times cited (at 5 years)
Median (1^{st} : 3^{rd} Quartiles)	Research Syntheses (N=22)	2.5 (2 : 3)	60 (29 : 85)
	Reviews (N=143)	2 (2 : 3)	52 (24 : 93.75)
Wilcoxon rank sum test		W = 1713.5, p=0.4505	W = 1625.5, p=0.7611

Though two of the three articles that introduced research synthesis methods to the field linked meta-analysis, as the method was introduced, to the concept of reviewing, meta-analysis has been used as a descriptor almost exclusively. Only occasionally do authors place meta-analysis in the context of "research synthesis" (e.g., Palmer, 2000). The language, statistical focus, and use of meta-analysis to analyze single studies with multiple treatments or species suggests that meta-analysis, in some contexts, appears to have been extracted from the composite process of research synthesis methods. Meta-analysis may be more commonly perceived as a statistical technique used to integrate selected results and traverse the tree of life.

Cadotte, Mehrkens, and Menge (2012) suggest a similar perspective in ecology. The authors compared use of meta-analysis with "papers" rather than with reviews (meta-analyses typically are written by larger teams[26] and are more cited than other papers in the ecology studies surveyed). Given that meta-analyses were referenced as often as reviews and exhibited similar collaboration patterns, a multi-way comparison of reviews, meta-analyses, and other study designs could provide insight into collaboration and use patterns. Additionally, use and collaboration should be examined longitudinally.

Conservation Biology

Conservation Biology is to biology, what surgery is to physiology, and war to political science (Soulé, 1985). The field began to coalesce in the late 1970s/1980s in part as a response to the recognition of the crisis brought on by humankind's domination and commodification of Earth's resources, which has had severe consequences for biological diversity, evolutionary potential, and ecological systems. The field is characterized as mission- and crisis- driven, concerned with the application of biological, social, and political knowledge to inform policy and management decisions amid uncertainty (Meine, Soulé, & Noss, 2006). Conservation Biology differs from fields such as

[26] Ecological meta-analyses retrieved from *ISI Web of Science* in September 2008 had an average of 3.64 authors versus 3.17 for papers. Cadotte and colleagues (2012) also found a positive relationship between subsequent use of papers and the number of publications, species, and years meta-analyzed.

wildlife management, fisheries, and forestry in that it is not focused on management of natural resources or specific species for human use; is focused broadly on biological diversity and ecological systems; and recognizes the intrinsic value of biodiversity in all its forms (Gibbons, 1992; Meine, Soulé, & Noss, 2006; Soulé, 1985). Ethically and philosophically, the field identifies with Western and Eastern naturalist beliefs that are echoed by Aldo Leopold's Evolutionary-Ecological Land Ethic, which "enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land"; it "changes the role of Homo sapiens from conqueror of the land-community to plain member and citizen of it. It implies respect for his fellow-members, and also for the community as such" (Leopold, 1949, p. 204).

Important precursors to the development of Conservation Biology include two post-World War II trends: growing economic pressures to sustain or increase commodity yields from natural resources; and an accelerated pace of scientific development across the biological sciences, which led to increased specialization and barriers to the use of science knowledge in practice and policy contexts. Following widespread recognition of environmental crisis in the late 1960s and 1970s, a series of US legislative acts and international agreements ensued, including the National Environmental Policy Act of 1969 and the Endangered Species Act of 1973. These and other policies required scientific expertise for their implementation.

Micro-level mobilization centered around Michael Soulé and his colleagues who, over the course of a decade (1978-1987), authored key texts, organized the first conferences, and established the Society for Conservation Biology (SCB) and the Society journal, *Conservation Biology* (Meine, Soulé, & Noss, 2006). The second decade saw the development of courses, academic programs, and, with funding from the Pew Charitable Trusts, the establishment of graduate programs (Jacobson, 1990). The MacArthur foundation and NSF special funds provided additional early funding (Gibbons, 1992).

Despite initial success, whether Conservation Biology would endure was, in the 1990s, questioned. For example, Gibbons (1992) highlighted concerns about the methods, evidence-base, cross-disciplinary data integration, and heavy reliance on theoretical models in the field as characteristics that caused some concern. Initiatives to develop an evidence-based framework for conservation biology and environmental conservation more broadly address some of these concerns (Pullin & Knight, 2009). Guided by the framework of EBP in medicine and the Cochrane Collaboration in particular, the UK-based Center for Evidence-Based Conservation (CEBC) was established in 2003. The CEBC coordinates the Collaboration for Environmental Evidence (CEE), and is the editorial home for the *Environmental Evidence Journal*[27], which began publishing systematic reviews, review protocols, and related publications in November, 2011 (Centre for Evidence-Based Conservation, 2012). As of January 2014, fifty-nine systematic reviews had been completed and published at the website, and thirty-one indicated as underway.

Findings: Research synthesis in the context of Conservation Biology

Half (20) of the forty journals identified in Biodiversity Conservation by the *JCR* include publications related to research synthesis methods; though thirteen titles include only one or two related publications. Most publications appear in *Global Change Biology* (46 publications), *Conservation Biology* (44 publications), and *Biological Conservation* (31 publications) (Table 24).

[27] As of January 2014, the *Environmental Evidence Journal* was not indexed in the *S/SCI*.

Publications are relatively concentrated in a few journals: 78.3 percent of all research syntheses are published in 19.5% of the journal titles listed in the *JCR* (Gini coefficient = 0.775; Figure 23).

Table 24. Conservation Biology journals with the most RSM-related publications

Journal	RS Count	Percent of RS	Cumulative pct.	Support (2008-2011 publications)*
Global Change Biology	46	22.68	22.68	16 (21)
Conservation Biology	44	21.65	44.33	16 (24)
Biological Conservation	31	15.98	60.31	12 (18)
Human & Ecological Risk Assessment	14	7.22	67.53	2 (4)
Ecography	8	4.12	71.65	2 (4)
Biodiversity and Conservation	7	3.61	75.26	3 (4)
Biological Invasions	6	3.09	78.35	2 (2)
Journal for Nature Conservation	6	3.09	81.44	5 (5)

* Number of associated papers, 2008-2001 with funding reported (and total number of publications in the journal, 2008-2011)

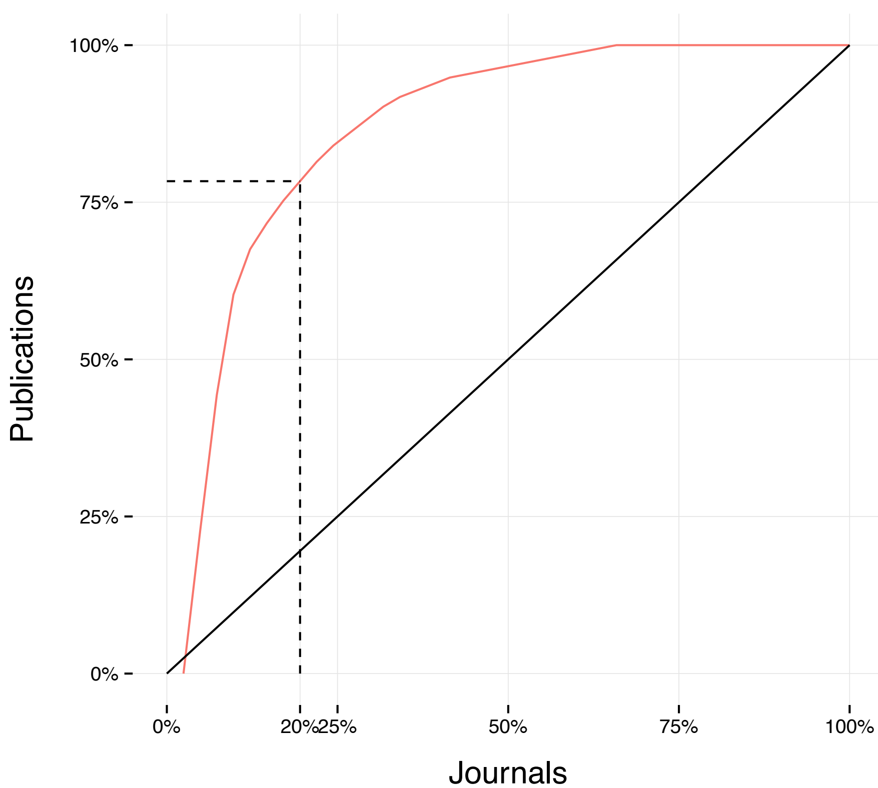


Figure 23. Conservation Biology: Distribution of publications across journals

Financial support: 2008 to 2011.

Of the 101 publications judged to have a primary or secondary relationship with research synthesis methods, sixty-eight (67.3%) indicated some form of financial support (Appendix I, Table I3). Among publications for which financial support was recognized, an average of about 2.5 supporting organizations (range 1 – 12) per publication was indicated. Appendix I, Table I4 presents funding organizations and years in which associated papers were published.

Of the sixty-eight publications associated with financial support, fifty-one reported a research synthesis but did not relate to research synthesis in other ways. Nine reported a research synthesis and related to research synthesis in other ways. Five of these publications reported a research synthesis and discussed the methods. One reported a research synthesis, and studied and discussed research synthesis (*Global Change Biology*, 2009). One reported a research synthesis and developed resources (*Conservation Letters*, 2009). One reported a research synthesis, developed resources, and discussed methods (*Oryx*, 2010). One reported and developed methods for research synthesis (*Journal for Nature Conservation*, 2010).

Two papers published in *Conservation Biology* (2008, 2009) developed resources for and discussed research synthesis methods. A third, published in *Conservation Letters* in 2009, focused on resource development for research synthesis methods.

Four publications had “other” relationships with research synthesis methods. Three of these papers, published in *Western North American Naturalist* (2011), *Conservation Biology* (2010), and *Avian Conservation and Ecology* (2008), used meta-analytic techniques within the reported studies. The fourth introduced a new journal section for systematic reviews (*Biological Conservation*, 2009). Two publications had a secondary relationship with research synthesis. These were published in *Natureza & Conservacao* (2011) and *Conservation Biology* (2011).

Knowledge base

Conservation biology draws primarily from biological, biomedical, environmental, and agricultural sciences (Figure 24). Though conceived as a field that would integrate social science approaches, only limited use of social science research is visible. Medicine and the health sciences are framed as fields to emulate with respect to the development of evidence-based practice, but few journal publications appear to be referenced from these fields. Diversity patterns were similar to those observed for Evolutionary Biology: The 194 Conservation Biology publications referenced slightly fewer fields (100 versus 107, Table 25). Distribution of references across fields is slightly more even (Shannon evenness = 0.637, versus 0.606); and the knowledge base integrated, slightly more disparate based on referencing patterns observed in science overall (Rao-Stirling diversity = 0.543 versus 0.524).

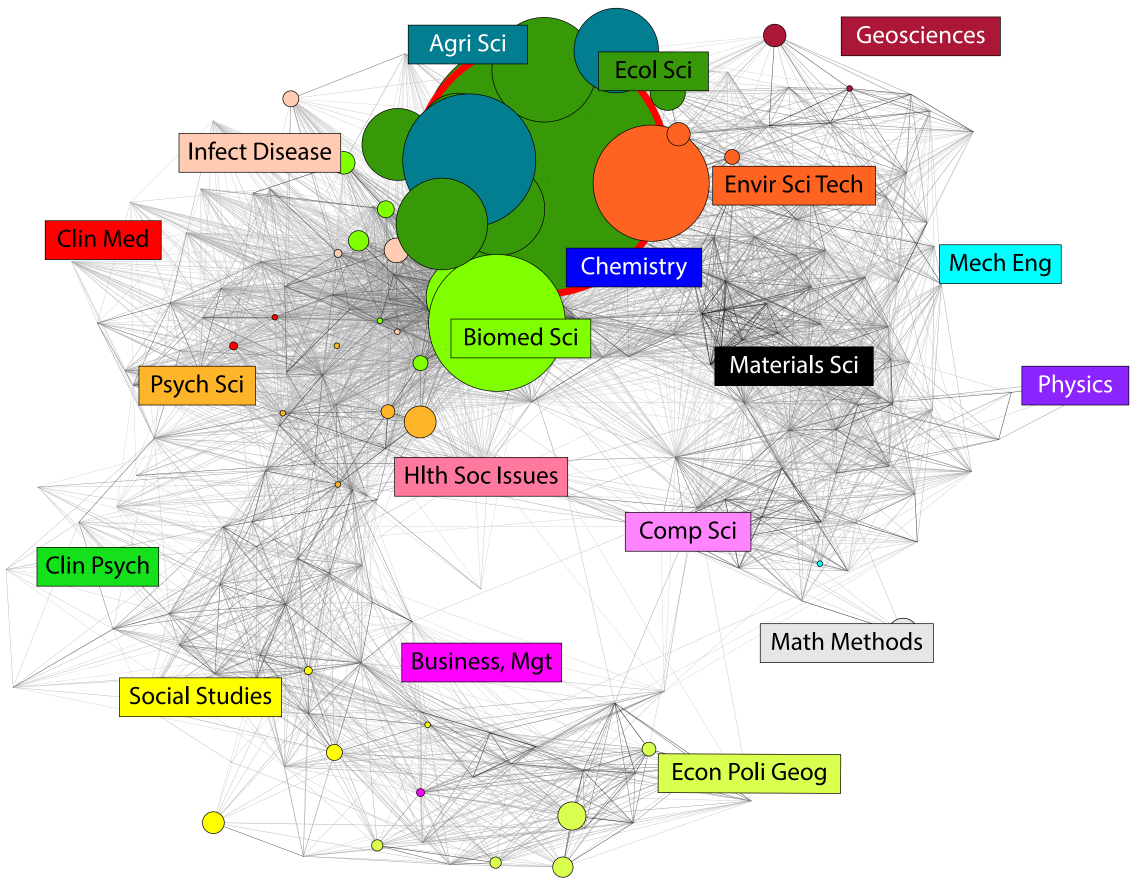


Figure 24. Conservation Biology: Knowledge base of RSM-related publications

Table 25. Conservation Biology: Diversity of fields referenced

Measure	Reference-Category count	Fields referenced	Shannon evenness	Rao-Stirling diversity
Value	8704	100	0.637	0.543

Modes of Engagement

The primary mode of engagement with research synthesis methods in Conservation Biology was application of the methods in research studies (85.71%, Table 26; Figure 25). Following application of the method, Discussion of the methods generally and as implemented in specific cases was common (16.93%). A number of papers focused on resources and methods development (10 papers each), but few studied the methods and their use. Eight publications reported use of meta-analytic techniques within a research study but did not relate to research synthesis in other ways.

Table 26. Modes of engagement with research synthesis in Conservation Biology

Mode	Reports	Methods	Resources	Study of	Discuss	Introduce	Other
Count	162	10	10	6	32	1	11
Percent	85.71	5.29	5.29	3.17	16.93	0.53	5.82

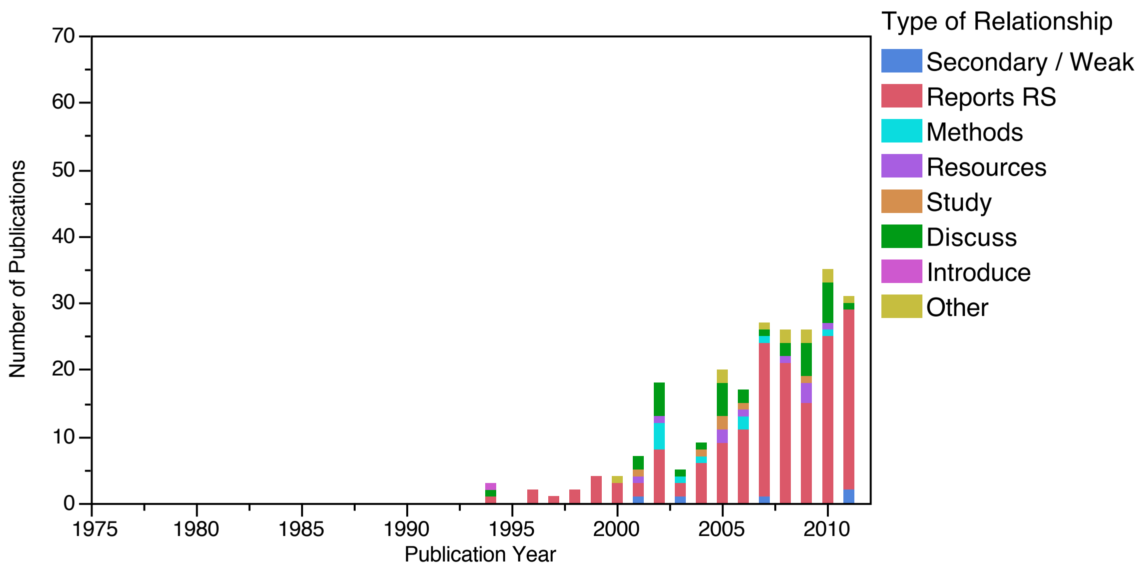


Figure 25. Conservation Biology: Number of publications, modes of engagement, by year

Introductions

Fernandez-Duque and Valeggia (1994) introduced meta-analysis as "not a statistical method per se, but rather an orientation toward synthesizing research using many of the available techniques of measurement and data analysis. It is a scientific review in which the emphasis is placed on providing a quantitative synthesis of data" (p. 556). To introduce research synthesis, the authors draw on literature from both the health (epidemiology) and social sciences to discuss issues related to the methods, such as study selection, moderator analysis, publication bias, selection of outcome metrics, and disagreements about the "conceptual basis" of meta-analysis. Complexity of systems of interest is introduced as a special challenge for the field; and the potential to inform policy makers through quantitative rather than narrative research reviews is emphasized as a potential benefit of RSM.

Fernandez-Duque and Valeggia (1994) argue that meta-analysis may be valuable to the field because of the large number of inconclusive studies; and because of consequences of Type II errors (failing to reject the null hypothesis when it is false) in studies designed to assess the magnitude of a negative effect of human activity. If studies are to be used to inform decision making, it is argued, it is better to be conservative because such errors could lead to decisions to take irreversible actions. The authors illustrate potential benefits of meta-analysis with a worked example that combines evidence from studies with conflicting results to find that bird density is lower in forests subjected to selective logging than undisturbed forests. This example demonstrates the potential danger of basing decisions on partial evidence, and implications related to Type II errors. If, for example, a decision to selectively log were made based on findings from a study that failed to find associated negative impacts, it would not be possible to later undo damage sustained from this decision.

The authors note that comprehensive literature search could be challenging because potentially relevant studies might be distributed across journals, doctoral theses, national reports, organizational reports, and so on. Additionally, "in [conservation biology], much research is carried out in underdeveloped countries, where access to major scientific journals is severely limited" (Fernandez-Duque & Valeggia, 1994, p. 558).

Methods

Six methodological papers published in *Human and Ecological Risk Assessment* (*HERA*) from 2002-2006 focused on a diverse but interrelated set of concerns related to surrogate or comparative data, risk, uncertainty, and maximization of findings from primary studies and survey data. *HERA* differs from other journals in the category in that it emphasizes risk assessment in the context of human and ecological health. This focus overlaps with primary issues of Biological Conservation such as biological diversity, but from a different perspective. Despite differences, some challenges to research synthesis presented in *HERA* reflect those of studies more centrally located in the field of Biological Conservation, including dealing with uncertainty, the need to work within the constraints of available data and studies, and time constraints in contexts of decisions that have potentially wide-ranging and irreversible consequences.

Methods articles in *HERA* include Goodman (2002), a discussion of managing uncertainty in risk assessments through attribution of uncertainty to random and predictor components. Goodman further proposed incorporation of comparative data, for example, data related to species or toxins not specific to the case of interest. This approach, argues Goodman, enables one to maximize available data, and estimate potential contributions of specific types of future studies, both of which are important when working with sparse evidence and resources. A later paper (Etterson & Bennet, 2006) discussed problems associated with using surrogate data from published literature to model species demographics and methods to mitigate these risks using Bayesian and meta-analytic methods and life history theory.

A framework for combining diverse lines of evidence, such as toxin concentration data and community (species or organism) surveys when there are differences in important aspects of reference and test sites (e.g., spatial and temporal factors) is presented in two related papers (Bailer, Hughes, See, Noble, & Schaefer, 2002; Reynoldson, Smith, & Bailer, 2002). Like others, the authors are concerned with maximizing use of available data from primary studies. The authors demonstrate the proposed approach through a study of Great Lakes contaminant impacts. The remaining two *HERA* papers examine epidemiological exposure-response and concentration-response scenarios in meta-analytic contexts (Schwartz, 2002; Roosli, Kunzli, Schindler, & Braun-Fahrlander, 2003). Roosli and colleagues argue an excess rate approach rather than relative risk approach may mitigate issues related to the "apples and oranges" problem when combining findings from studies with different population contexts.

The remaining methods papers appeared in *Biological Invasions, Conservation Biology,* and the *Journal for Nature Conservation* between 2004 and 2010. The first of these papers, Kimberling (2004) examines associations between life history and success in the context of intentional introductions of non-native insect species for control of pests. Kimberling uses logistic meta-regression based on 'historical' data extracted from publications into a database to develop guidelines to support the US National Invasive Species Management Plan (2001) for intentional insect introductions.

Researchers from the Centre for Evidence-Based Conservation at Bangor University (Gwynedd, UK) and their collaborators contributed three publications between 2006 and 2010. Pullin and Stewart (2006) broadened the discussion of methods in the field from one primarily concerned with meta-analysis to include research synthesis methods more broadly with their article, "Guidelines for systematic review in conservation and environmental management". Pullin and colleagues draw on evidence-based frameworks from other fields, especially medicine, but identify important considerations in their home field of Conservation Biology. Newton, Stewart, Diaz, Golicher, and Pullin (2007) introduce use of Bayesian Belief Networks (BBN) as a tool for evidence-based conservation management through explanation and brief demonstration in four case studies. In the case studies, findings from systematic reviews, studies that did not meet inclusion criteria for systematic reviews, and expert opinion are combined to develop BBN, which are similar to conceptual models and can be tested. The method enables synthesis across different types of knowledge and identifies differences in these knowledge bases. For example, the case presentation on control of *Rhododendron ponticum* clearly demonstrated differences in control methods investigated in research studies versus control methods used by conservation managers. Many research studies focused on a control method rarely used in practice (application of an herbicide, Imazapyr), and few studies focused on control methods used in practice (e.g., weeding and cutting back rhododendrons).

In the final methods paper, Gusset, Stewart, Bowler, and Pullin (2010) present a systematic review with meta-analysis as a means of cross validating, or using multiple evaluation methods, to assess intervention outcomes. The authors identified factors that contributed to success of reintroductions of the endangered wild dog of South Africa. The relatively expensive pre-release socialization program components were found to positively contribute to post-release survival rates more than many less expensive program components.

Resources

A diverse set of resources was identified for research synthesis in the context of developing a knowledge base for Conservation Biology. Discussion and development of resources spanned literature resources such as literature databases, and political, technical, and organizational resources. Advocacy appears to have been relatively important, perhaps due to the coordination efforts and allocations needed to develop larger scale resources.

A publication focused on more traditional research synthesis resources, databases, highlights special concerns in the context of Conservation Biology. Bajomi, Pullin, Stewart, and Takacs-Santainclude (2010) described distribution of reintroduction literature and programs across publication venues and taxonomic groups. The authors found that about a third of publications were available from a set of primary Conservation Biology titles. Distribution of programs was biased towards mammal, then bird reintroductions, with very few invertebrate reintroduction programs. This bias is amplified in the literature, with about half of all publications focusing on mammals, 27% on birds, and 3% on invertebrates. Peer reviewed journals and book publications exhibited less taxonomic bias than grey literature. The search across eight "databases and catalogues" was intended to be specific – resource names and a base search string were identified – but somewhat unclear. For example, the *Web of Knowledge* and *ISI Proceedings* were listed, which would seem to be redundant; and specific *Web of Knowledge* database units were not indicated. Given that review of methods described in several systematic reviews performed in association with the *CEE* did not reveal similar listings though similar resources were listed, the discrepancy may be an oversight or the result of journal space considerations.

Resources identified by authors as needed in the field include marine protected zones, repeated measures, and data from long-term monitoring (Green, Balmford, Crane, Mace, Reynolds, & Turner, 2005; Lepetz, Massot, Schmeller & Clobert, 2009; Henry et al., 2008). Such resources require financial and political commitments and coordination of research resources, but are seen as necessary to research synthesis efforts because through continued study and integration of knowledge, community and generational effects of interventions as well as associations between rates of change over time (e.g., with climate change) can be better understood. Researchers directly linked research to political mandates (e.g., The Convention on Biological Diversity (CBD) and the World Summit on Sustainable Development (WSSD) in e.g., Green et al., 2005); and databases kept to support some mandates are a source of data for subsequent syntheses that, in turn, can be used for guideline development and refinement (e.g., Clark, Hoekstra, Boersma, & Kareiva, 2002).

The Collaboration for Environmental Evidence (CEE), established in 2003 and modeled on the Cochrane Collaboration (Pullin et al., 2006), features prominently in the study data. Though the CEE established a journal to publish systematic reviews, review protocols, and related materials (not indexed by the *SCI*), it is significant that in 2009 a new 'Systematic Review' section of *Conservation Biology*, an established, mainstream journal, was announced. The announcement was made by Pullin and Knight (2009) of the Centre for Evidence-Based Conservation, who again stressed the need to support evidence-based decision-making and referenced the health sciences.

In *HERA*, Crump (2001) discussed the need to accumulate data on a potentially widely-prevalent condition, "hormesis", or favorable biological response to low-level toxin exposure, for which a method of study was not known. Such a database would enable analysis after data accumulation and methods were developed. *HERA* also reprinted an article from the *European Journal of Oncology* that investigated characteristics of studies with non-positive results, arguing that such studies should be made available for meta-analysis (Axelson, 2005).

Studies and Evaluations of Research Synthesis

Literature studies focus on topics generally associated with research synthesis, such as publication bias as it relates to null hypothesis statistical tests, but also in biological terms. In addition to publications reported in other sections, several studies of systematic reviews and their use were identified. These studies evaluated the extent to which research versus experiential knowledge is used to inform practice decisions (Pullin, Knight, Stone, & Charman, 2004; Pullin & Knight, 2005); compared reviews in the field to those in medicine based on Cochrane guidelines (Roberts, Stewart, & Pullin, 2006); evaluated early use of a systematic review framework (Stewart, Coles, & Pullin, 2005); and examined divergent results from meta-analyses related to effects of rising atmospheric CO_2 (Hungate et al., 2009).

Discussion

In introducing Conservation Biology, Soulé (1985) described the field's mission in pragmatic terms: "to modify significantly the rate at which biotic diversity is destroyed," increase survival odds for species at risk, and mitigate negative human impacts. Throughout the Conservation Biology literature, there is emphasis on scarce resources and overwhelming need to make optimal decisions to allocate these resources for maximum effect. In addition to topics mentioned elsewhere, discussion articles are used to demonstrate the translation of research-based knowledge to practice, discuss current levels and potential roles for research synthesis, discuss application contexts, and comment on specific studies.

Some discussion publications in Conservation Biology are similar to those in Evolutionary Biology in that they discuss different approaches to research synthesis, critique specific syntheses, focus on issues such as publication and taxonomic bias, and identify potential uses for the methods in the field – among other topics. The four items identified as "discussions" of research synthesis but which did not relate to the methods in other ways (van Buskirk, & Willi, 2005; Trontelj & Fiser, 2009;

Paillet et al., 2010; and Halme, Toivanen, Honkanen, Kotiaho, Monkkonen, & Timonen, 2010) commented on or replied to comments on specific studies. Issues of contention included techniques used to synthesize data, the extent of generalization of findings, interpretation, and data selection.

Topics of research syntheses

Research syntheses themselves span a variety of topics and environments (Figure 26). Both marine ("biodivers marin protect") and terrestrial ("forest rich biodivers abund bird") habitats are a focus, as are meta-analyses of CO_2 experiments ("elev co2 increas plant") and climate change research more generally ("chang climat respons"). Diversity is considered at multiple levels, including genetic ("invas popul genet"), population ("popul distanc spatial"), species, and habitat diversity. Studies likewise range across biotic and abiotic (e.g., "soil chang carbon") factors. Decision-making by professionals ("conserve review manage evid systemat") first appeared in 2001, and became more prevalent after 2003. Systematic reviews were associated with this topic. Table J2 in Appendix J summarizes the most frequently occurring word stems in the fifteen Conservation Biology topics.

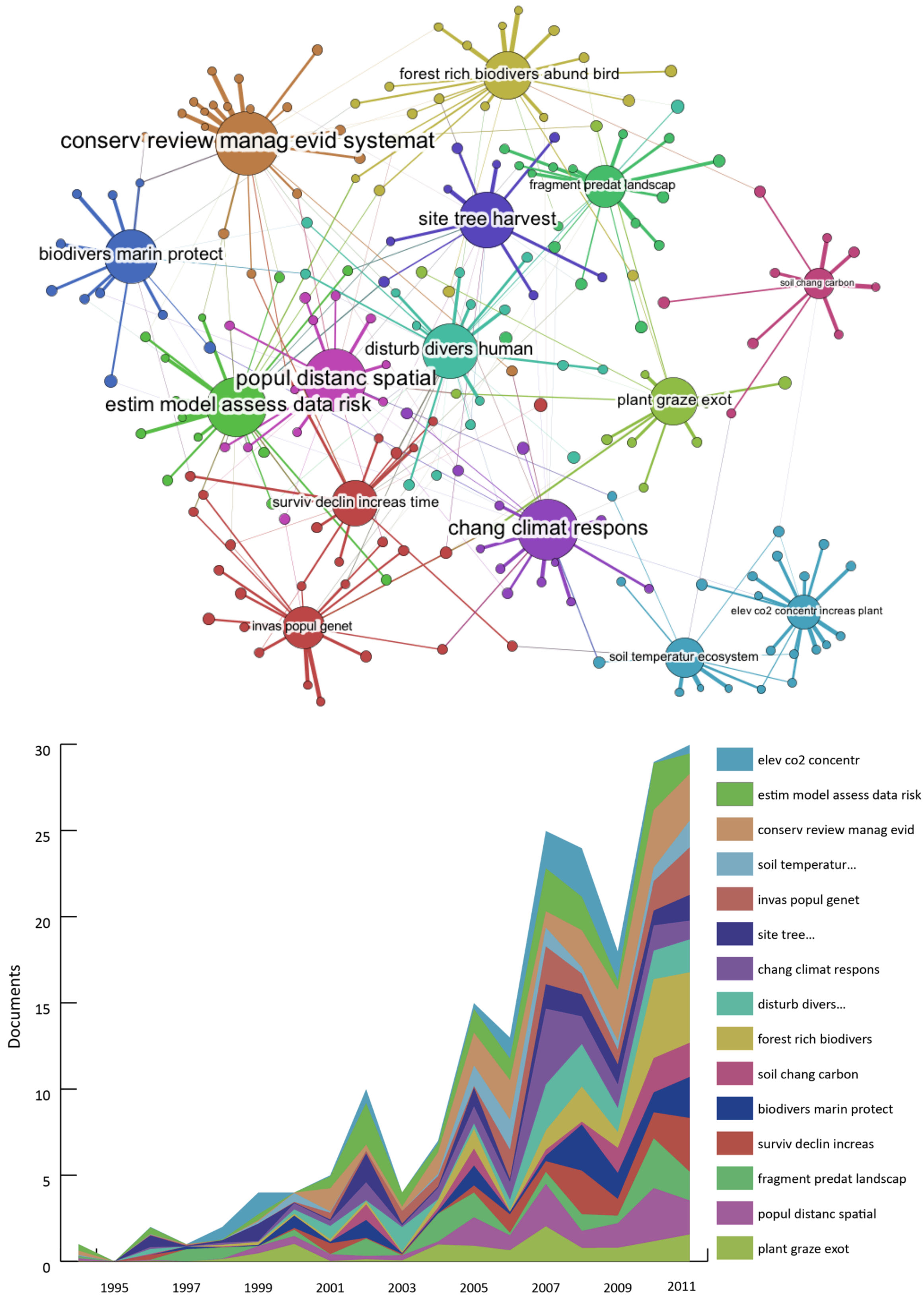


Figure 26. Topics associated with research synthesis in Conservation Biology

Impact: Shifts in practice

Though the years studied, 2006-2008, fall early on the adoption curve, analysis suggests that the research audience is receptive to research synthesis methods. Across all years, 84 syntheses and 117 reviews were identified (Table 27). While there was an increase in the number of research syntheses, there does not appear to have been a drop in the number of reviews produced. The Wilcoxon and van Elteren tests detected a difference in receptivity to reviews versus syntheses from the perspective of citations (Table 28). Examination of a broader span of years could verify whether subsequent use of research syntheses was growing during the time span sampled. No difference was detected in the level of collaboration in reviews versus syntheses.

Table 27. Number of reviews and syntheses, by year

Year	2006	2007	2008	Total
Research Syntheses	16	37	31	84
Reviews	36	41	40	117

Table 28. Summary statistics: Impacts associated with use of research synthesis

		Authors	Times cited (at 5 years)
Median (1^{st} : 3^{rd} Quartiles)	Research Syntheses	3 (2 : 4.25)	42 (24.0 : 78.0)
	Reviews	3 (2 : 4.0)	31 (14.0 : 51.0)
Wilcoxon rank sum test		W = 5404.5, p=0.1093	W = 6074.5, p = 0.00217
van Elteren test, controlling for publication year		U = 1.0539, df=1, p=0.3046	U = 9.1515, df=1, p = 0.0025

Diffusion of research synthesis methods in Conservation Biology is distinct from Evolutionary Biology given the focus on practice. Authors draw from precedents set in the medical and health sciences, and reference standards from the field for comparisons. Given the number of reviews identified through the CEE alone, it is evident that the dataset understates production of research syntheses in the field. Subsequent use – based on citations during the period examined – exceeded that of reviews, indicating research syntheses are of use to researchers. The prevalence of publications from authors associated with the CEE indicates the Center has become a strong proponent of systematic review, as well as home to researchers who implement the methods.

The extent to which research synthesis is used to support practice and policy decisions is unclear, though research suggests efforts to establish translational conservation biology have only begun. In a survey of conservation management plans written 1996-2002 compiled by conservation organizations in the U.K., Pullin, Knight, Stone, and Charman (2004) found that 11% referenced primary scientific literature, and 16% secondary reviews of literature. More often, habitat management handbooks (29%), biodiversity action plans (29%), and accounts of traditional management (71%) were used to justify proposed action plans. A recent examination of forty-three systematic reviews of conservation interventions found that the majority of interventions were relevant to policy decisions, and only about 35% considered those relevant to management decisions (Cook, Possingham, & Fuller, 2013). From the perspective of using systematic reviews to inform policy, Pullin, Knight, and Watkinson (2009) draw on the health sciences to argue that evidence-based environmental policy requires a substantial evidence base because any one policy question will require evidence from several systematic reviews, each assessing a potential intervention.

Social Work

Training programs to prepare professionals for social work practice first emerged in 1898 under the auspices of the New York Charity Organization Society (Abbott, 1995), and more formal credentialing practices were adopted in the 1930s after the formation of the American Association of Schools of Social Work in 1921 (Austin, 1983). During the same period, Social Work and Sociology diverged, though privileged ties between the fields were evident through about 1940 (Chapoulie, 1987). The Social Work Research Group (SWRG) formed in 1949 to support communication practices of social work researchers; and began abstracting relevant research (Greenwood, 1957), developing an early precursor to *Social Work Abstracts*, now published by the National Association of Social Workers (NASW). In 1955, the SWRG and six other organizations came together to form the NASW (McRoy, Flanzer, Zlotnik, 2012).

Though educational standards began to take shape relatively early, the relationship between practice and research is at the center of ongoing inquiry (Herie & Martin, 2002). Engagement with the evidence based practice movement has become an important extension of the ongoing debate (e.g., Herie & Martin, 2002). Similarly, tools associated with EBP, and research synthesis methods in particular, have focused the debate into a quest for empirical analyses amenable to the diverse research designs that constitute research in the field; and to demonstrate the relevance of research and practice to each other (Webb, 2001). Early research in Social Work, supported by organizations such as the Russell Sage Foundation, focused on community needs and the work of social workers (Zlotnick, 2008). Research funding has been a challenge for the field, though a supportive relationship with the National Institute on Mental Health (NIMH) beginning in the late 1980s has provided direction and resources that contribute to an increased research capacity (McRoy et al., 2012). In the context of research synthesis and EBP, organizations such as the Campbell Collaboration, and resources such as *Social Work Abstracts* have developed into important capacity building and knowledge sharing tools.

The underlying social justice mission of Social Work is occasionally discussed in professional and research literature (Galambos, 2008). This mission, which ties Social Work researchers and Social Workers to marginalized groups in society compounds status issues associated with being a traditionally female-dominated field (Abbott, 1995) and politicizes the activities of workers and researchers in the field (e.g., Galambos, 2008). The political nature of the field is also reflected in an active scholarly focus on social policy.

Findings: Research synthesis in the context of Social Work

Nearly all social work publications listed in the *JCR* have published one or more items related to research synthesis. Four titles were not matched to RSM papers. Two were foreign language publications, and the others regional publications (*Australian Social Work*, and the *Asia Pacific Journal of Social Work*). Though nearly a quarter of all publications were located in one journal title, *Research on Social Work Practice*, 80% of research synthesis publications are distributed across approximately 44 percent of *JCR* journal titles (Table 29; Figure 27), a distribution that is reflected in a relatively low Gini coefficient (0.555).

Table 29. Social Work journals with the most RSM-related publications

Journal	RS Count	Percent of RS	Cumulative Pct.	Support (2008-2011 publications)*
Research on Social Work Practice	71	22.33	22.33	0 (35)
American J. of Community Psychology	23	7.23	29.56	0 (4)
Children & Youth Services Review	23	7.23	36.79	0 (15)
Child Abuse & Neglect	20	6.29	43.08	0 (7)
Family Relations	16	5.03	48.11	0 (5)
Health & Social Care in the Community	15	4.72	52.83	0 (9)
Trauma Violence & Abuse	12	3.77	56.60	0 (11)
Social Work	11	3.46	60.06	0 (7)
Clinical Social Work Journal	9	2.83	62.89	0 (8)
Journal of Social Work Education	8	2.52	65.41	0 (0)
Social Service Review	8	2.52	67.92	0 (1)
Social Work Research	8	2.52	70.44	0 (1)
British Journal of Social Work	7	2.20	72.64	0 (2)
Child Maltreatment	7	2.20	74.84	0 (3)
Journal of Social Service Research	7	2.20	77.04	0 (4)
Social Work in Health Care	7	2.20	79.25	0 (2)
Social Work Research & Abstracts	7	2.20	81.45	0 (0)

* Number of associated papers, 2008-2001 with funding reported (and total number of publications in the journal, 2008-2011)

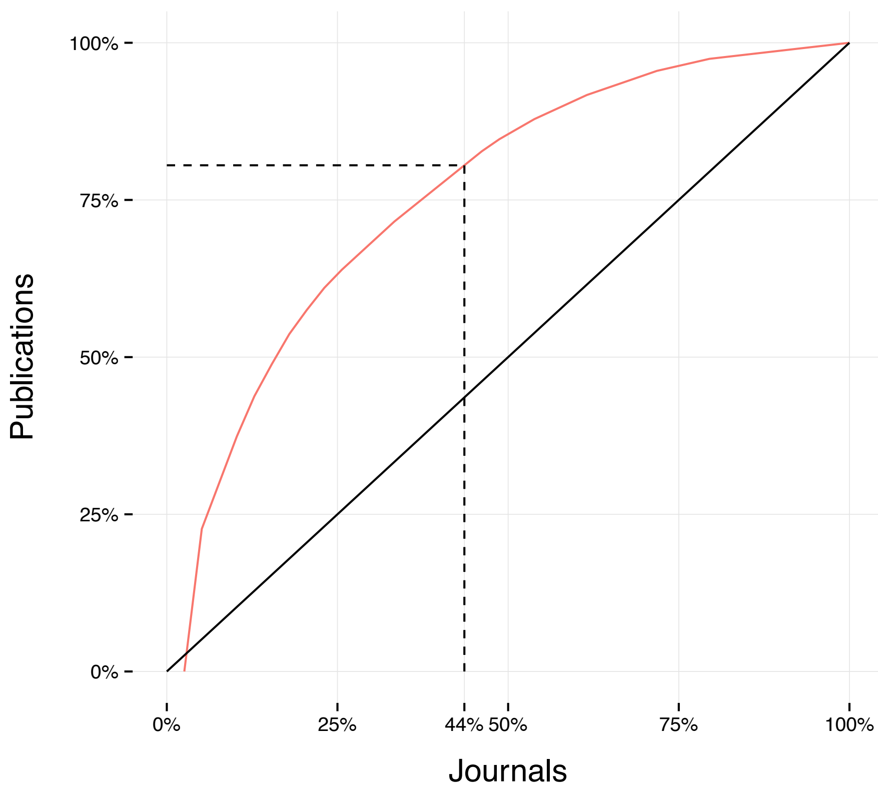


Figure 27. Social Work: Distribution of publications across journals

Financial support was recognized in only one (Koster, 2009) of the 145 social work items published 2008-2011 and judged to have a primary or secondary relationship with research synthesis (0.01%). This paper, which was published in the *International Journal of Social Welfare*, reported a research synthesis. Koster was financially supported by the Stichting Instituut GAK (Netherlands: http://www.sigv.nl/). A second paper (Benzies and Mychasiuk, 2009) acknowledged support from two individuals, one from the Calgary Children's Initiative and one from the 3 Cheers Parenting Project Coordinator, Calgary Health Region, for a paper that reported a research synthesis in *Child & Family Social Work*.

Knowledge base

Social Work references a large number of fields, but mostly concentrated within Social Work and cognate fields, especially in the Psychological Sciences. Extensive use of literature associated with the Psychological Sciences reflects use of research related to mental health, an area to which Social Work researchers also contribute (Abbott, 1995). Lower Rao-Stirling diversity (Table 30) and the proximity of larger nodes to Social Work (Figure 28, yellow node with red ring) reflect these differences. Social Work mobilizes research in Social Work and cognitively similar fields for the benefit of the field broadly.

Table 30. Social Work: Diversity of fields referenced

Measure	Fields referenced	Shannon evenness	Rao-Stirling diversity	Reference-Category count
Value	111	0.636	0.630	6758

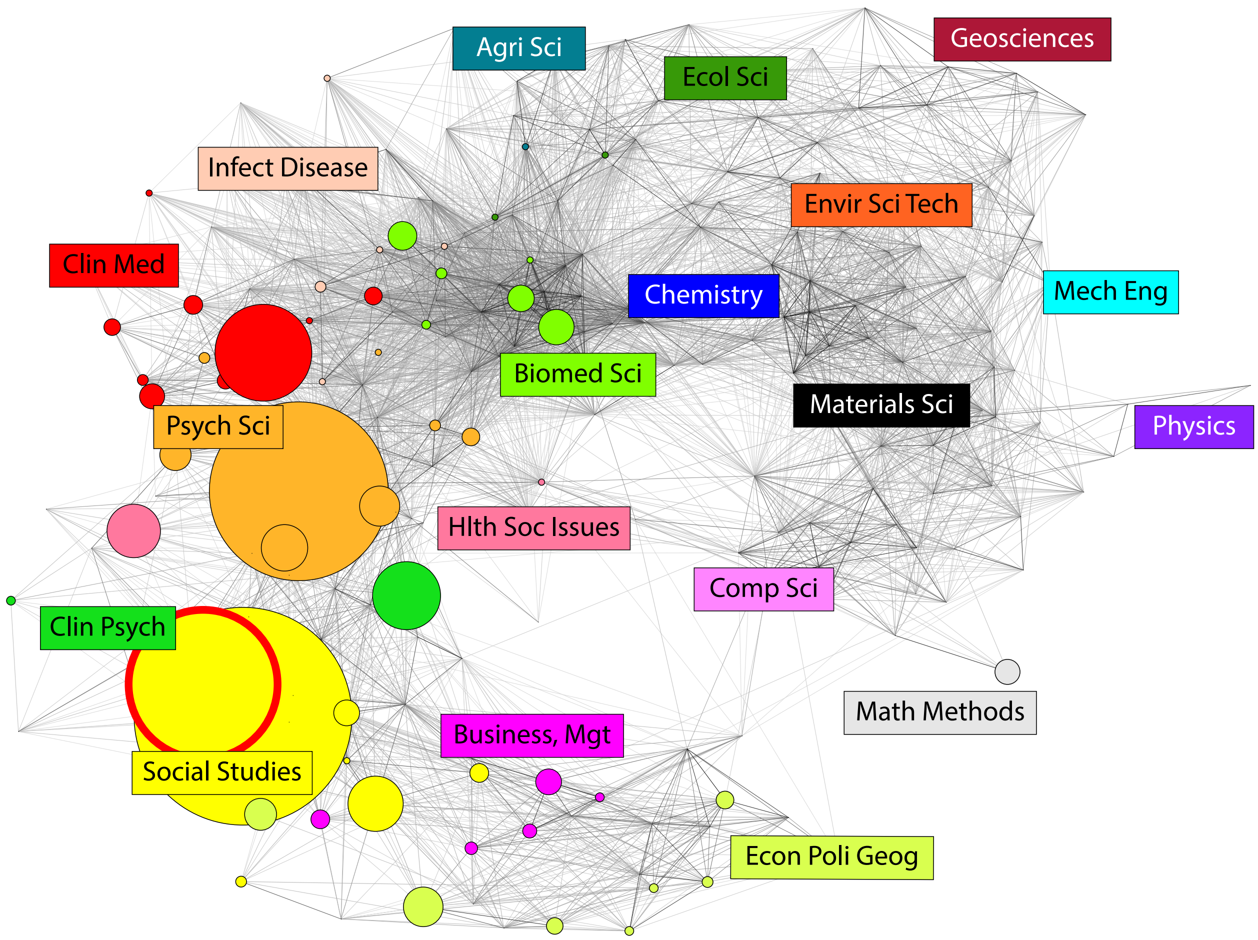


Figure 28. Social Work: Knowledge base of RSM-related publications

Modes of Engagement in Social Work

Like other fields, reports of studies were the most prevalent mode of engagement with research synthesis methods, though only 65.84 percent of publications reported a study (Table 31; Figure 29). Nearly half as many discussed research synthesis (33.10%). A number of publications focused on methods (18 items, 6.34%), resources (17 items, 5.99%), and studied or evaluated research synthesis (18 items, 6.34%).

Table 31. Modes of engagement with research synthesis in Social Work

Mode	Reports	Methods	Resources	Study	Discuss	Introduce	Other
Count	187	18	17	18	94	8	19
Percent	65.84	6.34	5.99	6.34	33.10	2.82	6.69

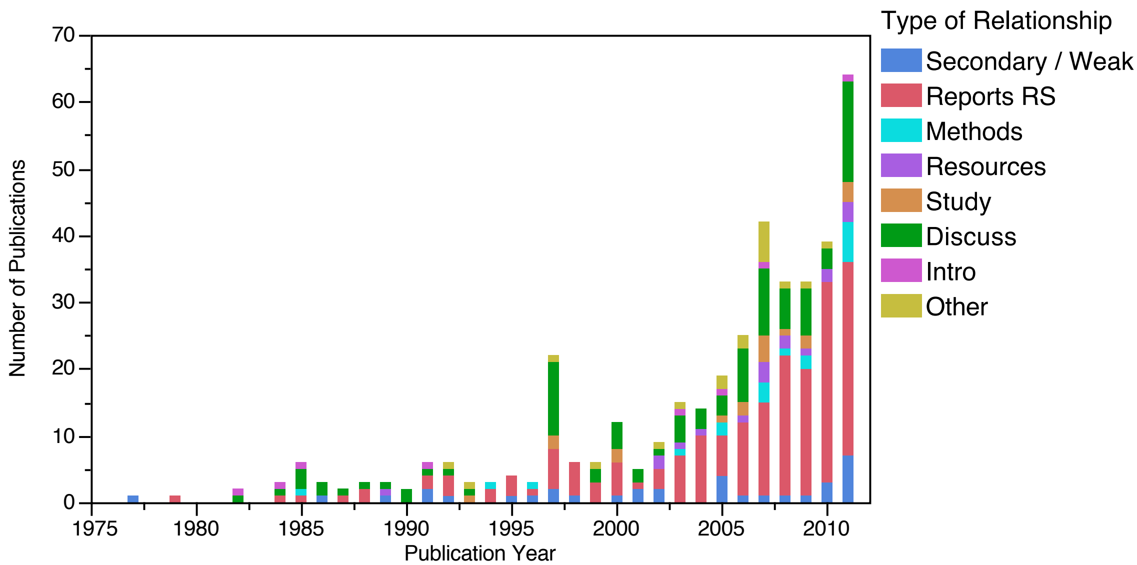


Figure 29. Social Work: Number of publications, modes of engagement, by year

Introductions

Research synthesis methods were introduced multiple times in Social Work between 1982 and 2011, in several different contexts. The first two articles, published in *Family Relations*, provide instruction (Nye, 1982) and demonstration (Ganong & Coleman, 1984) of integrative review. In both cases, the need to fit integrative review methods to Social Work research was emphasized. Soon after, a "meta-analysis" was demonstrated in the *American Journal of Community Psychology* (Medway & Updyke, 1985), where it was introduced again six years later by Durlak and Lipsey (1991). Publication of a collaboration between Lipsey and David B. Wilson (1993) two years later in the *American Psychologist* has been interpreted as contributing to increased interest in research synthesis methods in a broader spectrum of social sciences. Subsequent introductions are made in the *British Journal of Social Work*, *Children and Youth Services Review*, *Research on Social Work*, and lastly, in 2011, in the *Clinical Social Work Journal*, stressing the role of the Campbell Collaboration.

Methods

Methods works, published between 1985 and 2011, included contributions to specific components of the systematic review process, and overall approaches to research synthesis. Some methods papers identified difficulties related to conducting research synthesis in the field; others aimed to advance techniques and concepts related to established procedures.

In an examination of databases and search filters, Shlonsky, Baker, and Fuller-Thomson (2011) introduced the "Avalanche Index" (AI), a measure used to evaluate the efficiency of searches. The Avalanche Index is a measure of "the number of hits one would need to read through in order to find one of the desired studies" (i.e., a study included in a systematic review end-product). More specifically, AI is the total number of hits divided by the number of studies included in a review found with a given search. The authors suggest AI is a better tool to gage search effectiveness because, whereas specificity and sensitivity "describe predictive capacity of a strategy as it relates to previous searches", AI measures overall effectiveness.

Focusing on search in the context of the social sciences and social policy, Curran, Burchardt, Knapp, McDaid, and Li (2007) developed a "novel literature-sampling technique to facilitate a pragmatic approach to mapping" literature, demonstrated with a worked example. The authors were not able to meet their objective, but developed maps based on samples of the literature to characterize research in the areas examined. This study, intended to develop methods, identified a large number of barriers to study identification.

A multidimensional approach to primary study quality appraisal was explored by Taylor, Dempster, and Donnelly (2007). The authors advocated inclusion of a wider selection of studies in research syntheses, including those that focus on process, but identified common appraisal tools as desirable. In a review embedded at the intersection of meta-analysis and experimental research, Shadish (2011) discussed his ongoing examination of non-randomized experiments. The topic is presented in the context of meta-analysis: Shadish reflects on prior meta-analyses he performed to assess impact of study design on findings across studies, and interprets his findings in part based on the potential for meta-analyses to include a wider variety of research designs. One type of non-randomized design, regression discontinuity design (RDD), is evaluated favorably in comparison with randomized designs.

In research reminiscent of single subject design studies, Holden, Bearison, Rode, Fishman-Kapiloff, Rosenberg, and Onghena, (2003) presented an approach that combined single system design studies (SSD) with meta-analysis. Methods for more traditional quantitative meta-analysis were also extended. Nugent (2009) developed the concept of "standardized mean difference effect size invariance," which is concerned with the context of measurement. In order for effect sizes to be comparable and combinable, argues Nugent, facets of the measurement must be comparable.

A few methods articles extended more traditional systematic review frameworks or included systematic reviews as a component of more encompassing methodological frameworks. For example, Lee and Aos (2011) present an approach to cost-benefit analysis in which systematic review is the first step, followed by cost, benefit, linked outcome, and risk analyses. The approach is advocated for use in some policy contexts. In an approach developed for practice settings, Petr and Walter (2005) present a method they call "best practices inquiry," which incorporates research, consumer, and professional knowledge in seven steps: (1) question formulation, (2-4) identification of "multidimensional sources of knowledge" (quantitative and qualitative studies, "consumer wisdom", and "professional wisdom"), (5) summarization, comparison, and contrast of findings across sources, (6) source quality appraisal, and (7) application of findings to improve practice. In an effort to develop understanding about "continuity of care", Parker, Corden, and Heaton (2011) adapted critical inquiry synthesis and narrative synthesis methods to evaluate interim results from a research program. The syntheses were triangulated against the scoping study that set parameters for the research program.

Resources

Publications related to resources for research synthesis methods in Social Work focus on tools to facilitate use and evaluation of research synthesis studies; evaluation of literature and data sources; skills development; and the Campbell Collaboration. Resources intended to facilitate use of research synthesis methods include forms to evaluate primary studies (Gibbs, 1989; Taylor, Dempster, & Donnelly, 2007). Methodological search filters, common in the health sciences, are introduced to aid retrieval of study reports from databases (Shlonsky, Baker, & Fuller-Thomson, 2011).

Holden, Barker, and colleagues (2008, 2009) studied the adequacy of Social Work Abstracts and PsycINFO as resources for systematic reviews. Both databases provided less than optimal coverage of social work journals, and SWA performed significantly worse than PsycINFO. Similarly, review of seven literature databases led Taylor, Dempster, and Donnelly (2007) to conclude that information management skills were imperative for Social Work, and that the profession would benefit greatly from a dedicated international database on par with resources in other fields, such as MEDLINE, CINAHL, and PsycINFO. In a departure from the focus on literature databases, Johnson-Reid and Drake (2008) discuss the use, associated issues, and potential of multi-agency datasets to bolster evidence for EBP, and to provide information about what is being done and what agencies need evidence on. A review of four evidence-based clearinghouses by Soydan, Mullen, Alexandra, Rehnman, and Li (2010) is similarly positioned in the context of evidence-based practice. The authors identified the types of evidence available and how it is produced. Health and medical science resources, which provide some evidence on topics integral to social workers, are used as comparisons (e.g., the Cochrane Library) and to develop resources in some clearing houses (e.g., PRISMA is used in development of systematic reviews at the Swedish clearinghouse MetodGuiden).

Publications that focus on developing human resources discuss systematic reviews and evidence based practice in the context of student training (Ganong & Coleman, 1993; Howard, McMillen, & Pollio, 2003; Corcoran, 2007) and in social work practice (Crisp, 2004). Skills development is also an important facet of publications about Campbell Collaboration resources (Johnson & Austin, 2006; Hannes, Claes, & the Belgian Campbell Group, 2007).

The Campbell Collaboration, established in February 2000, is the subject of or presented as an important resource in several publications. Schuerman, Soydan, McDonald, Forslund, de Moya and Boruch (2002) discuss "the development, organization, and operation of the Campbell Collaboration, an international network of academics and practitioners who prepare, maintain, and make accessible authoritative systematic reviews of the effectiveness of interventions in the fields of social welfare, education, and criminal justice" (p. 309). As previously mentioned, systematic reviews and other resources (e.g., training) made available by the Campbell Collaboration, and how these intersect with needs of practitioners, policy makers, and researchers, are promoted as well.

Studies and Evaluations of Research Synthesis

A number of papers studied or evaluated research synthesis methods in Social Work. An early study, likely inspired by a prior study by Harris Cooper and Robert Rosenthal (1980), compared systematic or integrative coding and other methods as the basis to evaluate research (Ganong & Coleman, 1993). Several studies evaluated research syntheses compared to each other and other approaches (Cowen, 1997; Miller, 2000; Cwikel, Behar, and Rabson-Hare, 2000; Hillberg, Hamilton-Giachritsis, & Dixon, 2011); compared evidence available from qualitative versus quantitative primary studies (Graham & McDermot, 2006); and examined the ability to use syntheses to inform decision-making (Boaz & Pawson, 2005; Braye & Preston-Shoot, 2007).

Littell (2008) evaluated reviews based on systematic review evaluation criteria (using the structure of systematic review as a guide rather than a checklist. In the same study, Littell traced study references through secondary reports of studies, finding a tendency towards "confirmation bias" or simplification of complex studies, lack of attention to non-significant findings, and overstatement of positive results. These findings largely agree with those of Hilgartner (1990), though there is no evidence that Littell was aware of Hilgartner's work. Boaz and Pawson (2005) obtain similar findings through comparison of five approaches to synthesis to inform policy.

The issue of incorporating findings from qualitative studies in systematic reviews and to inform practice and policy decisions was a central concern of two studies (Graham & McDermott, 2006; Taylor, Dempster, & Donnelly, 2007). Mullen and Shuluk (2011) examined reviews of social work interventions, finding that "two-thirds of clients served by social workers benefit in measurable ways" (p. 49), suggesting that "theoretical orientation does not account for differential outcomes" though substantive issues such as interventions examined and populations targeted did lead to different implications. The authors suggest increased emphasis on comparative effectiveness with different populations in different contexts would be helpful.

A comparative meta-study (Lundahl & Yaffe, 2007) compared trends in the publication of meta-analysis in Social Work and four 'allied disciplines': family studies, nursing, psychology, and psychiatry. The authors examined whether articles reported meta-analyses, were methodologically oriented, or discussed previous meta-analyses. Production of meta-analyses was found to lag behind production in psychiatry, psychology, and nursing, but was slightly greater than the multi-disciplinary field of family studies.

Littell and Shlonsky (2010), in a discussion of the role of research in policy contexts, disparage many sources of evidence used in program evaluation, concluding, "much of what passes for empirical knowledge about the effects of child welfare programs is not based on sound principles of research synthesis. Instead, most sources of information on 'programs that work' are derived from unsystematic, partial, and potentially biased summaries of research evidence" (p. 724). The authors go on to compare evidence provided by Campbell and Cochrane reviews, before concluding with a discussion of "evidence-informed decisions," and the limitations of research to inform decision-making.

Discussion

Discussion of research synthesis was extensive. Discussion publications included book reviews, introductions to special issues, comments and replies to comments on specific studies, and a number of issues related to use of research synthesis methods in the field. Eight of forty-five studies that discussed research synthesis but did not relate to the methods in other ways. These publications reviewed monographs on the subject, including books on how to perform syntheses published by Hunter (1982), the NHS Centre for Reviews and Dissemination (1998), Littell (2008), and Cooper (2009); controversial issues associated with EBP in Mental Health;[28] and the historical development of family therapy practice, research, and research integration.[29] Book reviews indicate monographic content has been important to the development and diffusion of research synthesis methods in Social Work; the variety of fields from which methods may have been imported (Organizational Studies, Health Sciences, and Psychology); and that Social Work itself has contributed to the development of methods texts (Littell, 2008b).

Three special issues related to research synthesis were introduced, first in the *American Journal of Community Psychology* (1997) on meta-analysis of primary prevention programs for children and adolescents; second, in the same journal, but focusing on a framework developed to integrate work of researchers, practitioners, and funders (see Emshoff, 2008); and third, in the *Clinical Social Work Journal* (2011) on EBP in clinical social work. While only the first of these focused specifically on research synthesis, the methods were identified as an essential tool in the latter two. Research synthesis in the context of EBP was discussed otherwise, including in editorials (Gambrill, 2003), and in pedagogical (Gambrill, 2001; Howard, McMillen, & Pollio, 2003; Rubin & Parrish, 2007; Corcoran, 2007), policy (Gambrill, 2006), and practice (Hudson, 2009; Thyer & Myers, 2011) decision-making

[28] Norcross, J. C., Beutler, L. E., & Levant, R. F. (2005). *Evidence-based practices in mental health.* American Psychological Association.

[29] Roy, R., & Frankel, H. (1995). *How good is family therapy?: a reassessment*. Toronto,, Canada: University of Toronto Press.

contexts. Capacity building for EBP (Regehr, Stern, & Shlonsky, 2007; Gould & Kendall, 2007; Kindler, 2008), limitations of EBP (Aisenberg, 2008) and writing the history of evidence-based practice was also discussed (Corcoran, 2007).

Discussion articles also comment on specific research syntheses (Cowen, 1997; Price, 1997; Trickett, 1997; Weissberg & Bell, 1997; Kolbe, 1997; Hogarty, 1989; Miller, 2006; Drisko, 2011), including on controversial subjects such as sexual reorientation therapy and DARE (Drug Abuse Resistance Education) (West, 2000; Gorey & Leslie, 2001; Littell, 2006; Van den Noortgate, Geeraert, Grietens, & Onghena, 2006; Pignotti & Mercer, 2007). Use of research synthesis across broad areas of application was the focus of other discussion items (Rosenberg & Holden, 1999; Cowen 2000; Drisko, 2004).

Issues central to performing tasks integral to research synthesis were discussed broadly. Mullen (2006) focused on selection of outcome measures. Lundahl and Yaffe (2008) discussed methods and reporting practices associated with primary studies; and Soydan (2008), the need to focus research efforts on interventions. Commentary on databases from which to retrieve studies for syntheses emphasized the insufficiency of *Social Work Abstracts* and the need to search across multiple databases (Holden & Barker, 1990; Gambrill, 2001).

Topics associated with research synthesis

Topics associated with research synthesis publications suggest broad engagement with research synthesis across Social Work. Evidence-based practice, methodologies, and intervention research are salient issues in Social Work. In Figure 30 these issues are represented by the topics “practice evidence-bas”, “meta-analysis design result method”, “effect size meta-analysis”, “systematic search database”, and “intervent treatment effect”. The prevalence of topics associated with practice and EBP reflects the practice orientation of Social Work research (Anastas, 2000). EBP and RSM are central to discussions about research-practice divides; and have been cast in opposition to traditionally prevalent research approaches such as qualitative case studies (Herie & Martin, 2002), which are difficult to systematically synthesize.

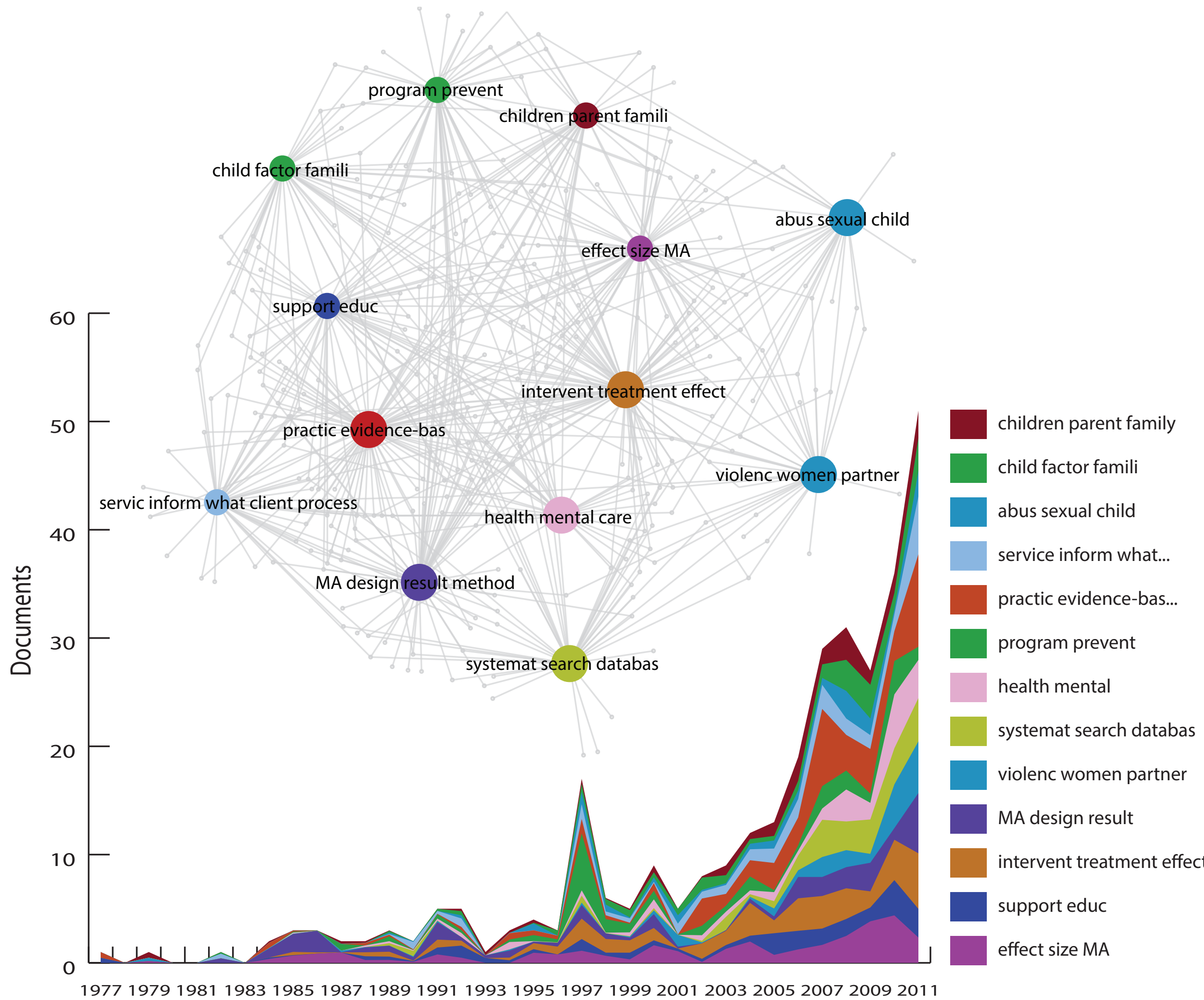


Figure 30. Topics associated with research synthesis in Social Work

Since the late 1990s, interest in intervention research, which is prototypically amenable to synthesis methods, has emerged. Preventative programs ("program prevent") and client services ("service inform what client process"), which are linked to EBP, are also focal interests. Social work topics subject to research synthesis include investigations of factors associated with un/successful foster care experience ("child factor family"), child abuse ("abus sexual child"), issues related to family structures ("children parent family"), and mental health ("health mental"). Preventative programs ("program prevent") and client services ("service inform what client process"), which is linked to EBP, are also focal interests. Table J3 in Appendix J summarizes the most frequently occurring word stems in each of the thirteen Social Work topics.

Impact: Shifts in practice

Though the first publications related to research synthesis methods in social work appeared relatively early, in *Clinical Social Work* in 1977 and *Family Coordinator* in 1979, sustained engagement did not occur until about twenty years later. The years initially examined to identify whether there have been shifts in practice associated with the diffusion of research synthesis, 2006-2008, are well beyond this period. A modest number of reviews and syntheses make up the dataset: 30 reviews and 45 research syntheses were found across all three years (Table 32.). The Wilcoxon and van Elteren tests detected a difference in collaboration patterns associated with reviews versus syntheses, but not a difference in receptivity based on citation patterns (Table 33).

Table 32. Number of reviews and syntheses, by year

Year	2006	2007	2008	2009	2010	Total
Research Syntheses	17	19	9	26	32	103
Reviews	8	13	9	15	3	48

Table 33. Summary statistics: Impacts associated with use of research synthesis

		Authors		Times cited	
		2006-2008, N=75	2006-2010, N=151	2006-8, at 5 yrs, N=75	2006-10, at 3 yrs, N=151
Median (1^{st} : 3^{rd} Quartiles)	Research Syntheses	2 (2:4)	3 (2:4)	12 (5:29)	6 (2:13)
	Reviews	2 (1:3)	2 (1:3)	10.5 (5.25:22)	6 (3:11)
Wilcoxon rank sum test		W = 879, p = 0.01145	W = 3336, p < 0.001	W = 733, p = 0.2668	W = 2510, p = 0.4403
van Elteren test, controlling for publication year		U = 4.8306 (df=1, p=0.0280)	U = 8.3159 (df=1, p=0.0039)	U = 0.5007 (df=1, p=0.4792)	U = 0.4005 (df=1, p=0.5268)

Given the small number of reviews and research syntheses published in Social Work from 2006 to 2008, the observed difference in collaboration but not citation patterns, and that it was feasible to collect and categorize reviews and syntheses published in 2009 and 2010, analysis of Social Work papers was extended. A substantial number of research syntheses were identified for 2009 and 2010: Fifty-eight were added for a total of 103 syntheses across five years. Only 18 additional reviews were added, for a total of 48 reviews across five years. The primary goals of an extended analysis were to (1) learn whether the patterns observed for 2006 to 2008 would be observed through more recent years; and (2) examine whether there was a trend in the number of reviews versus research syntheses that were published across years. With continued diffusion of research synthesis, it would be expected that more research syntheses would be published in later years. If research synthesis methods, in at least some contexts, were used in lieu of traditional narrative review methods, we would expect the relative number of reviews to decrease as the number of research syntheses increased.

These tests confirmed that collaboration patterns observed in 2006 to 2008 continued through 2010. Testing with the Wilcoxon rank sum test, it was found that research syntheses were more likely to be published in later years ($W=3036$, $p = 0.0105$), suggesting a trend towards increased use of research synthesis methods and decreased use of traditional review methods in later years. Taken together, the data indicate there has been a change in the practice of synthesizing research in Social Work overall. In some contexts, researchers are more likely to use research synthesis methods rather than traditional narrative reviews. Research synthesis is also likely to be a more collaborative process. Though there has been a reduction in the number of narrative reviews over time, narrative reviews, from the perspective of the audience of researchers who reference them, have not become obsolete.

While Conservation Biology presented the case of a field relatively new to the evidence-based movement, Social Work has engaged with the movement since at least 1989 (Hogarty, 1989). Subsequent discussions of evidence-based practice (EBP) identify the potential, benefits, and limitations of EBP – and of research syntheses as a basis for EBP. In some cases, authors are critical of not only research synthesis studies, but also the primary studies that are synthesized. Critiques range in tone, some suggesting the need for more research because, for example, the syntheses lack studies across cultures and political geographies, while some criticize use of the research methods and interpretations of synthesized research. More recently, exclusion of qualitative research from research syntheses intended to influence practice and policy decisions has become a topic of discussion. For example, Graham and McDermott (2006) write, “Qualitative research is ambiguously placed as a source of evidence for policy. It provides a way of accessing the experiences and perspectives of those targeted by welfare interventions, yet it is routinely excluded from the evidence reviews undertaken to inform these interventions…" (p. 21). Researchers were interested in more than just the ability to include findings from qualitative and process-oriented research: It was important to develop methods to do so, tools to facilitate repeatability, and a level of agreement on use of these methods and tools.

Women's studies

The interdisciplinary field of Women's Studies emerged in the late 1960s and early 1970s with the feminist movement (Brooks & Hesse-Biber, 2007; Reynolds, Shagle, & Venkataraman, 2007), and has retained an activist orientation (Arthur, 2009). Women's Studies grew from a handful of courses in the late 1969 to hundreds in 1971 (Stimpson, 1973). Integrated programs similarly expanded rapidly in the United States, from the first in 1970 (San Diego State University, followed by Cornell University) to 150 by 1975 and nearly 650 by 2007 (Boxer, 2002; Reynolds, Shagle, & Venkataraman, 2007). Institutionalization was aided through early establishment of journals, including the *Women's Studies Quarterly* in 1972 and *Signs* in 1975, and through philanthropical contributions, notably from the Ford Foundation, which provided substantial funding for fellowships, research centers, and projects beginning in 1972 (Hill, 1990), and the Rockefeller Foundation (Stimpson, 1973). In 1977, the National Women's Studies Association (NWSA) was created, providing an identity and institutional structure for informal networks and communication practices (Arthur, 2009; Boxer, 1982; Toth, 1977).

As a field, Women's Studies is concerned with race, gender, sexual orientation, class, and other dimensions of identity and social relations, in the context of human experience. Intersectionalities, or focus on experience at the intersection of multiple interrelating dimensions of social identity has developed into an important focus since introduced in the 1990s (Shields, 2008). The initial focus of courses on history, literature, and sociology expanded first to the other humanities and social sciences; and more recently to science and technology fields (McFadden, 2005). The phrase, “add women and stir,” has frequently emerged in discussion of new areas of scholarship, though, as noted by Klein (1996), this countertop metaphor belies the complexities of scholarship intended to transform established knowledge structures.

Women’s Studies scholars often have dual affiliation, with Women’s Studies and another discipline both intellectually and in organizational structures (Boxer, 1982; Klein, 1996; Reynolds, Shagle, & Venkataraman, 2007). A by-product of the multiple locations of Women’s Studies scholars is a fragmented literature more suited to multiple classifications (Searing, 1992). Themes such as gender, oppression, and the political nature of knowledge work unify the field. The greatest differences among Women’s Studies scholars are expressed in the methods used. Research approaches span empirical, critical, and interpretive approaches (Leckenby, 2007) and include methods such as survey research, ethnography, in-depth interviewing, focus groups, and oral history (Hesse-Biber, 2007). Due to the diversity of methods and approaches, “even when focused on the same topic, research results may be disparate and incommensurable” (Klein, 1996, p. 121).

Findings: Research synthesis in the context of Women’s Studies

Of the thirty-eight journal titles listed in Women’s Studies in the 2012 *Journal Citation Report* (*JCR*, Appendix H, Tables H3 and H4), only thirteen published at least one article related to research synthesis methods. Approximately eighty percent of all publications are concentrated in just four titles or 13 percent of all titles (Table 34). The relatively high Gini coefficient (0.869, Figure 31) reflects an uneven distribution.

Table 34. Women's Studies journals with the most RSM-related publications

Journal	Count	Percent	Cum. pct.	Support (2008-2011 publications)*
Journal of Women's Health	38	34.23	34.23	15 (27)
Sex Roles	32	28.83	63.06	0 (5)
Psychology of Women Quarterly	14	12.61	75.68	0 (5)
J. of Women's Health & Gender-Based Med.	6	5.41	81.08	0 (0)
Women's Health Issues	6	5.41	86.49	0 (3)

* Number of associated papers, 2008-2001 with funding reported (and total number of publications in the journal, 2008-2011)

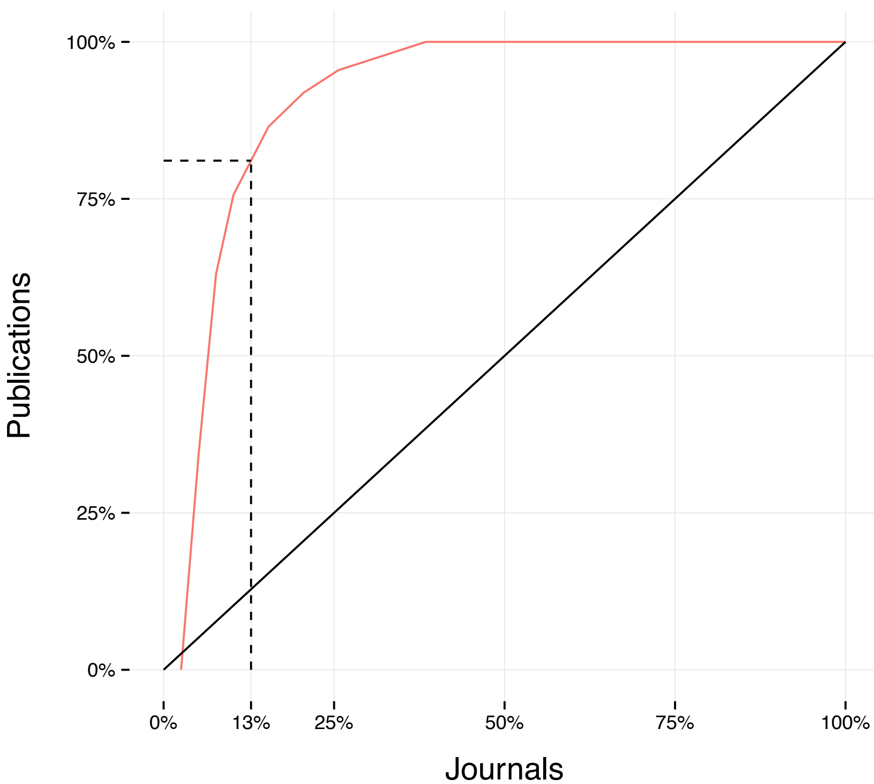


Figure 31. Women's Studies: Distribution of publications across journals

Financial support was recognized by fifteen of 47 Women's Studies publications judged to have a primary or secondary relationship with research synthesis (31.91%). All of these papers were published in the *Journal of Women's Health* between 2009 and 2011. Thirteen reported a research synthesis; one studied, developed methods, and developed resources related to research synthesis methods; and one was judged to have a secondary relationship to research synthesis methods.

Knowledge Base

Women's Studies references are relatively evenly distributed across fields, as indicated by higher Shannon evenness (0.732, Table 35) and nodes that are more similar in size (Figure 32). Women's Studies seldom references work published in Women's Studies journals (Figure 32, yellow node with red ring). The juxtaposition of a concentration of research synthesis publications within a few Women's Studies journals with broad referencing patterns suggests Women's Studies scholars engage with content of other fields through research synthesis. The pattern echoes observations that Women's Studies scholars tend to have dual allegiances: to Women's Studies and another field; and the description of feminist scholarship as one that "simultaneously challenges and is shaped by disciplinary inquiry" (Klein, 1996, p. 121).

Table 35. Women's Studies: Diversity of fields referenced

Measure	Reference-Category count	Fields referenced	Shannon evenness	Rao-Stirling diversity
Value	3047	88	0.732	0.726

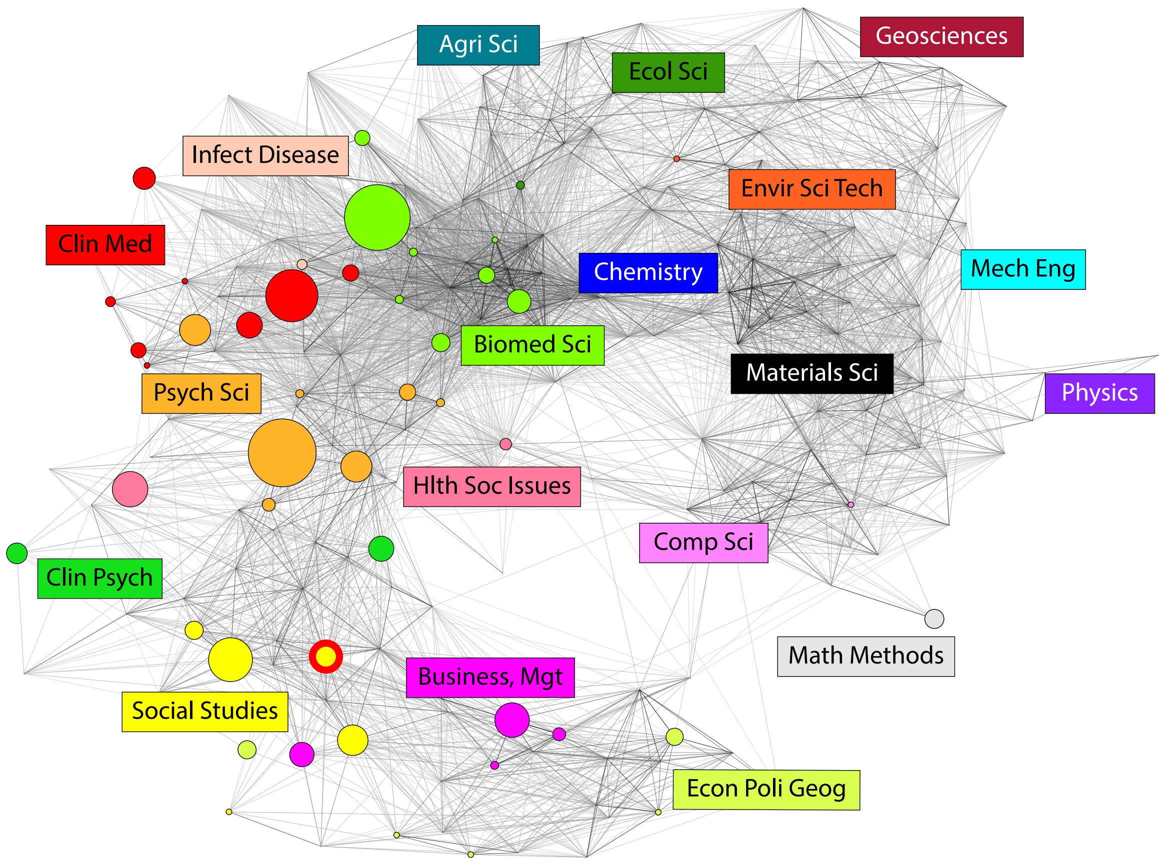


Figure 32. Women's Studies: Knowledge base of RSM-related publications

Modes of Engagement

Publications related to research synthesis methods in Women's Studies primarily reported research synthesis studies (83.16%), though the methods were discussed to an extent (14.73%). Other modes of engagement with the methods were minimal (Table 36, Figure 33).

Table 36. Modes of engagement with research synthesis in Women's Studies

Mode	Reports	Methods	Resources	Study	Discuss	Introduce	Other
Count	79	3	1	3	14	1	5
Percent	83.16	3.16	1.05	3.16	14.73	1.05	5.26

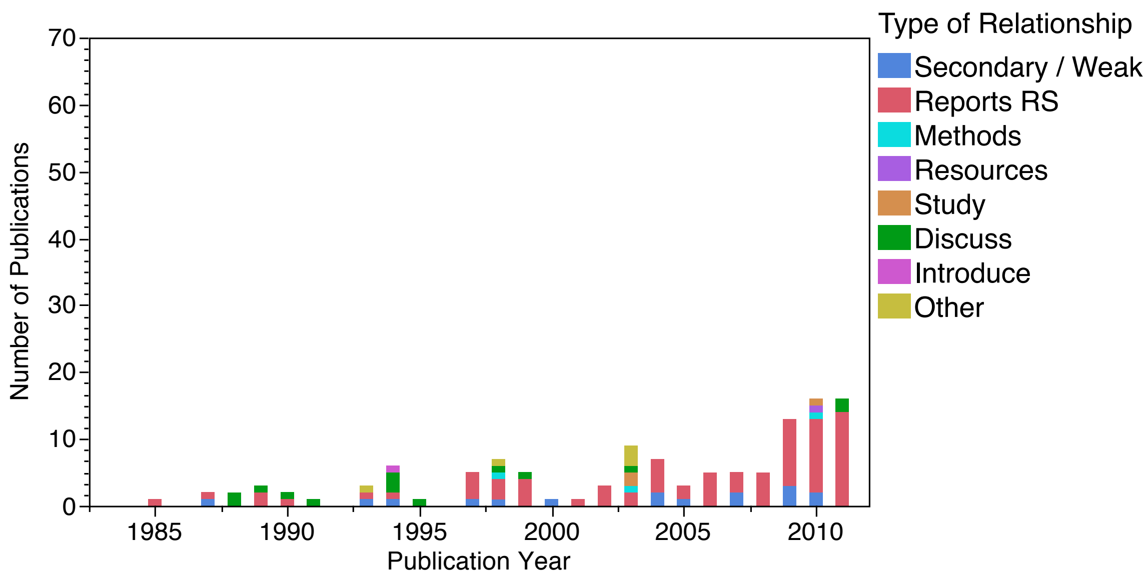


Figure 33. Women's Studies: Number of publications, modes of engagement, by year

Introduction

Hyde (1994) introduced meta-analysis through description of the process, review of meta-analytic studies of gender differences in psychology, and advocated use of quantitative methods such as meta-analysis as well as qualitative methods to make "feminist transformations" in psychology.

Methods and Resources

Nowell and Hedges (1998) exploit procedures used to examine between study variance in meta-analysis, and assess extreme scores to identify changes in gender differences over time reflected in *National Assessment of Educational Progress* (*NAEP*) long term trend data. The authors frame their discussion of meta-analysis and research on gender differences in the context of Women's Studies (especially research published in *Sex Roles*) and psychology and educational psychology more broadly. Doull, Runnels, Tudiver, and Boscoe (2010) step towards integration of Sex and Gender-Based Analysis (SGBA) in systematic reviews through application of the method via their newly developed Sex and Gender Appraisal Tool for Systematic Reviews (SGAT-SR) to a sample of reviews on interventions for cardiovascular diseases (CVD) from the Cochrane Library.

Studies and Evaluations of Research Synthesis

In addition to Doull and colleagues (2010), two studies evaluated whether gender differences were considered in previous systematic reviews focused on cardiovascular disease. Johnson, Karvonen, Phelps, Nader, and Sanborn (2003) examined systematic reviews in the *Cochrane Library* for inclusion of women and gender-based data analyses. The authors found scant data available for analysis. For systematic reviews in which gender-based data was available, about one third performed analyses to examine gender differences. Also in 2003, Whitlock and Williams examined U.S. Preventive Services Task Force (USPSTF) and the Task Force on Community Preventive Services (CTF) recommendations and the underlying systematic evidence reviews to assess the applicability of the recommendations to women.

Discussion

Two early book reviews highlight methodological diversity within the field. Reviews of *The worth of women's work: A qualitative synthesis* (Statham, Miller, & Mauksch, 1988, in Sokoloff, 1988 and Royster & Allgeier, 1989) and *The psychology of gender advances through meta-analysis* (Hyde & Linn, 1986, in Falbo, 1988) were published in *Sex Roles* and the *Psychology of Women Quarterly*. Diversity is further highlighted through discussions of the feminist critique as it relates to economics and psychometric evaluations (Flynn, 1999); and constructive criticism of the *Cochrane Library*. In a 2003 review of cardiovascular disease, for example, Johnson and colleagues (2003) advise, “the Cochrane Library would be a more useful tool for the evidence-based healthcare of women if the systematic reviews used all available gender-specific information in their analyses” (p. 449).

Twenge (2011) discussed research she and her colleagues performed, beginning with work from her time as a graduate student (Twenge, 1997a) and the method of "Cross-Temporal Meta-Analysis" (CTMA). Though in prior work included in the sample for this study (Twenge, 1997a; Twenge, 1997b), the author did not highlight her carefully explicated methods as "new," the discussion article, written fourteen years later, does. Twenge writes, "Unlike a traditional meta-analysis, which examines differences among groups across many scales, CTMA analyzes scores on only one scale at a time" to examine generational differences (p. 194).

Other discussions focused on the role of meta-analysis in gender role research (Hyde, 1990; Lewin & Wild, 1991; Eagly, 1994), and used meta-analytic studies to establish a baseline of what is known (Rojahn & Willemsen, 1994; Cahan & Ganor, 1995). The importance of meta-analytical research to gender-difference studies is highlighted by Hyde (1990) and Lewin and Wild (1991). Eagly (1994), in a discussion of sex- and gender-difference research, identifies meta-analysis as an opportune method to be used to examine and theorize why differences are observed between sexes/genders.

A news item, published in the *Journal of Women's Health* in 1997 (Anonymous, 1998) proclaimed, "Meta-analysis confirms relationship of alcohol to breast cancer," reflecting the tendency of publications removed from original research reports to simplify results such that they are represented as more certain and precise (Hilgartner, 1990).

Topics associated with research synthesis in Women's Studies

The limited range of topics and uneven distributions of content across topics provide evidence of selective engagement with research synthesis in Women's Studies. Research synthesis publications are centered on research related to gender differences in psychology and related fields;

women's health; and methodological issues (Figure 34). Psychology topics include work and leadership ("work role leadership"), gender differences and stereotypes, and abilities linked with sex such as spatial navigation ("differ sex abil"). Women's health issues include breast cancer, mammography, reproductive issues, and conditions not specific to females. Topics that link health-oriented and psychological gender-oriented research include those focused on literature and synthesis ("research literature review", "health review articl systemat guidelin"), and methods (e.g., "function sampl"), though topic locations reveal emphases on different methods topics in health versus psychology fields. For example, "test hypothesi measure" is embedded in psychology topics; and interventions and guidelines are associated with health topics. In aggregate, topics emphasize the diversity of literature included in "Women's Studies," though this apparent diversity is constrained to primarily health and psychology – the much broader field of Women's Studies is not represented. Table J4 in Appendix J summarizes the most frequently occurring word stems in each of the seventeen Women's Studies topics.

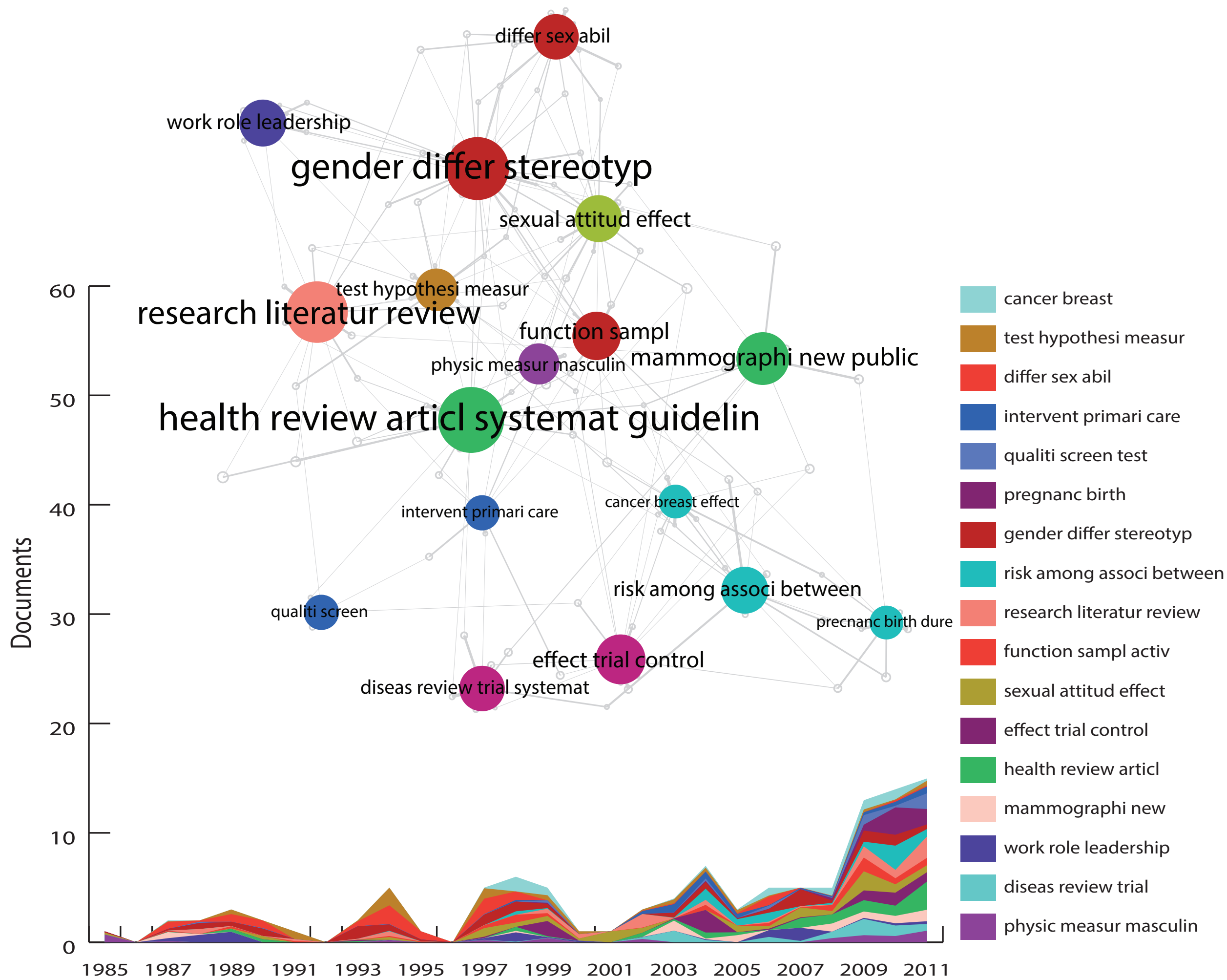


Figure 34. Topics associated with research synthesis in Women's Studies

Impact: Shifts in practice

In Women's Studies, the first publication related to research synthesis appeared in 1985 in the psychology literature, and 1998 in the health sciences. Engagement with the methods remained modest, but became more prevalent in 2003 and expanded again in 2009. The years examined to identify shifts in practice associated with use of research synthesis methods fall between these two periods of expansion. From 2006 to 2008, 23 research syntheses and 23 research reviews were identified (Table 37).

No difference in collaboration patterns was detected in reviews versus research synthesis (Table 38). Both the Wilcoxon and van Elteren tests detected a difference in subsequent use of research syntheses versus reviews: Research syntheses are more cited than reviews.

Table 37. Number of reviews and syntheses, by year

	2006	2007	2008	Total
Research Syntheses	8	6	9	23
Reviews	10	9	4	23

Table 38. Summary statistics: Impacts associated with use of research synthesis

		Authors	Times cited (at 5 years)
Median (1^{st} : 3^{rd} Quartiles)	Research Syntheses	3 (2 : 3)	14 (10.5 : 21.5)
	Reviews	2 (1 : 3)	9 (5 : 13.5)
Wilcoxon rank sum test		W = 327, p = 0.08014	W = 365.5, p = 0.01355
van Elteren, controlling for publication year		U = 2.8137 (df=1, p=0.0935)	U = 5.8146 (df=1, p=0.0159)

Few studies in Women's Studies used research synthesis methods. Those that did drew on forms prevalent in intersecting fields (psychology and health) to synthesize research from these fields using methods prevalent in the fields. The Women's Studies syntheses take an activist stance and demonstrate how a feminist perspective has or can contribute to research in these fields (e.g., psychology); or, alternatively, to emphasize that there is a need for greater attention to gender differences when systematically reviewing and synthesizing past studies (e.g., in health sciences). This approach reflects the nature of Women's Studies, which is a relatively young field without a deep archive of data or literature of its own to synthesize; identified as having an activist approach (Boxer, 1982; Klein, 1996); and in which scholars work at the intersection of Women's Studies topics and another field. The activist stance is exemplified by engagement with research of intersecting fields to communicate the value of the alternative lens Women's Studies; and to comment on prior research not compatible with addressing interests of diverse populations. Modest use of research synthesis methods may derive from preferences for qualitative, interpretive, and critical research methods in Women's Studies more broadly.

Information and Library Science

Information and Library Science (ILS) is alternatively described as two disciplines, Information Science and Library Science (Saracevic, 1992), one discipline, Library and Information Science with subfields (Åström, 2010), or one discipline, Information Science, with applied dimensions that include Library Science (e.g., Ingwersen, 1992). A third strand, Documentation, traditionally has been neglected in the United States but is recognized for close association with science information (Buckland, 1996); and a fourth, Archival Science, traditionally has been located between the constellation of information, library, and documentation fields, and history. Important developments in the field, or conglomeration of subfields (Baccini & Barabesi, 2011) include the institutionalization of Library Science as a research field through the establishment of the Graduate Library School (GLS) at the University of Chicago in 1928 with funding from the Carnegie Corporation (Anderson, 1963; Buckland, 1996; Burke, 2007); the rise of information science, especially in the post-World War II era, which diversified both resources available and research application contexts (Burke, 2007; Bonaccorsi, 2010); and the growth of interest in and recognition of technology as an integral component of professional and research problems (Bowles, 1989).

Though library training predates its presence in the academy (Heim, 1986), as is the case with many professions, professional training of librarians has been an important component of the academic presence of ILS programs even before the GLS was established (Martin, 1994; Heim, 1986; Lynch, 2008). Despite early similarities in the development of training programs for Social Work and Librarianship, including uneasy relationships between research and practice (Heim, 1986; Webb, 2001), subsequent developments in the fields and their social and political contexts have led to vastly different outcomes. The primacy of librarian training has waned with increasing emphasis on 'information' in society and increasingly diverse information professions, ILS faculty, students, and programs (see, e.g., Abbott, 1998; Bobinski, 1986; Marchionini & Moran, 2012; Lynch, 2008).

Areas of research in information and library science have proliferated, but broadly focus on access to information across time, space, and other barriers; information organization and representation; social and organizational contexts; human interactions with information; political and economic aspects of information; and development, design, and use of information services and technologies in these contexts. ILS research has at times been data-driven (Ingwersen, 1998), and generally viewed as not having a deep field-specific theoretical tradition (Fisher, Erdelez, & McKechnie, 2005; Kumasi, Charbonneau, & Walster, 2013; Pettigrew & McKechnie, 2001). Like other fields surveyed here, approaches, methods, and measures in ILS research are diverse (e.g., Jarvelin, & Vakkari, 1990; Eldredge, 2004; Ford, 2000); and preferred approaches tend to vary with specialism.

Though the contributions of information and library scientists to the conduct of research syntheses is recognized frequently outside the field, research synthesis has been neglected in ILS literatures (Hjørland 2001, 2002). Exceptions include ILS communities associated with health and medical information, and the evidence based librarianship (EBL) movement (e.g., *Evidence Based*

Library and Information Practice). White, a contributor to a handbook for research synthesis (1994, 2009), which he describes as one of his most-cited works (2002), observed that the apparent lack of attention to RSM may be due to the publication venues authors select. ILS authors may be more likely to publish research synthesis-related work in venues read by those who use RSM in other fields.

Findings: Research synthesis in the context of Information and Library Science

Publications related to research synthesis methods were found in 46 of the 84 titles listed in the *JCR* ISLS category in 2012. Early publications were found scattered throughout a number of journals (e.g., *College & Research Libraries*, 1985; *Behavioral & Social Sciences Librarian*, 1988, and *Journal of Documentation*, 1989). The journals that publish the greatest number of publications are associated with the health and medical sciences. Scientometrics and Management titles have several publications. The distribution of publications across journal titles approximates the 80/20 rule: About 80 percent of all RSM publications were found in 18% of ILS titles (Gini coefficient = 0.796; Figure 35). Journal titles with the greatest number of publications are listed in Table 39.

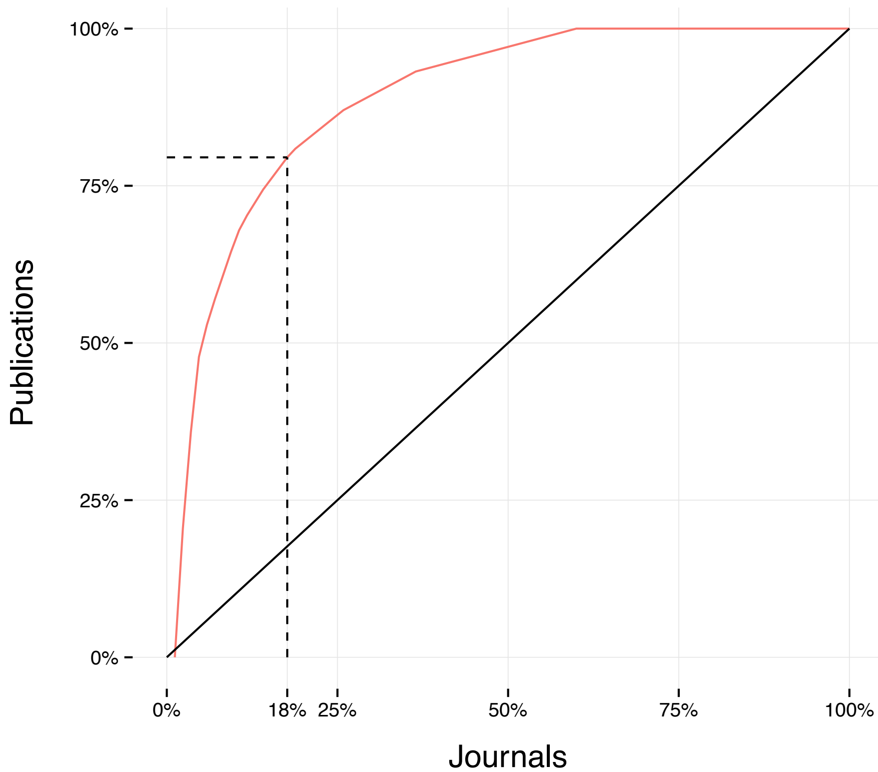


Figure 35. Information and Library Science: Distribution of publications across journals

Table 39. Information and Library Science journals with the most RSM-related publications

Journal	Count	Percent	Cum. pct.	Support (2008-2011 publications)*
J. of the American Medical Informatics Assoc.	60	20.48	20.48	10 (22)
Bull/J. of the Medical Library Association	45	15.36	35.84	0 (13)
Health Information and Libraries Journal	35	11.95	47.78	0 (23)
Journal of Health Communication	15	5.12	52.90	0 (8)
JASIST/JASIS	12	4.10	57.00	0 (3)
Information & Management	11	3.75	60.75	0 (1)
Scientometrics	11	3.75	64.51	2 (4)
MIS Quarterly	10	3.41	67.92	0 (2)
Library & Information Science Research	7	2.39	70.31	0 (2)
Journal of Documentation	6	2.05	72.35	0 (2)
Library Trends	6	2.05	74.40	0 (0)
Information Research: An Intl. Electronic J.	5	1.71	76.11	0 (2)
Journal of Information Science	5	1.71	77.82	0 (0)
Scientist	5	1.71	79.52	0 (0)
European Journal of Information Systems	4	1.37	80.89	0 (4)

* Number of associated papers, 2008-2001 with funding reported (and total number of publications in the journal, 2008-2011)

Financial support was recognized in fourteen of the 111 Information and Library Science publications (12.61%). Of these, ten reported a research synthesis (eight in the *Journal of the American Medical Informatics Association* (*JAMIA*); two in *Scientometrics*). Three developed methods for research synthesis (two in *JAMIA*, and one in *Social Science Computer Review*); and one, which was judged to have a secondary relationship to research synthesis was published in *Aslib Proceedings*. Funding for these papers was provided by multiple organizations in Australia, Canada, the United Kingdom, the United States; and also by organizations in Colombia, Japan, New Zealand, Taiwan, and an Ibero-American association. The full list of funding organizations is presented in Appendix I, Table I6.

Knowledge Base

The 293 Information and Library Science papers judged to have a primary or secondary relationship with research synthesis methods collectively reference journal publications that were associated with 5175 counts across *S/SCI* categories (Table 40). ILS publications reference publications in the field (Figure 36, pink node with red ring) and draw extensively from other fields. Publications from a large number of fields (136) are referenced, including from Clinical Medicine and Business and Management fields. The distribution of references across fields is relatively uneven (Shannon evenness = 0.678), and fields referenced are relatively dissimilar (Rao-Stirling diversity = 0.752).

Table 40. Information and Library Science: Diversity of fields referenced

Measure	Fields referenced	Shannon evenness	Rao-Stirling diversity	Reference-category count
Value	136	0.678	0.752	5175

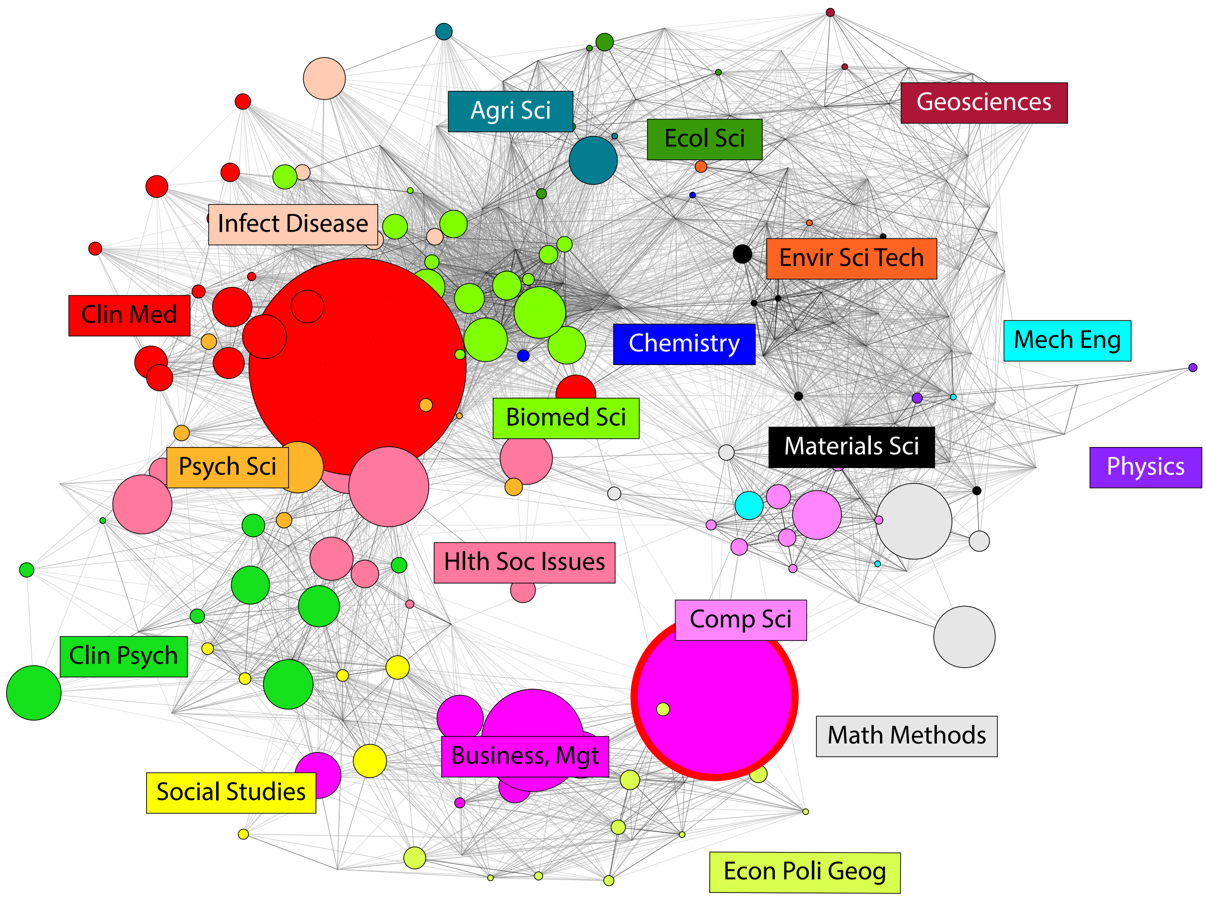


Figure 36. Information and Library Science: Knowledge base of RSM-related publications

Modes of engagement with research synthesis in ILS

Publications in ISLS demonstrate that researchers engage with research synthesis in a variety of ways (Table 41; Figure 37). More than anything, researchers apply research synthesis methods (135 records, or 54.2%). Following use, publications that discuss the methods (80 items, or 32.1%) and those that contribute to methods development were most common (37 studies, or 14.9%).

Table 41. Modes of engagement with research synthesis in Information and Library Science

Mode	Reports	Methods	Resources	Study	Discuss	Introduce	Other
Count	135	37	26	24	80	9	33
Percent	54.22	14.86	10.44	9.64	32.13	3.61	13.25

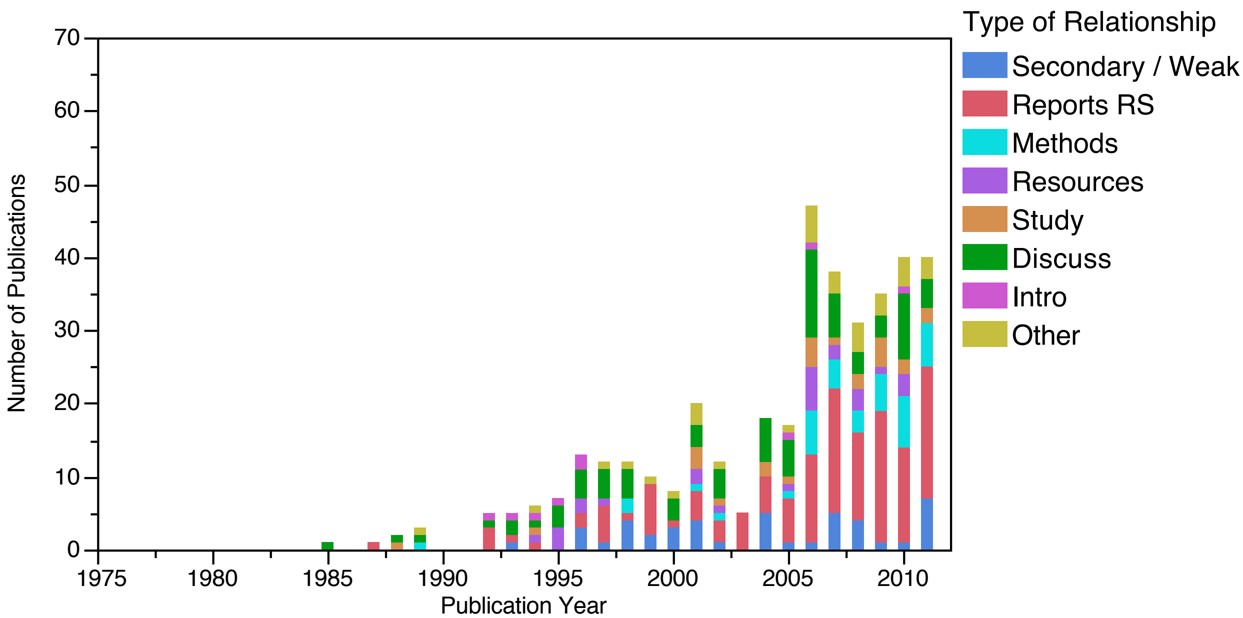


Figure 37. Information and Library Science: Number of publications, modes of engagement, by year

Introductions

The first items related to research synthesis within the ISLS category appeared in 1985, only nine years after Glass's (1976) article that introduced "meta-analysis" to a wide audience. Of these articles, one (Schell & Rathe, 1992) introduced readers of the *Bulletin of the Medical Library Association* to meta-analysis and predicted that medical librarians would play a significant role in the future application of this "tool for medical and scientific discoveries" (p. 219). Trahan (1993), drawing on past commentary to disparage library research as "often repetitive descriptive studies with little cumulation" (p. 73), presents meta-analysis as a method that might address these shortcomings, and also provide the opportunity to conduct research relevant to library practice. The introduction includes a description of 'meta-analysis' and describes implementation of a 'pilot study' published elsewhere. A third introduction (Tsuda & Muranushi, 1994), published in Japanese but for which an English abstract is available, examines three recently published reviews on the information needs and information seeking behavior of clinicians according to standards for systematic reviews. Mead and Richards (1995) and Smith (1996) introduce research synthesis as a collaborative research endeavor for which librarians may occupy a critical role in the context of interdisciplinary research teams. Hwang (1996) describes meta-analysis and its limitations in the context of MIS research, approximately four years after the first application of meta-analysis in MIS captured in this study (Alavi & Joachimsthaler, 1992), on psychological factors associated with decision support system (DSS) implementation success.

Alavi and Joachimsthaler (1992) published a meta-analysis in *MIS Quarterly*, which found that user-situational variables were more important than psychological factors to decision support system (DSS) implementation success. Alavi and Joachimsthaler drew on research synthesis methods from education and psychology, primarily from the early 1980s (1980-1985), including those by researchers considered RSM pioneers such as Gene Glass, Harris Cooper, Robert Rosenthal, and Donald Rubin. The authors included an extended discussion of meta-analytic techniques both within the paper and in an appendix. Bibliographic information for the thirty-three studies that were summarized in the meta-analysis was included in an appendix rather than the list of references. Nearly a decade later, Ankem (2005) and Saxton (2006) introduced the methods again, stressing the special context of research in Information and Library Science. Finally, Urquhart (2011) reported endeavors in Information and Library Science sub-fields related to research synthesis, and introduced and demonstrated use of two meta-synthesis methods suitable for syntheses of more heterogeneous primary research studies.

Methods

Publications that contributed to methods ranged from those that adapted the method, such as in the case of the development of a meta-evaluation method (Edler, Ebersberger, & Lo, 2008); to a great number of articles that focused on developing data collection strategies (i.e., search strategies and tools) and data evaluation (e.g., text classification methods).

Research reported in ILS literature contributed to development of methods to synthesize research in other fields via scientometric approaches, search, and machine learning. Search strategies and methods (Boynton, Glanville, McDaid, and Lefebvre, 1998; Helmer, Savoie, Green, and Kazanjian, 2001; Wong, Wilczynski, & Haynes, 2006; Sampson, McGowan, Cogo, & Horsley, 2006; Booth, 2006; Glanville, Lefebvre, Miles, & Camosso-Stefinovic, 2006; Golder, Mcintosh, Duffy, & Glanville, 2006; Eisinga, Siegfried, & Clarke, 2007; Golder, Mason, & Spilsbury, 2008; Chapman, Morgan, & Gartlehner, 2010), including search filter development (Ritchie, Glanville, & Lefebvre, 2007; McKibbon, Wilczynski, Haynes & Hedges, 2009; Pienaar, Grobler, Busgeeth, Eisinga, & Siegfried, 2011) and application of search filters in new contexts (Hoogendam, Robbe, Stalenhoef, & Overbeke, 2009) constitute topics of frequent inquiry in the context of medical and health science and services research. From a related perspective, Golder and Loke (2009) evaluated relative availability of information on adverse effects from a variety of information resources. In work that contributes to methods and resources, Booth (2006) studied search methods and developed an approach, STARLITE (sampling strategy, type of study, approaches, range of years, limits, inclusion and exclusions, terms used, electronic sources) for qualitative systematic reviews. One study (Papaioannou, Sutton, Carroll, Booth, & Wong, 2010) focused on search across several fields, including the social sciences, information and library science, education, and health.

From a machine learning approach, studies focused on developing automatic classification methods to reduce workloads associated with initial evaluation of primary research (Cohen, Hersh, Peterson, and Yen, 2006; Matwin, Kouznetsov, Inkpen, Frunza, & O'Blenis, 2010; Cohen, 2011; Matwin, Kouznetsov, Inkpen, Frunza, & O'Blenis, 2011) and prioritize studies (Cohen, Ambert, & McDonach, 2009) for evaluation in the context of systematic reviews. Ananiadou, Rea, Okazaki, Procter, and Thomas (2009) described the application of text mining approaches to aid search, screening, mapping, and synthesis processes in systematic reviews.

Rivas et al. (1998) developed and tested Information Synthesis and Validity Analysis (ISVA), which integrates meta-analysis with education and communications theories and literature management technologies. ISVA was intended to synthesize knowledge and facilitate development of research questions in the context of interdisciplinary problem-focused research. Also from a scientometrics perspective, Porter, Kongthon, and Lui (2002) describe “research profiling” to perform broad literature scans to discover topical relationships, research trends, and complementary approaches and technologies to contextualize research synthesis, an approach extended and more explicitly tied to systematic review processes in Porter, Schoeneck, Roessner and Garner (2010).

Methods developed for ILS include meta-evaluation approaches in the context of policy interventions (Edler, Ebersberger, & Lo, 2008; Hyvärinen, 2011); research focused on modification of hierarchies of evidence as applied in the medical and health sciences for library and information science research (Law, 2005; Booth, 2010); and an approach to evaluate primary studies (Williams, Nicholas, & Rowlands, 2010). MIS researchers developed meta-analytic techniques to assess contribution of study methods to differences observed between studies in syntheses of correlation research (Sharma, Yetton, & Crawford, 2009) and a framework for syntheses intended for interdisciplinary contexts when a broad selection of research is potentially of interest (Jahangirian et al., 2011). In an innovative application of methods, Brown (2008) combined systematic review of research and review and content analysis of news content to reveal that though the "freshman fifteen" is a popular topic in the media, research shows it is an exaggeration. McGrath (1996) argued that terminology and definition of units of analysis in scientometrics research was inconsistent and should be attended to more carefully by researchers in order to facilitate synthesis of research.

Resources

In addition to search filters, ILS researchers have developed a variety of resources to support conduct of systematic reviews. McKibbon, Wilczynski, Hayward, Walkerdilks, and Haynes (1995) review resources developed by the Health Information Research Unit of McMaster University Faculty of Health Sciences to facilitate EBP, including user guides, search tools, and abstract guidelines. Other resources developed include data extraction tools (Balas, Stockham, Mitchell, Austin, West, & Ewigman, 1996); a checklist to help design and evaluate search filters (Glanville et al., 2008); a critical appraisal instrument to aid selection of search filters (Bak, Mierzwinski-Urban, Fitzsimmons, Morrison, & Maden-Jenkins, 2009); a data registry (Balas et al., 1995); a preliminary tool and design principles to support collaborative information synthesis (Blake & Pratt, 2002; Blake & Pratt, 2006b); and conceptual frameworks to translate research-based knowledge for use in decision-making (Haynes, Hayward, & Lomas, 1995). Based on examination of moderator analysis in past research, Hwang and Schmidt (2011) developed guidelines for Information Systems researchers conducting moderator analyses in meta-analytic studies.

Research focused on data sources included one study that examined electronic database and grey literature sources for systematic reviews intended to inform pharmaceutical policy (Greyson, 2010); and sources of evidence available for evidence-based librarianship were examined by Sampson, Daniel, Cogo, & Dingwall, (2008). Web applications to interface with PubMed and facilitate search, organization, and preliminary analysis of results were reviewed by Michan-Aguirre, Calderon-Rojas, Nitxin-Castaneda-Sortibran, and Rodriguez-Arnaiz (2011). Focus on information resources for health and biomedicine included evaluation of regional (Abhijnhan, Surcheva, Wright, & Adams, 2007; Waffenschmidt, Hausner, Kaiser, 2010) and other databases (Brettle & Long, 2001; Alpi, 2005; Falzon & Trudeau, 2007) for use in systematic reviews. Professional search skills for public health (Alpi, 2005) and development of medical students for finding and interpreting systematic reviews and meta-analyses also received attention (Wolf, Miller, Gruppen, & Ensminger, 1997; Ojasoo, Maisonneuve, & Dore, 2001).

Studies and Evaluations of Research Synthesis

In addition to studies performed primarily to develop methods and resources for research synthesis, studies focused on research synthesis in the health and biomedical sciences, information and library science, and the social sciences. The earliest study (Hjørland, 1988) examined information retrieval methods used in a Swedish dissertation in psychology as a case study, with the goal of "promoting the necessary change in the perception of information retrieval and literature work in psychology" (p. 40).

Subsequent studies focused on search and retrieval include several in the health sciences:

Wright and McDaid (2011) examined the visibility of article retractions in MEDLINE, EMBASE, and CENTRAL. An audit of study retrieval strategies reported in a sample of meta-analyses published 1996-2002 and indexed in MEDLINE were examined to determine the extent to which search strategies and their effectiveness were reported, finding that three fourths reported search strategies, but only 6.7 percent strategy effectiveness. In response to a similar question, Yoshii, Plaut, McGraw, Anderson, and Wellik (2009) examined the extent to which Cochrane Reviews adhered to search and retrieval reporting guidelines specified in the Cochrane Handbook. Use of systematic review versus a previously proposed abbreviated method reliant on literature search and expert opinion to update clinical guidelines was examined, finding the latter approach acceptable when the research process was refined by involvement of librarians (Voisin, de la Varre, Whitener, Gartlehner, 2008). Golder and Loke (2009) performed a systematic review of studies of searches for adverse effects data for systematic reviews.

Use of appraisal instruments was considered by Booth (2007). The extent of use of research synthesis in health journals was examined in 2001 (McKibbon, Wilczynski, & Haynes, 2001); and the role of librarians in health science systematic review research was examined in case studies (Harris, 2005; Swinkels, Briddon, & Hall, 2006). Blake and Pratt (2006a), through situated observation of and interviews with participants in a collaborative research synthesis of biomedical studies, developed the Collaborative Information Synthesis model. Grant and Booth (2009) developed a typology of reviews through a review of information and library science reviews; and Khoo, Na, and Jaidka (2011) investigated the structure of literature reviews, with the goal of developing automatic summarization techniques to work towards automatic production of literature reviews.

Discussion

Publications that discussed research synthesis methods but did not relate to the methods in other ways included four book reviews. In 1985, Light and Pillemer's *Summing up: The science of reviewing research* was reviewed in *College & Research Libraries.* Other reviews featured books on meta-analysis (Rosenthal, 1991) in the *Library Quarterly* (1993), and literature reviews (Fink, 2005; Fink, 2010) in *Information Research* (2005) and *Library & Information Science Research* (2010). Editorials highlighted news related to research synthesis in medicine, including on a breakthrough related to risk factors for vascular disease achieved through meta-analysis in the *Scientist* (1997) and a comment about a report in *BMJ* on the value of librarians for Cochrane reviews and meta-analyses.

In 2007, *MIS Quarterly* announced the establishment of the MISQ Theory and Review Department, indicating that comprehensive syntheses of previously published research with strong theoretical implications were welcomed (Markus & Saunders, 2007). Evidence provided via a systematic literature review was used to perform a meta-study on a popular topic associated with collaboration in the *European Journal of Information Systems* (2010); and a guest editorial in *Library & Information Science Research* discussed the "scientification" of the literature review, arguing that art should also contribute (Dilevko, 2007).

Letters discussed publication bias and clinical trial registries (Adams, 1998); and the relationship between Information and Library Science research and research synthesis methods (Hjørland, 2001; White, 2002; Hjørland, 2002). The extent to which Information and Library Science research can and does contribute to research synthesis methods, and the visibility of publications in the field versus in the literature of other fields were prominent topics in the exchange between

Hjørland and White. In the medical librarianship literature, Santesso (2004) wrote to respond to a critique of documentation of a Cochrane review search strategy – agreeing that documentation is appropriate, but critique of the given review was not.

Topics in publications

Information and Library Science topics reflect contributions of the field to use of the methods in other fields, especially medicine and the health sciences, and indicate a few lines of research that have been the subject of research syntheses (Figure 38). Topics such as “Search Eval & Filters”, “Databases, Search & Retrieval”, and “Text Classification” align with papers that investigate, evaluate, and discuss search and retrieval for research synthesis studies and literature resources. Similarly, the “Text classification” topic includes papers that report machine learning and text analysis techniques developed to reduce the workload associated with research synthesis methods.

The topic “EBM/EBP” intersects publications associated with evidence-based medicine and evidence-based librarianship. Associations with medical and health research are reflected in the topics “Clinics & Patient Care”, “Patient Care”, and “Med Lit”. Medical topics are associated with research synthesis studies on topics such as physician preferences for information sources and health information systems in addition to literature on development of methods and resources for application of research synthesis in the medical and health science fields.

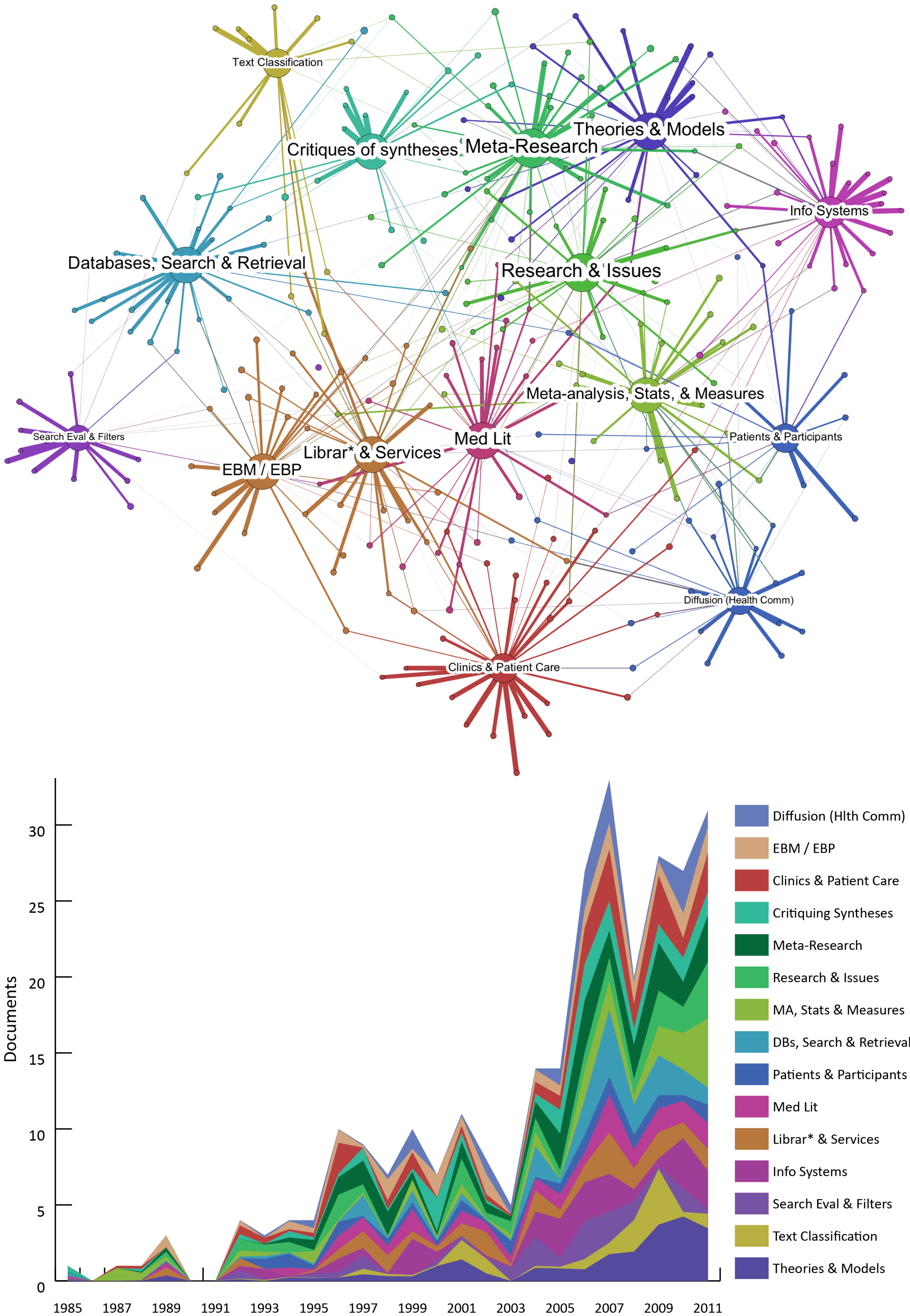


Figure 38. Topics associated with research synthesis in Information and Library Science

The “Librar* & Services” topic is associated with studies designed to integrate library service studies. “Diffusion” is dominated by health campaign studies; and “Meta-Research” includes bibliometric research and self-studies in journals associated with MIS. “Theories & Models” likewise intersects LIS and MIS publications, and includes models of information behavior and the Technology Acceptance Model. “Systems and Technologies” is related to systems and technologies associated with performing research synthesis; and system and technology-related interests that research synthesis is used to study. Table J5 in Appendix J summarizes the most frequently occurring word stems in each of the fifteen Information and Library Science topics.

Impact: Shifts in practice

Information and Library Science researchers first became aware of research synthesis methods in the 1980s and 1990s, long before the years examined to identify shifts in collaboration and reviewing practices. Given the emphasis on work intended to facilitate use of research synthesis methods in the health and medical sciences and concentration of publications in health science journals, however, it would be difficult to describe the methods as having been broadly adopted in the field.

Between 2006 and 2008, 54 research syntheses and 92 reviews were identified (Table 42). Research reviews in ILS appear to adhere closely to the traditional model of single-author reviews (Table 43). Slightly larger groups collaborated in research synthesis studies. Based on citations, subsequent use of research synthesis studies was substantially lower compared to reviews. These findings suggest that research synthesis publications were not as integral to the field as a whole when compared to traditional reviews, though some research synthesis publications are relatively highly cited. This finding suggests that some sectors of ILS may share Dilevko's (2007) perspective, that art is a valuable component of literature review. Alternatively, given that reviews are generally performed by one or two authors, experience or prestige may play a role in reviewer selection or self-selection; and, given the small number of review publications in the field's journal literature, broader, less specific traditional research reviews may offer a more pragmatic approach to collocating and interpreting past research.

Table 42. Number of reviews and syntheses, by year

Year	2006	2007	2008	Total
Research Syntheses	17	21	16	54
Reviews	29	36	27	92

Table 43. Summary statistics: Impacts associated with use of research synthesis

		Authors	Times cited (at 5 years)
Median (1^{st} : 3^{rd} Quartiles)	Research Syntheses	2 (1:3.75)	23 (8.25:51.75)
	Reviews	1 (1:2)	35 (15.67:85.52)
Wilcoxon rank sum test		W = 3552, p<0.001	W = 1927, p=0.0241
van Elteren test, controlling for publication year		U = 22.5998, df = 1, p<0.001	U = 5.9004, df=1, p=0.015

Though the majority of publications in ILS were applications of research synthesis, the uneven distribution of research synthesis publications overall suggests that subfields vary greatly with respect to the extent the methods are used. Overall, research synthesis methods are not widely used; and, as a field, ILS researchers tend to use reviews more than research syntheses. Given that research syntheses are generally considered more laborious to perform compared to reviews, and that use of the methods in ILS is associated with greater levels of collaboration, these patterns suggest that, when benchmarked against traditional literature reviews, researchers are generally not highly rewarded for research synthesis studies.

ILS engages with research synthesis methods in a variety of modes, which reflects the "meta-disciplinary" nature of the field. The subset of ILS associated with health and medical information and libraries has made substantial contributions to the practice of research synthesis in those fields, especially in areas related to search and information resources. Additionally, use of text analysis and machine learning techniques to support syntheses in the health and medical sciences has been investigated. Research synthesis studies within the field are more prevalent in literatures related to health, Management Information Systems (MIS), and more recently, Scientometrics.

Contexts of diffusion: Cross-field comparison

The fields examined in Stages II and III were diverse: Two life sciences, two social sciences, and Information and Library Science. Comparison across fields provides the opportunity to examine differences that may have influenced the extent to which each of the fields adopted research synthesis methods; identify key field characteristics that may have modified diffusion; and identify characteristics that may be associated with changes in research practices as reflected in collaboration and citation patterns.

Examination at the field level suggested that Social Work has adopted research synthesis methods, especially in the form of systematic reviews. In contrast to the dominant view in clinical medicine, it appears that adoption of research synthesis methods in Social Work has refined rather than replaced the role of traditional reviews. Conservation Biology appears to have been moving in the direction of adoption during the period examined, 2006-2008. In Women's Studies, researchers selectively use research synthesis to comment on and critique research in the subfields of Women's Studies that intersect psychology and the health sciences.

Though the evidence contributed by this study is less clear, it appears that Evolutionary Biology selectively uses meta-analysis as a tool to increase statistical power, analyze potential moderators, and traverse phylogenetic heterogeneity. To an extent, subfields of Information and Library Science associated with the health sciences and Management Information Science adopted research synthesis methods. Other subfields, including applied librarianship and informetrics have used the methods on occasion. Information and Library Science has engaged with the methods to a greater extent to support use of the methods in other fields, primarily the health and medical sciences. Traditional literature reviews were more integral to the field as a whole during the years in which 'impact', or shifts in practice, was examined (2006-2008).

Modes of engagement with research synthesis methods

The proportions of publications that reflected engagement with research synthesis by modes considered in this study varied across fields (Table 44; Figure 39). Across all fields, reports of studies in which research synthesis methods were used was the most frequent mode of engagement. Considered as a proportion of all publications with a primary relation to research synthesis, those that reported research synthesis studies ranged from 54.22% in Information and Library Science to 85.71% in Conservation Biology. Relative proportions of other modes of engagement varied by field, but were generally most prevalent in Information and Library Science. Exceptions include "Other" publication types in Evolutionary Biology, and discussions in Social Work.

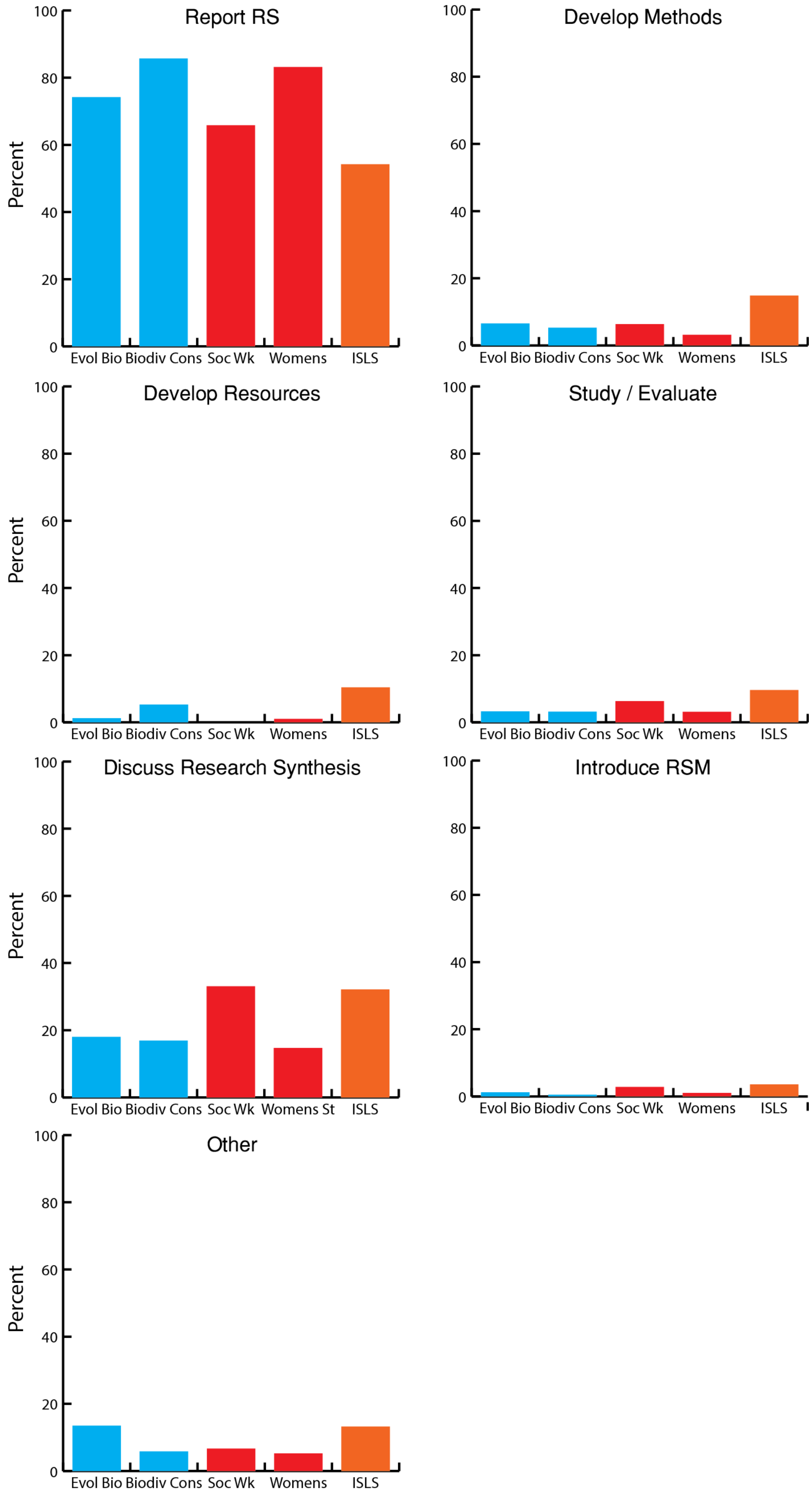


Figure 39. Modes of engagement with research synthesis methods, by field

Table 44. Modes of engagement with research synthesis methods, by field

	Evolutionary Biology		Conservation Biology		Social Work		Women's Studies		Information Library Sci	
	Ct.	**Pct.**	Ct.	**Pct.**	Ct.	**Pct.**	Ct.	**Pct.**	Ct.	**Pct.**
Reports RS	181	**74.18**	162	**85.71**	187	**65.84**	79	**83.16**	135	**54.22**
Methods	16	**6.56**	10	**5.29**	18	**6.34**	3	**3.16**	37	**14.86**
Resources	3	**1.23**	10	**5.29**	17	**5.99**	1	**1.05**	26	**10.44**
Study	8	**3.28**	6	**3.17**	18	**6.34**	3	**3.16**	24	**9.64**
Discuss	44	**18.03**	32	**16.93**	94	**33.10**	14	**14.73**	80	**32.13**
Introduce	3	**1.23**	1	**0.53**	8	**2.82**	1	**1.05**	9	**3.61**
Other	33	**13.52**	11	**5.82**	19	**6.69**	5	**5.26**	33	**13.25**
Total[1]	288		232		361		106		344	

1. 'Total' refers to the total number of category assignments in a given field.

Introductions

Research synthesis methods were introduced multiple times in Evolutionary Biology, Social Work, and Information and Library Science. In Evolutionary Biology, introductions varied in form from instance to instance. First, the methods were briefly introduced in the context of a discussion of field experiments; second, the methods were the focus of an article; and third, the authors demonstrated use of the methods when reporting results of a study. Some of the same variety was observed in Social Work, but authors also focused on different forms of research synthesis methods, and use of the methods in the practice context. Journals within the Social Work category reflect both applied characteristics of the field, and differences in orientation and topics of interest across researchers. While use of the methods immediately followed introductions in Evolutionary Biology, a lag between first introductions and use was apparent in Social Work. This lag may be a reflection of the lack of compatibility between the methods as first introduced, and Social Work research broadly. It is possible that the time lag necessitated subsequent introductions because early introductions were, in a sense, forgotten in the archives.

Introductions in Information and Library Science included the variety observed in Social Work. Subfields such as Management Information Science and health and medical librarianship each had their own introductions, and introductions were presented in the context of the applied nature of the field. The potential for ILS researchers and practitioners to contribute to research synthesis studies in health and medical sciences was of special interest. Additionally, different forms of research synthesis were introduced to resistant subfields by researchers whose work overlaps with fields in which the methods were prevalent (e.g., Ankem, 2005; Urquhart, 2011).

Introductions in Conservation Biology and Women's Studies were rare. In the case of Conservation Biology, it appears that communication with other fields and research interests that cut across biological science fields may have provided familiarity with meta-analysis in particular. Pullin and Stewart reframed and reintroduced research synthesis, as systematic review, in 2006**.** This reintroduction cast the purpose of the methods directly in the context of evidence-based practice, and framed practice in the health sciences as a model to emulate and adapt to Conservation Biology.

In Women's Studies, it appears that researchers became familiar with the methods primarily in the context of intersecting fields. The contrast in engagement with research synthesis by researchers aligned with psychology and other social sciences and those in the health sciences reflects this. Research synthesis appeared first in the psychological literature and was more closely related to meta-analysis; while health science publications were more closely associated with systematic review. Some researchers in the social science sectors of Women's Studies wrote to legitimize use of quantitative meta-analysis in the field. Such methods are sometimes interpreted as androcentric, and therefore in need of critical examination.

Discussions

Following reports of research synthesis studies, discussion of research synthesis methods was the second most frequent mode in which authors engaged with the methods (range: 14.73%-33.10% across fields). Discussions ranged broadly. Evolutionary Biology, Conservation Biology, and Social Work scholars engaged in discussions and debates about specific studies. These discussions were most prevalent in Evolutionary Biology. Evolutionary Biologists' discussion items often included analysis or re-analysis of studies, sometimes with additional data. Such discussion likely reflects a greater degree of field-level coherence and shared expectations compared to fields in which discussions were not observed, including Women's Studies and Information and Library Science. Discussion in Evolutionary Biology also reflected selective use or emphasis on some elements of research synthesis. Several comments centered on selection of data for syntheses, and presented re-analysis with additional data, leading to different conclusions.

Broader discussions of the methods were observed in Social Work, Information and Library Science, and Conservation Biology. In Social Work, a number of authors discussed the fit of the methods in the context of research in the field. Discussions of this type occurred in Information and Library Science to a lesser extent, reflecting the overall lower engagement with the methods in ILS. Social Work discussions also focused on selection of research for research synthesis studies that were subsequently used to inform policy discourses. Discussion of this type emerged in Conservation Biology in more recent years.

In Social Work, Information and Library Science, and Conservation Biology, discussions and research focused on research synthesis in practice contexts was prevalent. In Information and Library

Science, two practice contexts were considered – practice in relation to contributing to systematic reviews in the health sciences, and practice in the context of informing library decisions. The former, perhaps more successful context of engagement with the methods, was more prevalent in the study dataset. Difficulties associated with translating research into practice contexts occupied Social Work researchers, and emerged in Conservation Biology. Researchers in both Social Work and Conservation Biology investigated and discussed questions related to the lack of use of research in decision-making and lack of research that can inform professional and policy decision-making. Drawing on general findings to inform specific cases was identified as a difficulty in Social Work practice.

Other

"Other" modes of engagement with research synthesis methods noted include use of the meta-analysis within the context of single studies that included multiple experimental treatments or species, and discussion of use of the methods in pedagogical contexts. Use of meta-analysis within studies was most prevalent in Evolutionary Biology, but also observed in Conservation Biology and promoted in the context of Single System Design studies in Social Work. Social Work authors were interested in incorporating material about research synthesis as it relates to evidence based practice in educational contexts, and in teaching use of the methods. In contrast, incorporation of meta-analysis in training of Evolutionary Biology and likely Conservation Biology students has been limited (Koricheva, Gurevitch, & Mengersen, 2013). In Information and Library Science, articles focused on teaching medical students to read and find studies, and librarians to search for primary studies for systematic reviews conducted in other fields.

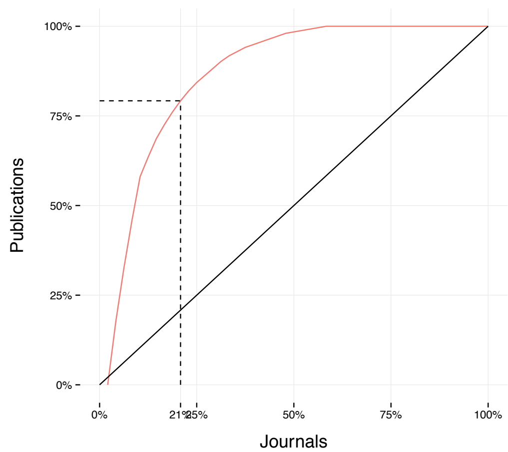
Extent of diffusion within research fields

Comparison of the relative distributions of research synthesis publications across journals, as summarized by the Gini coefficient, and in the context of when research synthesis first appeared in the fields underscores field-level differences (Table 45; Figure 40). Engagement with research synthesis methods was most pervasive in Social Work, and most uneven in Women's Studies. Engagement with the methods in Evolutionary Biology, Conservation Biology, and Information and Library Science is relatively unbalanced, and approximates the eighty-twenty rule. The more recent appearance of the methods in the biological sciences and relatively consistent increases in use (Figure 41), suggests adoption of the methods has been relatively smooth in the biological sciences compared to Women's Studies and Information and Library Science.

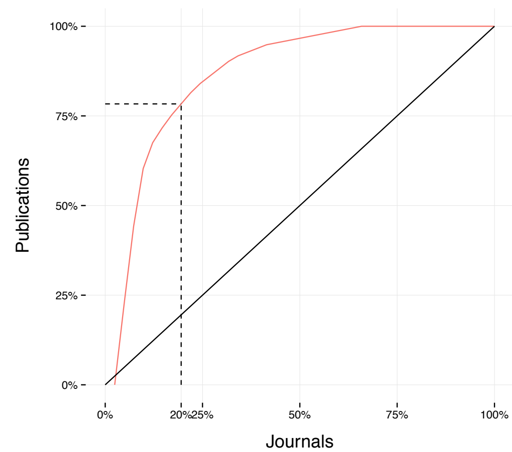
Table 45. Relative balance of research synthesis publications across journals

Field	Evolutionary Biology	Conservation Biology	Social Work	Women's Studies	Information & Library Sci
Gini Coefficient	0.767	0.775	0.555	0.869	0.796
1st Year	1991	1994	1977	1985	1985

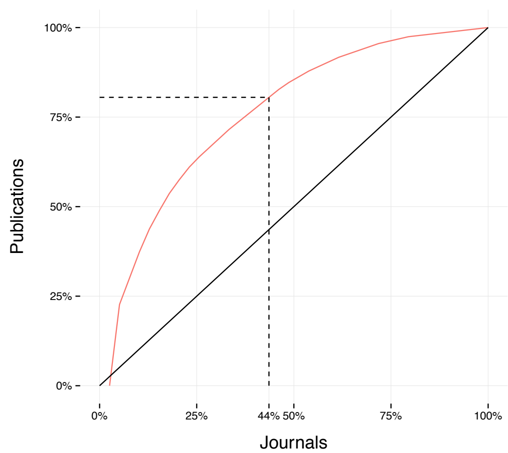
Contrasts between fields become clearer when the relative timing of first engagement with research synthesis methods is considered (Table 45). While the Social Sciences and Information and Library Science first engaged with research synthesis methods in the 1970s and 1980s, the Life Sciences did not engage with the methods until the 1990s. The timing suggests the diffusion process is at an earlier stage in the biological sciences, and therefore we should expect less even distribution of research synthesis publications across biological science journals. Gini coefficients should be interpreted in light of these expectations. Comparison of the relative levels and modes of engagement with research synthesis over time provides greater contrast (Figure 41).



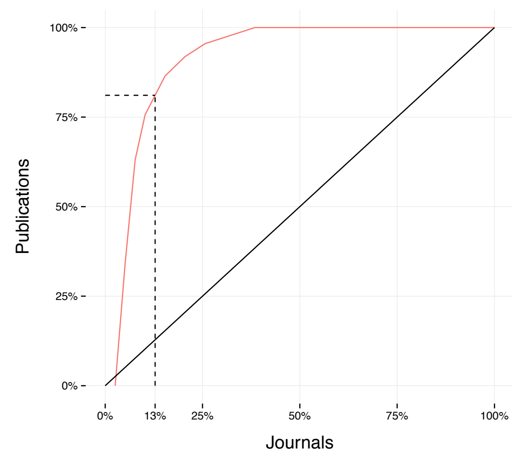
a. Evolutionary Biology



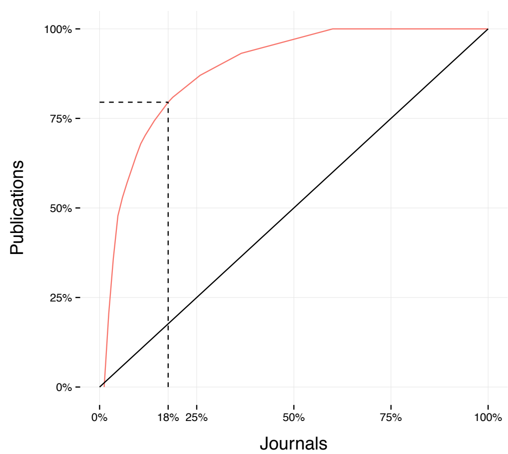
b. Conservation Biology



c. Social Work

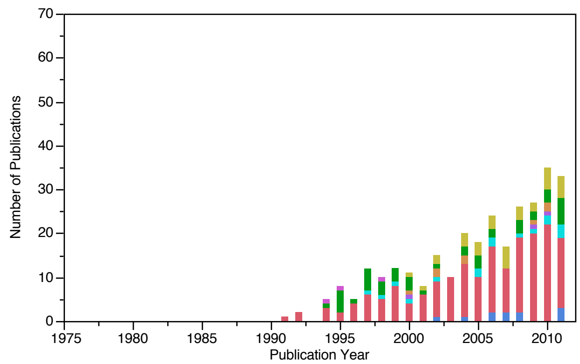


d. Women's Studies

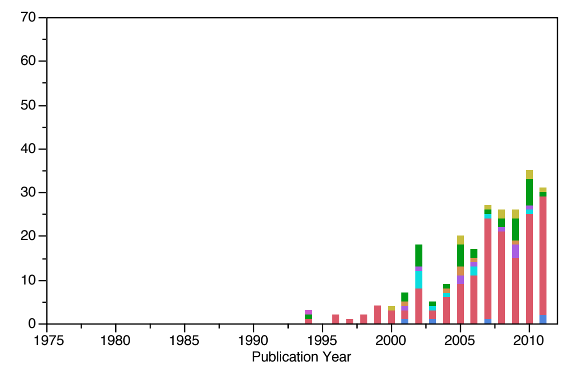


e. Information & Library Science

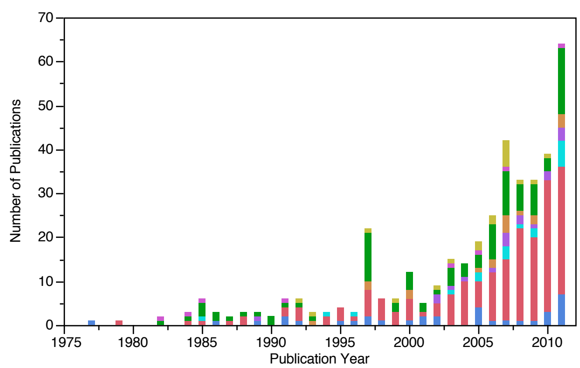
Figure 40. Relative extent of diffusion within research fields



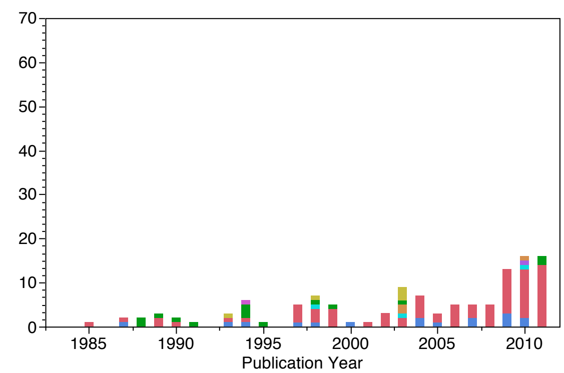
a. Evolutionary Biology



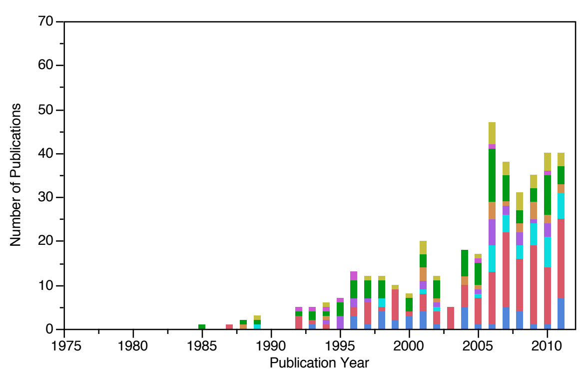
b. Conservation Biology



c. Social Work



d. Women's Studies



e. Information & Library Science

Key: Modes of Engagement

Figure 41. Timing, extent, and modes of engagement with research synthesis methods

Use of the methods in Evolutionary Biology is marked by a relatively steady increase over the years from the time it first appeared in the 1990s, though this use is somewhat overstated due to ecological meta-analyses published in shared venues (e.g., *TREE, American Naturalist*). A number of primary studies used meta-analytic techniques within the primary research studies (coded as "other" mode of engagement in the chart). In Conservation Biology, engagement with the methods occurred slightly after and at a pace similar to Evolutionary Biology, though the increase in use was steeper in later years. A few studies in Conservation Biology used meta-analytic techniques within the context of primary studies. Patterns in the Social Sciences are more diverse: Social Work engaged with the methods to a much greater extent in all modes compared to Women's Studies. Information and Library Science became aware of the methods relatively early, but engaged to a greater extent only after the advent of the evidence-based medicine movement in the 1990s. Use of the methods became more prevalent in the mid-2000s.

Resources

Resources associated with the diffusion of research synthesis methods include research funding, organizations that more directly support use and development of the methods, and availability of information infrastructures such as databases that contain information about primary studies to be synthesized (Table 46). When engagement with research synthesis methods first began in the fields examined, none had a primary literature resource that was considered sufficient to identify primary studies. Though *Social Work Abstracts* is a prominent (U.S.) resource for Social Work literature, several studies indicated use of *Social Work Abstracts* alone was inadequate. Researchers in Conservation Biology emphasized the diverse locations of materials that might be synthesized. In addition to information in the research literature, conservation organizations, governmental bodies, and biological institutions such as zoos and botanical gardens, might possess information that could contribute to research syntheses.

Table 46. Resources associated with research synthesis

Field		Evolutionary Biology	Conservation Biology	Social Work	Women's Studies	Information & Library Sci
Organization focused on research synthesis?		NESCent (2004)	CEE (2003)	Campbell Collaboration (2000)	(of intersecting fields)	Not observed within field; Cochrane Collaboration important to health
Central, primary literature resource		No	No	No	No	No
Funding support (location)		Broad	Broad	1 publication	*J. Women's Health*	*JAMIA,* some *Scientometrics*
Funding support, 2008-2011 publications	Pct.	61.68	67.33	0.01	31.91	12.61
	Ct.	66 (107)	68 (101)	1 (145)	15 (47)	14 (111)

In Social Work, the Campbell Collaboration, established in 2000, was an important resource. High profile researchers, including Littell, advocated for use of Campbell Collaboration resources and use of research synthesis methods in the form of systematic reviews and meta-analyses. Additionally, the Campbell Collaboration provided training and educational resources. The Center for Environmental Evidence (CEE), established in 2003 and modeled after the Cochrane Collaboration, similarly appears to be rising in importance in relation to the use of research synthesis methods in Conservation Biology. Since establishment of CEE, there has been an increase in use of research synthesis methods. While work before the establishment of CEE primarily discussed research synthesis in terms of meta-analysis, terminology has shifted. Pullin and colleagues began advocating for "systematic reviews", shifting emphasis away from statistical techniques and towards concepts related to evidence-based practice, including the search for all available evidence. Unlike the Campbell Collaboration, CEE is not directly affiliated with the Cochrane Collaboration, and therefore likely realizes benefits from this established example less directly.

The National Evolutionary Synthesis Center (NESCent) supports “synthetic” research in Evolutionary Biology. Unlike the Campbell Collaboration and CEE, however, NESCent supports a broader profile of research. The concept of synthesis has a rich history in the field, and directly resulted in the emergence of Evolutionary Biology through the Modern Synthesis. Similarly, synthesis in the field is interpreted as including not only integration across research, but also integration across fields and specialties. Sidlauskas et al. (2010) defined synthesis as the integration of concepts, research, methods, and data across and within fields. Projects supported by NESCent reflect this broader conceptualization. Though NESCent is oriented towards synthesis more broadly, the Center has supported projects led by prominent methodologists, including Jessica Gurevitch and Jason Hoekstra. Mark Lajeunesse, a leader in phylogenetic meta-analysis, was a post-doctoral scholar at NESCent.

Though neither Women’s Studies nor Information and Library Science are associated with field-specific organizations that support production of research synthesis, The Cochrane Collaboration is an important resource for areas of the fields that are concerned with health. Researchers in Information and Library Science directly contribute to Cochrane Collaboration resources through collaborative efforts with researchers in other fields; and practitioners and researchers engage with Cochrane resources in a variety of modes, including, for example, study and evaluation of search protocol reporting practices (Yoshii et al., 2009).

Data related to funding should be interpreted with caution because it is widely thought that research sponsorship is under-reported. However, the presence of funding for work related to research synthesis is clear in the case of the biological sciences examined, including for the development of methods and their application. Across all research synthesis-related publications (2008-2011), 61.68% of Evolutionary Biology and 67.33% of Conservation Biology items were associated with grant-funded projects. Further, publications were often associated with multiple grants (Tables I1-I4, Appendix I). Comparison with funding for other types of research could be undertaken to understand the relative level of support for projects related to research synthesis versus other research.

Social Work research, if *SSCI* data is accurate, was not supported. This finding likely reflects research funding challenges in the field more broadly. Again, comparison with other types of studies would clarify whether research synthesis studies are comparatively underfunded in the field. Only research synthesis projects associated with health and medicine were funded in Women's Studies and Information and Library Science. Uneven funding in Women's Studies may be explained in part by the "intersectional" structure of the field – in some ways, Women's Studies' subfields extend research of the fields with which they identify. In Women's Studies, almost a third of all research synthesis-related papers were associated with funded projects, and these were published exclusively in the *Journal of Women's Health.* Only 12.61% of all publications in Information and Library Science were associated with grant funding. These publications appeared primarily in *JAMIA*. More recently, research syntheses related to informetric studies have received funding. Whether this is a sign of potential future support for research synthesis projects is unclear.

At a more granular level, journal resources in Social Work, Conservation Biology, Evolutionary Biology, and Information and Library Science have been provided for research related to research synthesis. In addition to general publications, at least three special issues have been devoted to topics related to research synthesis in Social Work; and one to meta-analysis in Evolutionary Biology (though in *Evolutionary Ecology*, and therefore shared with Ecology). More enduring resources, journal sections, have been provided by *MIS Quarterly*, and *Conservation Biology.* The *MIS Quarterly* section was established for theory papers, including those that use research synthesis methods. The *Conservation Biology* section is devoted entirely to systematic reviews.

Relationship to evidence-based practice and other intellectual movements

Concurrent engagement with evidence-based practice and policy was a compelling driver for engagement with research synthesis methods in Social Work and Conservation Biology (Table 47). Though both fields have a more applied research orientation generally, conceptualization of this orientation in terms of the evidence-based practice and policy (EBP) movements was strongly tied to engagement with research synthesis methods. A shift towards EBP was clearly articulated in Conservation Biology, and was concurrent with efforts associated with the establishment of the CEE. Further, the example of the health sciences was often recognized explicitly and used as a model of comparison.

Though Information and Library Science has a practice component, this does not appear to have compelled researchers in the field broadly to use research synthesis methods. It is possible that this is a function of literature indexed in the data source used for this study. Alternatively, this could indicate a separation of research and practice; lack of methodological compatibility, or something else. This study captured some discussion of evidence-based librarianship in association with research synthesis methods, but EBP discussion often focused on evidence-based medicine.

Table 47. Intersection of research synthesis methods and evidence based practice

Field	Evolutionary Biology	Conservation Biology	Social Work	Women's Studies	Information & Library Sci
Field(s) used for RS comparison	Related biological science fields	Health Sciences	Health Sciences	Not observed	Health Sciences
Focus on Practice?	No	Yes	Yes	Mixed	Yes
Interest in practice knowledge?	Not observed	Yes	Yes	(Health)	Yes
Focus on Policy?	No	Yes	Mixed	(Health)	Not observed
EBP Count	14	45	552	50	320
EBP per 10,000	1.58	9.85	148.89	15.00	16.01

In Women's Studies, EBP was clearly an interest in research associated with the health sciences, especially in publications in the *Journal of Women's Health*. Following Arthur (2009), Women's Studies can be viewed as an intellectual or knowledge movement in itself. In this context, research synthesis methods can be interpreted as a tool used by researchers to demonstrate how a feminist perspective has or can contribute to research in these fields (e.g., psychology); or, alternatively, to emphasize that there is a need for greater attention to gender differences when systematically reviewing and synthesizing past studies (e.g., in health sciences).

Researchers across fields that concurrently engaged in evidence-based practice expressed interest in diverse forms of knowledge. In Conservation Biology, Social Work, and to a lesser extent, Information and Library Science, "professional wisdom" or experience-based knowledge was discussed and/or studied. In Social Work, consumer or client knowledge was considered important. In Women's Studies, interest expressed related to diverse forms of knowledge primarily focused on knowledge that is not androcentric.

Characteristics of research and research concerns in the context of research synthesis

In the context of research synthesis, researchers in each of the fields examined expressed concerns about primary research studies and research synthesis (Table 48). In Women's Studies, research of intersecting fields rather than research in "Women's Studies" was of primary interest. In Information and Library Science, the process of research synthesis in other fields, especially health and medicine, and research within the field was of interest.

Table 48. Research related issues

Field	Evolutionary Biology	Conservation Biology	Social Work	Women's Studies	Information & Library Sci
Focus on own field	Yes	Yes	Yes	Intersections	Not predominant
Large research archive?	Yes	No (CB) Yes (biology more broadly)	No	No (WS) Yes (other fields)	No
Reporting practices problematic?	Yes	Yes	Yes	Yes	Yes
Experimental research prevalent?	Some Drosophila, others	Some CO_2,, field experiments, others	No – interventions later emphasized	From psychology, health science	Not observed
Meta-analysis used within studies	Yes	Yes	Suggested, perhaps rarely (SSD-MA)	Not observed	Not observed
Strong theoretical orientation?	Yes	To an extent	No	Yes	No
Complexity of research problems emphasized in RS context?	Taxonomic heterogeneity; small effect sizes	Yes	Yes	Not Observed	Not Observed
Measurement issues of concern?	Taxonomic; Small effect sizes; Outcome	Outcome measure selection	Measures of effect / Outcome measures	(Records of sex/gender differences in health)	Variability of measures

Across all fields, only Evolutionary Biology had a large archive of past research. Though Evolutionary Biology has a large research archive, the archive is small in comparison to the diversity of life and subjects of interest. Some data of interest to the field is simply unavailable. For example, the fossil record is uneven and incomplete, and historical dating is notoriously problematic. The fields of interest to Women's Studies scholars whose work intersects with research synthesis, psychology and the health sciences, have large research archives. Similarly, though Conservation Biology does not have a large archive of research specific to the field, in some cases, research from across the biological and ecological sciences may inform research synthesis studies. Some Conservation Biology researchers endeavored to overcome the lack of data through making inferences to a target topic using data from related species or toxins.

Two commonalities across the research fields were observed in relation to reporting practices and use of experimental research designs. Researchers in all fields complained about problematic reporting practices associated with primary studies. Whether this changed over time was unclear. It would be interesting to learn, for example, if the Journal Article Reporting Standards (JARS) had a positive effect on research reports in Psychology, which might be noted by Women's Studies scholars. Though the health sciences are well known for the proliferation of research reporting guidelines in recent years – many are collocated on the Equator.net website – data of interest to Women's Studies scholars was often not reported in research syntheses examined by researchers.

Across fields, use of experimental research designs was generally the exception rather than the rule. Again, in areas of Women's Studies in which research synthesis was used, intersecting fields were an exception. Experimental designs were more prevalent in specific lines of research in

Evolutionary Biology and Conservation Biology, but not more broadly. Meta-analysis was sometimes used within studies in lines of research in which experimental designs were prevalent, including in *Drosophila* and CO_2 research. In Evolutionary Biology, meta-analysis was also used within the context of primary studies to examine effects across species. In Social Work, there has been at least an interest in shifting towards a focus on intervention research.

Though experimental research designs are more prevalent in some subfields of Information and Library Science such as information retrieval, research in these subfields was not encountered in association with research synthesis methods. Interest in evidence-based practice in Social Work seems to have spurred interest in intervention-oriented research and systematic review methods, following the model of the health sciences. Though Conservation Biology researchers who adopted the evidence-based practice philosophy were interested in systematic review and this was discussed with reference to the health sciences; there was relatively limited discussion about promoting experimental or intervention research for the purpose of syntheses intended to inform decision-making. The lack of discussion might reflect a trend towards use of experimental designs when possible generally, or the need to rely on natural experiments and phylogenetic comparisons in the case of subjects that are not amenable to experimental research (Jennions, Lortie, & Koricheva, 2013).

Evolutionary Biology and Women's Studies both have strong theoretical orientations, which focuses research questions and reduces the perceived complexity of research in the fields. In Evolutionary Biology, specific issues were seen as complex: Taxonomic heterogeneity and prevalence of small effects associated with biological phenomena such as fluxuating asymmetry. These complexities were, at least in part, conceptualized and approached as measurement problems. This conceptualization enabled researchers to approach and develop at least partial solutions to the problems. Complexities of research in Conservation Biology and Social Work were often discussed. In the case of Conservation Biology, perceived complexity of systems of interest and interactions within these systems was a challenge. In Social Work, the uniqueness of individual cases and importance of contexts in professional Social Work practice were considered a source of complexity. At some level, measurement issues were a concern across fields.

Research synthesis first appeared in both of the biological sciences in the form of “meta-analysis”, a technique described as easy to perform by Arnqvist and Wooster (1995). Notably, in rating effort required to perform each stage of a research synthesis in ecology and evolution, Côté and Jennions (2013) annotated only the “full search” and “advanced issues” of model selection stages with the maximum of four sweat drops. Effort required to locate studies may be a barrier to adoption of some steps of research synthesis in the fields. Given the extent of discussion related to data included in studies, and observations by Cadotte and colleagues (2012) in the neighboring field of ecology, transition through an “easier” approach of meta-analysis, which focuses on statistical techniques, may serve as a bridge to adoption of other steps of the methods more broadly.

Diverse research orientations were discussed in the Social Science fields and in Information and Library Science. The extent of engagement with the issue varied across fields (Table 49). The greatest level of engagement was observed in Social Work, driven by the concurrent and overriding interest in translating research knowledge for use in practice and policy decisions. Social Work scholars sought resolution to problems associated with diverse research orientations through modification of research synthesis methods and of primary research practices. In the policy context, modification of research synthesis methods predominated; modification of research practices in primary studies were considered more in areas associated with Social Work practice. Discussions about modification of research practices in primary studies were observed in Information and Library Science, though to a lesser extent.

Table 49. Research concerns across fields

Field	Evolutionary Biology	Conservation Biology	Social Work	Women's Studies	Information & Library Sci
Diverse research orientations discussed	Not observed	Not observed	Yes	As related to goals of Women's Studies	Yes
Biases observed	Publication bias, taxonomic bias, research bias; confirmation bias	Publication bias, taxonomic bias	Publication bias, research sampling bias; confirmation bias	(Gender bias)	Publication bias

Researchers in all fields expressed concern about research and reporting practice biases. In the biological sciences, concern about taxonomic bias and publication bias was prevalent. In Evolutionary Biology, "research bias" was defined as the tendency for researchers to focus on exceptional species in which biological phenomena present to a greater extent (Gurevitch, Morrison & Hedges, 2000). Social Work (Littell, 2008) and Evolutionary Biology researchers expressed concerns about confirmation bias, though it was described in terms of publication bias in Evolutionary Biology (Palmer, 2000). In Social work, research sampling bias, or exclusion of some research based on research design motivated researchers to develop and use novel approaches to research synthesis. Though not specific to research synthesis studies, research biases associated with gender bias were investigated in Women's Studies. Publication bias was discussed widely across research fields. The widespread discussion of bias associated with research practices indicates that engagement with research synthesis methods provides researchers the opportunity for reflexivity and to confront meta-science issues critically.

Impacts of research synthesis methods

Analysis of collaboration and citation data for items published 2006 through 2008 (but only in 2007 for Evolutionary Biology) indicated that changes in research practices associated with use of research synthesis methods varied across fields.

Collaboration patterns

Data analyzed to compare the number of authors who contribute to reviews versus syntheses indicated that one or two authors typically wrote reviews in Information and Library Science, one to three in Social Work and Women's Studies, two to three in Evolutionary Biology, and two to four in Conservation Biology (Table 50). In two fields, Social Work and Information and Library Science, more authors contributed to research syntheses than reviews. It should also be noted that the non-significant finding in Women's Studies ($U = 2.8137$, $df=1$, $p=0.0935$) may be a reflection of the small number of publications, 23 research reviews and 23 research syntheses, identified in the years examined (2006-2008). Differences in the number of authors who contribute to research syntheses versus reviews in Social Work and Information and Library Science suggests that adoption of research synthesis methods in a field can contribute to changes in research practices, especially in the case of fields in which few authors generally contribute to research reviews.

Table 50. Collaboration patterns associated with research syntheses and reviews, 2006-2008

Field	Evolutionary Biology*	Conservation Biology	Social Work	Women's Studies	Information & Library Sci
Review authors	2 (2:3)	3 (2:4)	2 (1:3)	2 (1:3)	1 (1:2)
RS authors	2.5 (2:3)	3 (2:4.25)	2 (2:4)	3 (2:3)	2 (1:3.75)
Collaboration different: RS and Reviews	No	No	Yes: RS involve more researchers	No	Yes: RS involve more researchers

* 2007 only

There are several reasons research synthesis studies may be associated with higher levels of collaboration compared to traditional research reviews, and therefore contribute to changes in collaboration patterns. First, methods texts generally advocate or specify that multiple people should contribute to the selection of studies and data extraction. For example, the first key point highlighted in the "Selecting studies and collecting data" chapter of the Cochrane Handbook specifies, "Assessment of eligibility of studies, and extraction of data from study reports, should be done by at least two people, independently" (Higgins & Green, 2011). Similarly, the Centre for Evidence-Based Conservation recommends that at least a random sample of 25% of items identified be reviewed by a second person when judging whether studies should be included and when extracting data from study reports (2009). Second, identification of studies for inclusion in a research synthesis generally involves filtering out hundreds or thousands of potentially relevant and usable studies (e.g., Côté, Curtis, Rothstein, & Stewart, 2013). Third, research syntheses may require a broader set of skills or specializations compared to traditional research reviews, for example to devise comprehensive search strategies, construct databases for extracted data, or conduct advanced statistical analyses.

Citation patterns

Across fields, comparison of review versus research synthesis citations indicated that research syntheses were used more than reviews in Conservation Biology and Women's Studies (Table 51). Further examination of Social Work indicated that though research syntheses and reviews were cited at similar levels, production of reviews decreased and production of research syntheses increased between 2006 and 2010. These trends suggest that traditional reviews have remained valuable to Social Work researchers, though in an increasingly narrow range of contexts. At the same time, research syntheses were becoming the predominant method of review, and were useful to researchers across the contexts in which they were produced.

Table 51. Citation of reviews and research syntheses produced 2006-2008, at 5 years

Field	Evolutionary Biology*	Conservation Biology	Social Work	Women's Studies	Information & Library Sci
Review citations	52 (24:93.75)	31 (14:51.0)	10.5 (5.25:22)	9 (5:13.5)	35 (15.67:85.52)
RS citations	60 (29:85)	42 (24.0:78.0)	12 (5:29)	14 (10.5:21.5)	23 (8.25:51.75)
Citation different: RS and Reviews	No	Yes: RS more highly cited	No	Yes: RS more highly cited	Yes: Reviews more highly cited

* 2007 only

In contrast, traditional research reviews in Information and Library Science were produced and used at a higher rate compared to research syntheses. Trends in the field suggest that research reviews are a relatively rare but highly prized – or at least frequently used – resource (Table 52). Though research syntheses generally have a greater number of authors, which we might expect to be associated with higher levels of citation (Levitt & Thelwall, 2009), this was not the case. The small number of review publications in the journal literature in the field and limited resources devoted to reviewing activities may contribute to greater use of traditional research reviews, which tend to be broader and less specific than research syntheses.

Table 52. Comparable document types and extent of engagement with past research

Field	Evolutionary Biology*	Conservation Biology	Social Work	Women's Studies	Information & Library Sci
Comparable document type	'Papers'	Review (after CEE)	Review	Review (Health); (Psychology unclear)	Review
Engagement with past research (proportion of 'Document Type: Review' publications from Stage I)					
Reviews (%)	4.762	5.686	1.326	0.120	0.882

* 2007 only

Though no difference between use of research syntheses and research reviews was observed in Evolutionary Biology, examination at the field level indicated that research reviews might not be the most appropriate type of comparator publication (Table 52). Research synthesis methods as defined in this study appear to be used sometimes in the context of research review publications, but more often in the context of studies that are labeled "original research". This interpretation is congruent with the general observations that research data is relatively frequently reused in Evolutionary Biology studies, especially in molecular research; and that statistical meta-analytic techniques appear to be the most salient aspect of research synthesis in Evolutionary Biology based on examination of topics and full text documents of research synthesis-related publications. Content analysis of specific procedural steps reported in research syntheses, or systematic collection of data from researchers who perform research synthesis would provide stronger evidence to support this view. If consistent, this might suggest that an alternative comparator, such as papers from the same issue of the same journal, might be more appropriate to research in the field. Anecdotally, discussion with a small group of researchers involved in the development of meta-analytic methods in the field revealed that though the researchers recalled prior discussion of meta-analysis in the context of reviews, such contexts were not considered primary for the application of meta-analytic techniques. This observation is in contrast to other fields, in which research syntheses were compared to reviews.

CHAPTER 5. CONCLUSION

Research synthesis methods have contributed to changes in the practice of research in diverse fields across science. Past studies have described increased use of research synthesis methods in specific fields (e.g., Cadotte, Mehrkens, & Menge, 2012; Patsopoulos, Analatos & Ioannidis, 2005; Barrios, Guilera, & Gomez-Benito, 2013); and methods books often illustrate increased prevalence of research synthesis methods over time (e.g., Cooper, Hedges, & Valente, 2009; Koricheva, Gurevitch, & Mengersen, 2013). The first stage of this study described the increasing extent and diversity of fields that engaged with research synthesis methods over four decades across science broadly; the second stage examined diffusion and diffusion contexts of five fields: Evolutionary Biology, Conservation Biology, Social Work, Women's Studies, and Information and Library Science. The third stage established whether, during the latter half of the 2000s, research syntheses contributed to changes in collaboration patterns and were used more or less than traditional research reviews. Findings across fields were examined in Stages II and III to identify characteristics of research field contexts that may have modified diffusion of research synthesis and to aid contextualized interpretation of results.

Relatively modest engagement with research synthesis methods in the 1970s and 1980s was followed by expansion in both the extent of engagement and diversity of fields that engaged with the methods in the 1990s. This period coincides with the popularization of the evidence-based practice movement first, in medical and health science fields (Evidence Based Medicine Group, 1992), and later, in an increasing number of fields (Trinder & Reynolds, 2000). Engagement with the methods continued to increase and spread to a greater diversity of fields through the first decade of the 2000s.

Measures of association between the extent of engagement with research synthesis methods within science fields indicate the number of years a field has engaged with the methods ($\rho = 0.706$, $p < 0.001$) and engagement with EBP ($\rho = 0.893$, $p < 0.001$) are strongly related to engagement with research synthesis. Though a correlation between the number of years a field engaged with research synthesis methods and the extent of use is not surprising, the strength of correlation suggests that fields with publications related to research synthesis in early years were more likely to continue rather than cease publishing material related to research synthesis. Whether this will be the case for fields that did not have publications related to research synthesis until later years is unclear since there are likely differences between fields that engaged with the methods earlier versus later.

The strength of association observed between engagement with EBP and engagement with research synthesis is likely influenced by the great quantity of medical and health sciences research. The extent to which the strength of association can be explained by research in these fields alone is unclear from the findings of this study. Examination of fields at a more granular level suggested that the use of systematic reviews in the health sciences has been emulated in other fields, including fields with topical foci as different as Social Work and Conservation Biology.

A relatively weak association between engagement with the methods and whether a field is more "pure" or "applied" in nature based on prior studies ($\rho = 0.279$, $p = 0.011$) presents an interesting contrast to the strong correlation between engagement with EBP and research synthesis. The difference in levels of association in part may be explained by a lack of engagement with the methods in technology-focused fields. Fields in the technology field group engaged with research synthesis to a lesser extent. One Technology field, Microscopy, was not found to engage with the methods at all.

An association between the extent to which fields engage with past research and engagement with research synthesis methods was found, though the strength of that association was moderate ($\rho = 0.403$, $p < 0.001$). To an extent, this finding supports commentary that suggests the methods are used to cope with vast quantities of research information in some fields. Findings at the field level provide insight into factors that might contribute to a moderate rather than high correlation between engagement with research synthesis and engagement with past research. Some fields likely conceptualize "synthesis" in terms that are partially congruent with research synthesis methods; and others without large archives of past research may engage with EBP and, therefore, also with research synthesis methods. Evolutionary Biology is an example of the former, and Social Work and Conservation Biology the latter. In part, it is likely that engagement with research synthesis methods in Evolutionary Biology was moderated by the concept and tradition of synthesis in the field. Additionally, trends towards reuse of data and combination of different types of data in primary studies may complicate interpretations of what it means to synthesize Evolutionary Biology research. Social Work and Conservation Biology, on the other hand, prioritized research to support practice and policy decision-makers. In both fields, the lack of primary research and data on which to draw was a concern.

At the field level, presence of organizations to advocate and support use of research synthesis methods; dismantling, adaptation, and re-construction of the methods; prevalence of EBP; and efforts to reshape primary research and resources to fit research synthesis methods were observed at different levels across fields. The presence of organizations and organizational affiliates was most central in Social Work and Conservation Biology. In part, this is likely due to concurrent engagement with EBP. Notably, organizational affiliates were vocal advocates for use of research synthesis methods to translate research knowledge for use in practice and policy contexts. The visibility of advocacy in the context of research methods diffusion suggests a political dimension to the diffusion of research synthesis methods. In applied fields, and in fields with subfields that engage with health and medical science research, the Cochrane Collaboration was a focal point. The Collaboration is identified as an example, a center of resources, and a successful if improvable representation of how research is done in the highly visible health and medical science fields. Women's Studies researchers commented on the lack of attention to gender variables in Cochrane Reviews; and ILS researchers evaluated and contributed to data collection (i.e., search) and filtering methods.

In fields in which use of research synthesis is a priority, researchers endeavored to reshape research practices to fit prevailing models of methods implementation, fit methods to the field, or a combination. This finding extends observations by Platt (1996), made in the context of a study of Sociology research methods between 1920 and 1960. Platt suggested that research methods diffused easily when packaged and easily implementable. Other research has suggested that an innovation is a complex package composed of an irreducible hard core of essential elements plus multiple layers of technologies and knowledge, with soft boundaries of supporting structures and modifiable components (Denis, Hébert, Langley, Lozeau, and Trottier, 2002; Adler & Kwon, 2012). In a given context, the essential elements of an innovation are kept intact, and others translated (Latour & Woolgar, 1986) and edited (Shalin & Wedlin, 2008) to fit the needs of the use context. This research suggests that interpretations of what constitutes the "hard core" and essential elements of an innovation varies by context, and is influenced by historical contexts, values, and goals that intersect with the innovation use context.

In Evolutionary Biology, meta-analytic techniques could be interpreted as the "hard core" of research synthesis methods. In Social Work and Conservation Biology, especially in later years, the broader process of research synthesis as presented by Cooper and Hedges (1994), Higgins and Green (2011), and Koricheva, Gurevitch, and Mengersen (2013) was central. Accordingly, data collection protocols were more likely to be reported, and meta-analysis, though preferred where appropriate, was not a necessary element.

To an extent, findings in Social Work and Conservation Biology echo findings of Boyle (2012). Boyle found that Complementary and Alternative Medicine (CAM) research was adapted to the standard health sciences research model, which relies on the combination of experimental research and research synthesis. In Social Work, interest in adapting research to this model was expressed by some authors. Other authors sought to simultaneously reshape primary research practices in the field and research synthesis methods to fit the field. Unlike the CAM case study, this research did not reveal a strong association between NIH funding and field practices associated with research synthesis, though authors discussed increased engagement with NIMH. Whether a research funding policy intervention would affect Social Work research is an open question, but findings across Boyle's research and this study suggest that at least to an extent, such a change could be anticipated. Calls for such funding from advocates of systematic review for evidence-based or evidence-informed practice and policy in Conservation Biology (Pullin, Knight, & Watkinson, 2009) suggests some Conservation Biology researchers would welcome implementation of such a policy intervention.

In fields investigated at the meso-level in this study, engagement with the methods was secondary to other goals. In Conservation Biology and Social Work, the prevailing goal was to apply research-based knowledge in practice and policy contexts. In Evolutionary Biology, researchers sought to increase statistical power and investigate biological phenomena across different species. As noted by Lajeunesse, Rosenberg, and Jennions, the "apples and oranges" problem is literal in ecology and evolution (2013, p. 284). Feminist critique and elucidating health implications associated with biological differences between men and women were primary interests in Women's Studies. In Information and Library Science, researchers had multiple interests, including facilitating research in other fields where the methods are prevalent; informing professional practices; and integrating research for researchers. These patterns support Platte's (1996) observation that for most researchers, methods are of secondary importance.

Though research methods may be of secondary importance in the minds of many researchers, engagement with new ways of doing research can have far-reaching implications for how research is practiced within science fields. As observed in Stage III of this study, patterns related to fundamental relationships such as collaborations may change. In Social Work and Information and Library Science, more authors contributed to research syntheses than reviews. Recently, Barrios, Guilera, and Gomez-Benito (2013) observed a similar pattern in Psychology: one to three authors wrote Psychology reviews (median 2 (1 : 3)), and two to four contributed to research synthesis studies (median 3 (2 : 4)) . The combination of these findings suggests that, at least in some fields in which reviews are typically written by one or a few researchers, use of research synthesis methods contributes to higher levels of collaboration. Such a trend supports assertions that research synthesis methods often require collaboration to accommodate triangulation of researcher observations, process large quantities of research information, and incorporate a broader set of technical skills. Though research synthesis studies did not have more contributing authors compared to traditional reviews in the biological science fields examined, the number of authors typically contributing to both types of publications would be sufficient to conduct a research synthesis study.

Comparison of citation counts indicated that research syntheses were used more than reviews in Conservation Biology and Women's Studies. These findings echo past findings in other fields: Patsopoulos, Analatos and Ioannidis (2005) and Barrios, Guilera, and Gomez-Benito (2013) found that meta-analyses were more cited than reviews in clinical medicine and psychology. Further examination of Social Work indicated that, though research syntheses and reviews were cited at similar levels, production of reviews has decreased over time and production of research syntheses has increased. These trends suggest that while research synthesis was becoming the predominant method of review, traditional reviews remained valuable to researchers, though in an increasingly narrow range of contexts. Arguments for different roles for different types of reviews have been advanced in the health sciences (e.g., Dijkers, 2009), though may be considered an alternative perspective. Findings from this study, however, suggest role differentiation across review types may be a reality in Social Work.

In Information and Library Science, engagement with past research was relatively low and research reviews were used more than research syntheses. Trends in the field suggest that research reviews are a relatively rare but highly prized – or at least frequently used – resource. Though research syntheses generally were written by a greater number of authors, they generally received fewer citations. A possible explanation for these observations is that, like publications examined in the second investigation of Levitt and Thelwall (2009), traditional research reviews were written by 'elite' or 'influential' information scientists, who tend to have higher citation rates whether or not they engage in collaboration. Examination of who authored research reviews versus research syntheses, and direct examination of the relationship between collaboration and citation levels would be useful in interpreting these findings. The small number of review publications in the ILS journal literature and limited resources devoted to reviewing activities may contribute to greater use of traditional research reviews, which tend to be broader and less specific than research syntheses.

Though no difference between use of research syntheses and research reviews was observed in Evolutionary Biology, examination at the field level indicated that research reviews might not be the best comparison in the field. Research synthesis methods as defined in this study appear to be used sometimes in the context of research review publications, but more often in the context of studies that are considered "original research". Increasing levels of data reuse, especially in molecular Evolutionary Biology may further complicate perspectives of what it means to perform a research synthesis – or meta-analysis – in the field. Though whether reuse of data constitutes a research synthesis, secondary data analysis, or an original study technically might be determined by the nature and direction of hypotheses in the primary studies, availability of information about primary studies, researcher specialty, and past practices in the field likely influence researcher perspectives in practice. Focus on research synthesis as a set of statistical techniques might contribute to interpretation of 'independent participant data' (IPD) meta-analysis and meta-regression simply as "regression". Even so, it would be important to account for study-level variables in analyses.

Implications

This study has contributed to our knowledge of the diffusion of research synthesis methods across science broadly and in the context of the selected fields. Findings from this study extend current concepts related to diffusion, including those that address the nature of innovations in context presented by Denis, Hébert, Langley, Lozeau, and Trottier (2002), Latour and Woolgar (1986) and Shalin and Wedlin (2008). For example, this study identified meta-analysis as the "hard core" of research synthesis in Evolutionary Biology; and processes that included communication of search protocols central to research synthesis in Social Work. Similarly, research synthesis methods were edited and adapted to incorporate professional experience in Conservation Biology and Social Work; and client or patient experience in Social Work. Women's Studies researchers mobilized the methods to critique research at the intersections of Women's Studies and psychology and the health sciences; and ILS researchers contributed to incremental adaptations in other fields. Through extending work by Shalin and Wedlin and Denis and colleagues, this research connects diffusion research in Information and Library Science with that in organizational studies and organizational studies in health sciences and services.

This study identified changes in collaboration patterns associated with adoption of an innovation, and associated changes in subsequent use of research in some fields. These findings link and contribute to Information and Library Science research related to collaboration and research practices. The design of this study provides an example of how studies of broad patterns and more qualitative and detail-oriented research can complement each other. Finally, this study identifies the intersection of research synthesis methods and information and library science as a site of inquiry likely to yield information valuable to researchers and practitioners alike. For example, the proliferation of research reporting guidelines associated with adoption of research synthesis methods (e.g., APA Publications & Communications Board Working Group, 2008; Vandenbroucke, 2009) has been understudied though it affects the nature of scholarly communications and researcher interactions with information resources.

Broader implications: Professional practice and open science

At the broader level, this study has implications for professional practice in Information and Library Science and related to issues associated with open science advocacy and practice.

Implications for practice

This research has contributed to our knowledge of how researchers in a diverse set of fields perceive, implement, and discuss research synthesis methods. Professional librarians and information specialists can draw on this evidence to inform interactions with clients or patrons engaged in research synthesis studies; and to inform development of services. Similarities and differences identified in Social Work and Conservation Biology versus health and medicine suggest, for example, that a broader selection of research may be desirable for research syntheses in these fields. Knowledge of levels of collaboration in these fields might also be used to inform service design since tendencies towards more independent versus more collaborative research synthesis study designs has implications for how researchers engage with information resources and share data.

On a broader scale, the lack of primary, centralized information resources was notable across fields. ILS researchers and practitioners can contribute to research syntheses through continued efforts to collocate, organize, integrate, and provide access to research materials in a manner that is commensurate with the types of data and studies in the fields. The intersection of research synthesis and Information and Library Science examined in Stage II clearly identified some of the ways ILS has contributed to research synthesis in health and medicine. This study suggests that a broader set of fields could benefit from ILS research and practice. Finally, this study offers guidance on future studies that could inform practice at a more detailed level. For example, it might be helpful to identify frequently used information resources through analysis of research synthesis publications.

Open science

Issues of concern to investigators who engage with research synthesis methods suggest that open access and open science practices should be considered in a broader context. To perform a research synthesis, findings and data need to be reported such that subsequent researchers may directly incorporate them into research syntheses. Open access should imply open access to the original research study through reports and archival data materials that are easy to identify and retrieve through information systems. As researchers develop methods amenable to data synthesis, which in some cases may be conceptualized as research synthesis methods based on the importance of study variables, the importance of accessible, interoperable, and reusable data will only increase.

Research on and discussion of issues associated with research synthesis, including publication bias (Rosenthal, 1979; Chavalarias, & Ioannidis, 2010), has the potential to inform scholarly communications initiatives. Such studies suggest that it is preferable for a broader selection of research reports, if not all reports, to be published. Further, development of prospective research registries has been identified as a valuable tool to locate studies for research synthesis and to mitigate the effects of publication bias. Examination of other types of bias in research related to research synthesis may shed light on biases in how researchers write about past research (e.g., confirmation bias) and biases associated with research problem selection (e.g., research bias, taxonomic bias). Information resources such as research registries have the potential to enable researchers to revisit and radically reinterpret collaboration and research practices. For example, with information available at study conception, possibilities for research coordination, role specialization, and evaluation of resource allocation would be enhanced. At the same time, approaches that are broadly more collaborative could be impeded by competitive tendencies and concerns related to credit allocation and priority claims.

Limitations

Limitations of the current research include the definition of research fields, the selective data set used, issues associated with document type categorizations, and coding. As discussed by others (e.g., Rafols & Leydesdorff, 2009), the *Web of Science* categories only approximate research fields. The categories are intended for information retrieval though they are used to study research fields. Limitations associated with the categories should be considered across all three stages of this research. Engagement with content at the meso-level during Stage II provides some insight into the contours of each field. In addition to inclusion of research across fields or subfields that are variously interpreted, research in "multidisciplinary science" categories was excluded. Exclusion of this research likely affects evaluation of research in the biological sciences more than other fields examined in Stages II and III.

Selection of journal titles for inclusion in the *S/SCI* provides an unbalanced view of research in fields (e.g., Åström, 2010; Meho & Yang, 2007). The extent to which selection distorts research fields varies by field and is not well documented across fields. In the context of this study, inclusion of journals not indexed in the *S/SCI* such as *Evidence Based Library and Information Practice* (*EBLIP*), *Environmental Evidence*, *Research Synthesis Methods,* and *Systematic Reviews* would have been preferable. Similarly, some important earlier work was excluded because earlier volumes of journals such as the *Educational Research Review* are not indexed in the *S/SCI.*

Additionally, *WOS* document type categorizations were problematic in the context of this research project. Though I endeavored to negotiate this issue, the resolution found was less than optimal, in part due to resource limitations associated with this study. Overall, the issues encountered reflect difficulties associated with bibliometric research more broadly, or at least in cases in which commercial data resources are used for research and in which data are of interest at greater levels of detail. An ideal solution to this problem might be to redouble efforts to create open databases designed for informetric research. If broadly adopted, such databases could also increase the transparency and repeatability of informetric studies; mitigate the effects of the unequal distribution of resources across researchers and their institutions; and facilitate synthesis and accumulations of research knowledge in the field.

Additionally, this study suggests that development of flexible, specifiable, and repeatable units to operationalize concepts such as science fields should be a priority. Current approaches draw on approximations based on units intended for information retrieval; selection based on journal titles; or algorithmic methods that are sensitive to the materials that comprise a data set. Development of suitable approaches to categorization could enable informetrics research to better account for differences across and within fields such as field size and intensity of research in a given area. Such approaches might incorporate traditional categorization approaches, algorithmic approaches, or intermediate approaches, such as the use of reference points and distances to communicate how a field was conceptualized and operationalized in a given study.

Dramatic increases in the levels of engagement with research synthesis methods in latter years measured in this study in part may reflect expectations that authors identify research synthesis studies as such in titles since *Web of Science* topic searches query the Keywords Plus™ field as well as publication title, abstract, and author-provided keywords. Identification of whether a paper reports a research synthesis is recommended by research reporting guidelines in the medical, health, and psychological sciences (e.g., APA Publications & Communications Board Working Group, 2008); and may appeal to researchers in fields in which hierarchies of evidence are recognized since research synthesis studies are rated highly in such hierarchies.

Findings related to coding and reliability should be examined in more detail. Though agreement for some categorizations was good or very good, including whether or not a research synthesis was reported and whether or not a publication was a false positive, coding agreement measures were low for infrequently occurring categories. The use of Cohen's kappa to describe agreement should be supplemented with prevalence-adjusted kappa measures (Byrt, Bishop, & Carlin, 1993) to gain a better understanding of coding reliability. Cohen's kappa is more likely to indicate low levels of agreement if a category of interest is rare (Hallgren, 2012).

Primarily, this study relied on "presence" data. Areas of non-occurrence were inferred through use of overlay techniques in Stage I. Some absences were documented in Stage II through, for example, examination of journals in which publications do and do not occur. In Stage II, it would have been preferable to use overlay techniques more broadly. For example, it would be would have been interesting to compare topics in which research synthesis methods are and are not used. Such a summary would provide information vital to understanding what lines of research have been impervious to research synthesis methods; and whether and to what extent engagement with research synthesis is confined to certain lines of research.

Finally, examination of both more pure and more applied fields within this study can be interpreted as both a strength and limitation. It is a limitation in that the differences across fields were a challenge to analyze together while maintaining ecological validity. Additionally, one can imagine that this research might have resulted in findings more directly applicable to professionals in the fields examined, and librarians and information specialists that support the professions had only more applied research fields been included. Selection of diverse fields was a strength in that these extremes exposed adaptations to both the innovation, research synthesis methods, and the use contexts. Examination of diverse and less studied fields complements prior Information and Library Science research, which has focused primarily on the health and medical sciences, and suggests opportunities for ILS researchers and practitioners to become more engaged with efforts to implement the methods in a broader set of fields.

Future Research

Widespread adoption of systematic approaches to research synthesis has had a profound impact on how researchers interact with prior research in the medical and health sciences, psychology, education, and at least to an extent in other fields, including Social Work and increasingly, Conservation Biology. Use of the methods has affected collaboration patterns and how researchers interact with literature, data, and information infrastructures. Some changes associated with use of the methods are visibly manifested in research reporting guidelines and the development of resources, organizations, and tools to support research synthesis. More subtle changes may relate to what is included in reference lists, and how research is evaluated and used to support subsequent research.

The current study suggests a number of future directions. First, "engagement" could be examined in more detail across a broader selection of fields, or even at the macro-level. The role of different types of publications might be examined in more detail in concert with research that unpacks "engagement". Examination of discussion surrounding the diffusion of research synthesis suggested that a wide variety of genres, including editorials and letters, might have contributed to diffusion of the methods.

Comparison across macro- and field-level findings also suggests that some of the fluctuations observed in measures of the extent to which fields have engaged with research synthesis methods may reflect controversies within the field, special issues, or other events. Such events would lead to a temporary increase in the extent of engagement, and subsequent decrease. Therefore, we would expect the first and second derivatives to reflect these changing levels of engagement. Analysis of such patterns might enable more fine-grained understanding of how events affect the diffusion of ideas in science. For example, one that indicated a decline in engagement following an increase might indicate to a turning point in a field.

Diffusion was characterized as occurring in a political environment. In the case of research synthesis methods, the political nature of contexts in which they are used may be amplified not only by co-occurrence of engagement with EBP, but also because researchers seem to tend towards reflexivity and engage in discussions of biases associated with research in literature associated with the methods. The intersection of the political nature of research, scientific movements, modifications of research practices, and the implications of such modifications presents a rich field of inquiry that related to the diffusion of innovations. For example, it would be interesting to examine relationships between use of research synthesis methods and advocacy for open access to research resources.

On introduction of this research project, it was noted that research synthesis methods, like collaboration and interdisciplinary scholarship, promote integration of research-based knowledge, an important counter-balance to specialization. Research synthesis differs in that it involves integration at levels that are more granular and in response to specific questions. Future research should investigate relationships between approaches to research integration; and outcomes of programs designed to promote integration of science knowledge. A better understanding of how these approaches complement each other and differ would lead to a better understanding of integration, or synthesis, in science overall; and could inform design of research policy programs.

Appendix A. Comparison of Research Area (SU) and *Web of Science* categories (WC)

The Research Areas (SU's) considered in this study correspond with the one hundred thirty-six Research Areas included in records in the *Web of Science* in June and July 2011 and not identified as one of the fourteen Research Areas in the Arts and Humanities research domain (as identified in Thomson Reuters support materials). The Arts & Humanities were not included in the analysis because these fields are believed to differ in terms of publication patterns, in the use of language related to "synthesis" and in approaches to synthesizing research.

The *Web of Science* Categories (WC's) correspond with those available in 2010. The 2010 rather than 2011 categories were used because cross-category citation data is readily available for this year (Leydesdorff, et al., 2013). The "Audiology Speech Language Pathology" category was added to the *Journal Citation Reports* in 2011, and therefore is not included in the cross-citation data. This set includes records for Arts and Humanities WCs to the extent that they are indexed in the *S/SCI*.

The 123,881 records that comprise the dataset for this study correspond with 176,128 Research Area (SU)-record, and 186,151 *Web of Science* Category (WC) instances. Therefore, the dataset records were assigned approximately 1.422 Research Areas, and 1.503 WCs. As a result, the category counts inflate the apparent total number of records by about 42% when Research Areas are used; and about 50% when WCs are used. The average number of SU and WC cross-categorizations for the study data set is higher than the average number of cross-categorizations for records of all items published 1972 to 2011. Across the four decades, 41,268,729 records were found with publication year searches. About 53,542,935 Research Areas are indicated across the set, which corresponds to an average of 1.297 Research Areas per record. About 56,847,805 WCs are recorded across the set, about 1.378 categories per record for the categories considered in the analysis. Since the figures across the database for 1972-2011 includes all records, and is not stratified to reflect the relative number of records per year in the data set used for this study; it's possible that some other factor accounts for the difference. For example, it is possible that earlier publications could be less likely to be cross-classified in several categories. Evidence from other studies suggests that this could be the case (Rafols & Leydesdorff, 2009; Rinia, Van Leeuwen, Bruins, Van Vuren, & Van Raan, 2002), which could be explainable if, for example, titles added to the *S/SCI* in more recently more likely to be multiply categorized than were ones added less recently.

In order to identify the relationship between the two category systems, a search for each WC, limited to documents published between 1972 and 2011 was performed. WCs were matched with SUs that included 100% of the SU publications. These searches indicate that approximately 110 Research Area and WC categories appear to be approximately equivalent based on record counts and title similarity (Table A1); fifteen SUs aggregate two WCs (Table A2); three SUs aggregate three WCs (Table A2); two aggregate four WCs (Table A3), and eight SUs aggregate five or more WCs (Table A3).

Table A1. *WOS* Categories and Research Areas with approximately one-to-one relationships

	Category (WC = SU)	WC count Feb. 2013	SU count Sep. 2012	(WC-SU / SU)*100
1	Acoustics	124262	124201	0.049
2	Allergy	107082	107082	0.000
3	Anatomy & Morphology	79566	79735	-0.212
4	Anesthesiology	176787	176769	0.010
5	Anthropology	164597	161979	1.616
6	Area Studies	128714	125661	2.430
7	Astronomy & Astrophysics	413964	413792	0.042
8	Automation & Control Systems	130306	129978	0.252
9	Biodiversity Conservation	61062	58314	4.712
10	Biology (WC) = Life Sci Biomed Other Topics (SU)	555206	562520	-1.300
11	Behavioral Sciences	160533	160094	0.274

	Category (WC = SU)	WC count Feb. 2013	SU count Sep. 2012	(WC-SU / SU)*100
12	Social Sciences, Biomedical	78962	78963	-0.001
13	Biophysics	480844	480696	0.031
14	Biotech & Applied Microbiology	440164	440234	-0.016
15	Communication	70252	70045	0.296
16	Construction & Building Technology	78902	78891	0.014
17	Criminology & Penology	49701	49563	0.278
18	Crystallography	210052	211936	-0.889
19	Demography	36616	36576	0.109
20	Dentistry, Oral Surgery & Medicine	288050	287788	0.091
21	Dermatology	267551	267544	0.003
22	Developmental Biology	134182	134127	0.041
23	Electrochemistry	178209	178189	0.011
24	Emergency Medicine	63999	63992	0.011
25	Energy & Fuels	291566	291431	0.046
26	Entomology	170554	170520	0.020
27	Ethnic Studies	18783	18713	0.374
28	Evolutionary Biology	120722	120609	0.094
29	Family Studies	53361	53336	0.047
30	Fisheries	106668	106443	0.211
31	Food Science & Technology	394182	393323	0.218
32	Forestry	88451	88364	0.098
33	Gastroenterology & Hepatology	526901	526745	0.030
34	Genetics & Heredity	519116	517961	0.223
35	Geochemistry & Geophysics	257459	257594	-0.052
36	Geography	109667	109349	0.291
37	Geography, Physical	64176	63763	0.648
38	Hematology	491584	639261	-23.101
39	Imaging Sci & Photographic Tech	48103	48066	0.077
40	Immunology	720525	719996	0.073
41	Infectious Diseases	281022	280679	0.122
42	Information Sci & Library Science	276813	276787	0.009
43	Instruments & Instrumentation	319976	319973	0.001
44	Integrative & Complementary Med	26830	26830	0.000
45	International Relations	145357	144721	0.439
46	Medicine, Legal	37,939	37924	0.040
47	Linguistics	102042	101824	0.214
48	Mathematical & Computational Bio	75052	75069	-0.023
49	Social Sciences, Math Methods	49664	49652	0.024
50	Mechanics	306883	306494	0.127
51	Medical Ethics	17565	17467	0.561
52	Medical Informatics	42700	42645	0.129
53	Medical Laboratory Technology	140879	141056	-0.125
54	Metallurgy & Metallurgical Eng	405814	404631	0.292

	Category (WC = SU)	WC count Feb. 2013	SU count Sep. 2012	(WC-SU / SU)*100
55	Meteorology & Atm Sciences	199119	198509	0.307
56	Microbiology	458608	458299	0.067
57	Microscopy	48234	48234	0.000
58	Mineralogy	58660	58325	0.574
59	Mining & Mineral Processing	71622	71581	0.057
60	Mycology	47479	47479	0.000
61	Nuclear Science & Technology	314702	314687	0.005
62	Nursing	119463	118823	0.539
63	Nutrition & Dietetics	218164	217835	0.151
64	Obstetrics & Gynecology	336451	335998	0.135
65	Oceanography	139278	139214	0.046
66	Oncology	838723	833953	0.572
67	Operations Research & Mgmt Sci	142971	142843	0.090
68	Ophthalmology	308072	308078	-0.002
69	Optics	428999	428742	0.060
70	Orthopedics	207828	207825	0.001
71	Otorhinolaryngology	140150	139985	0.118
72	Paleontology	49995	49161	1.696
73	Parasitology	88517	88517	0.000
74	Pathology	372638	372612	0.007
75	Pediatrics	477861	476073	0.376
76	Physiology	437083	436885	0.045
77	Plant Sciences	559895	559479	0.074
78	Polymer Science	369565	369403	0.044
79	Psychiatry	555935	555120	0.147
80	Public, Envtl & Occup Health	546566	543771	0.514
81	Radiol, Nucl Med. & Med. Imaging	552332	551881	0.082
82	Rehabilitation	146722	146057	0.455
83	Remote Sensing	40431	40346	0.211
84	Reproductive Biology	155440	154572	0.562
85	Medicine, Research & Experimental	577830	577602	0.039
86	Respiratory System	272308	272005	0.111
87	Rheumatology	163652	163560	0.056
88	Robotics	19653	19653	0.000
89	Social Issues	125065	124770	0.236
90	Social Work	64773	64763	0.015
91	Sociology	232663	232492	0.074
92	Spectroscopy	208428	208443	-0.007
93	Sport Sciences	173510	172860	0.376
94	Substance Abuse	79932	78200	2.215
95	Surgery	946986	946775	0.022
96	Telecommunications	242188	241793	0.163
97	Thermodynamics	132803	132362	0.333

	Category (WC = SU)	WC count Feb. 2013	SU count Sep. 2012	(WC-SU / SU)*100
98	Toxicology	276244	274927	0.479
99	Transplantation	185666	185625	0.022
100	Tropical Medicine	76661	76654	0.009
101	Urban Studies	50772	50771	0.002
102	Urology & Nephrology	377271	377317	-0.012
103	Veterinary Sciences	461226	460841	0.084
104	Virology	162359	162141	0.134
105	Water Resources	178497	180634	-1.183
106	Women's Studies	41175	41112	0.153

Notes: At least four additional categories appear to also have a one-to-one relationship between the *WOS* Category and Research Area: (1) Audiology Speech Language Pathology; (2) Cultural Studies; (3) History; and (4) History & Philosophy of Science. These categories were not uniformly used across analyses in this study. Therefore, the data is not included here.
A large difference in the total number of documents for Hematology was observed between September 2012 and February 2013. It is possible that this difference is due to changes in the database. February 2013 data indicates that the Hematology WC and SU include the same documents. This similarity is not evident based on the data presented here and used in this study.

Table A2. Research Areas that contain two or three *Web of Science* Categories

Research Area (SU)	Publications	*WOS* Category (WC)	Publications
Biochem Molecular Bio	1997020	Biochem Research Methods	257520
		Biochem & Molecular Bio	1840814
Cardiovasc Syst Cardiology	986704	Cardiac & Cardiovascular Syst	691154
		Peripheral Vascular Disease	501467
Cell Biology	903240	Cell & Tissue Engineering	17548
		Cell Biology	920056
Endocrinology Metabolism	566200	Endocrinology & Metabolism	553300
		Andrology	14412
Geology	413929	Geology	60076
		Geosciences, Multidisciplinary	359220
General Internal Medicine	1544518	Critical Care Medicine	168761
		Medicine, General & Internal	1371400
Geriatrics Gerontology	155562	Geriatrics & Gerontology	109702
		Gerontology	99275
Government Law	595809	Law	199816
		Political Science	399857
Health Care Sci Services	202443	Health Care Sci & Services	155052
		Health Policy & Services	110811

Research Area (SU)	**Publications**	***WOS* Category (WC)**	**Publications**
Marine Freshwater Bio	256669	Marine & Freshwater Bio	226488
		Limnology	41762
Pharmacology Pharmacy	1186054	Pharmacology & Pharmacy	1099503
		Chemistry, Medicinal	225884
Public Administration	158391	Planning & Development	108840
		Public Administration	57195
Science Tech Other Topics	995004	Multidisciplinary Sciences	831535
		Nanoscience & Nanotech	178724
Transportation	51239	Transportation	26317
		Transportation Science & Tech	38344
Zoology	390356	Ornithology	37926
		Zoology	352956
Education Educational Research	383431	Educ & Educational Research	259021
		Education, Scientific Disciplines	93008
		Education, Special	42446
Environmental Sciences Ecology	897526	Ecology	320369
		Environmental Sciences	539677
		Environmental Studies	121229
Neurosciences Neurology	1549823	Clinical Neurology	781469
		Neuroimaging	41680
		Neurosciences	1001499

Notes: 'Publications' is equal to the total number of documents in the category published between 1972 and 2011. Publication counts for Research Areas and *Web of Science* Categories were downloaded in September 2012, February 2013, respectively.

Table A3. Research Areas that contain four or more *Web of Science* Categories

Research Area (SU)	Publications	*WOS* Category (WC)	Publications
Agriculture	775587	Ag Economics & Policy	28469
		Ag Engineering	35,181
		Ag, Dairy & Animal Science	206496
		Ag, Multidisciplinary	147,947
		Agronomy	238229
		Horticulture	91245
		Soil Science	109483
Business Economics	837940	Business	180575
		Business, Finance	108605
		Industrial Relations & Labor	47637
		Management	188886
		Economics	449986

Research Area (SU)	Publications	*WOS* Category (WC)	Publications
Chemistry	3640430	Chem, Analytical	489425
		Chem, Applied	260103
		Chem, Inorganic & Nuclear	353791
		Chem, Multidisciplinary	1440415
		Chem, Organic	562243
		Chem, Physical	876762
Computer Science	843514	CS, Artificial Intelligence	161220
		CS, Cybernetics	34070
		CS, Hardware & Architecture	136652
		CS, Information Systems	201564
		CS, Interdisciplinary App	195388
		CS, Software Engineering	194118
		CS, Theory & Methods	228121
Engineering	2934201	Eng, Aerospace	121508
		Eng, Biomedical	184415
		Eng, Chemical	586512
		Eng, Civil	215575
		Eng, Electrical & Electronic	988690
		Eng, Environmental	149360
		Eng, Geological	33350
		Eng, Industrial	111467
		Eng, Manufacturing	85300
		Eng, Marine	22739
		Eng, Mechanical	325328
		Eng, Multidisciplinary	232454
		Eng, Ocean	21991
		Eng, Petroleum	115233
		Ergonomics	29213
Materials Science	1418194	Mat Sci, Biomaterials	47517
		Mat Sci, Ceramics	126929
		Mat Sci, Char & Testing	69497
		Mat Sci, Coatings & Films	160728
		Mat Sci, Composites	49182
		Mat Sci, Multidisciplinary	962317
		Mat Sci, Paper & Wood	69307
		Mat Sci, Textiles	36692
Mathematics	1002303	Math	496594
		Math, Applied	355912
		Math, Interdisciplinary App	126337
		Statistics & Probability	174864

Research Area (SU)	Publications	*WOS* Category (WC)	Publications
Physics	3080679	Phys, Applied	914926
		Phys, Atomic, Molecular & Chem	412922
		Phys, Condensed Matter	702813
		Phys, Fluids & Plasmas	145039
		Phys, Mathematical	196057
		Phys, Multidisciplinary	757295
		Phys, Nuclear	176192
		Phys, Particles & Fields	241996
Psychology	1088569	Psychology	258796
		Psychology, Applied	114115
		Psychology, Biological	78077
		Psychology, Clinical	189656
		Psychology, Developmental	104912
		Psychology, Educational	63131
		Psychology, Experimental	175589
		Psychology, Mathematical	30160
		Psychology, Multidisciplinary	269423
		Psychology, Psychoanalysis	33724
		Psychology, Social	87737
Social Sciences Other Topics	301875	Ethics	49439
		History of Social Sci	55563
		Hosp, Leisure, Sport Tourism	27532
		Social Sci, Interdisciplinary	171021

Notes: 'Publications' is equal to the total number of documents in the category published between 1972 and 2011. Publication counts for Research Areas and *Web of Science* Categories were downloaded in September 2012, February 2013, respectively.

Appendix B. Keyword Search Phrases

Query terms used to search the topic index of the *Social Science* and *Science Citation Indexes* (*S/SCI*) using the *Web of Science* 5.x interface, on July 9 - 10, 2012. UNC licensed the *Science Citation Index Expanded* (*SCI-Expanded*), 1955-present and the *Social Sciences Citation Index* (*SSCI*), 1956-present at the time of data collection.

Search for publications related to research synthesis methods:
TS=("meta-study") OR TS=(metastudy) OR TS=("meta-studies") OR TS=(metastudies) OR TS=("meta-summar*") OR TS=(metasummar*) OR TS=("meta-review*") OR TS=(metareview*) OR TS=("best-evidence synthes?s") OR TS=("comparative effectiveness review*") OR TS=("systematic review*") OR TS=("systematic theor* review*") OR TS=("systematic research review*") OR TS=("systematic multidisciplinary review*") OR TS=("systematic method* review*") OR TS=("systematic literature review*") OR TS=("systematic evidence review*") OR TS=("systematic international review*") OR TS=("systematic critical review*") OR TS=("systematic clinical review*") OR TS=("systematic mixed method* review*") OR TS=("systematic qualitative review*") OR TS=("systematic narrative review*") OR TS=("systematic quantitative review*") OR TS=("research synthes?s") OR TS=("integrative review*") OR TS=("integrative research review*") OR TS=("integrative mechanistic review*") OR TS=("integrative literature review*") OR TS=(Cochrane NEAR/1 review*) OR TS=("interpretative synthes?s") OR TS=("interpretive synthes?s") OR TS=("realist synthes?s") OR TS=("metaethnograph*") OR TS=("meta-ethnograph*") OR TS=("qualitative synthes?s") OR TS=("qualitative evidence synthes?s") OR TS=("metasynthes?s") OR TS=("meta-synthes?s") OR TS=("meta-analy*") OR TS=("metaanaly*") OR TS=("meta-regress*") OR TS=(metaregress*)

Databases=SCI-EXPANDED, SSCI Timespan=1976-01-01 - 2011-12-31

Diverse research synthesis search
TS=("meta-study") OR TS=(metastudy) OR TS=("meta-studies") OR TS=(metastudies) OR TS=("meta-summar*") OR TS=(metasummar*) OR TS=("meta-review*") OR TS=(metareview*) OR TS=("systematic mixed method* review*") OR TS=("systematic qualitative review*") OR TS=("systematic narrative review*") OR TS=("interpretative synthes?s") OR TS=("interpretive synthes?s") OR TS=("realist synthes?s") OR TS=("metaethnograph*") OR TS=("meta-ethnograph*") OR TS=("qualitative synthes?s") OR TS=("qualitative evidence synthes?s") OR TS=("metasynthes?s") OR TS=("meta-synthes?s")

Databases=SCI-EXPANDED, SSCI Timespan=1976-01-01 - 2011-12-31

Appendix C. Seed Publications

Table C1. Seed publications, search phrases, and records identified

Note: A "yes" in the "Diverse Search" column indicates whether a publication was included in the search for less traditional forms of research synthesis.

Seed Publications	Cited reference search			Records	Diverse Search
	Author	Work	Year		
BOOKS					
Bergh, J.C.M. van den, Button, K.J., Nijkamp, P., & Pepping, G.C. (1997). *Meta analysis in environmental economics*: Dordrecht, The Netherlands: Kluwer.	Bergh*	Meta*		35	
Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). *Introduction to meta-analysis.* Chichester, West Sussex, UK: Wiley.	Borenst*	Intro*		405	
Centre for Reviews and Dissemination. (2008, 2009). Systematic reviews: CRD's guidance for undertaking reviews in health care. York, UK: Centre for Reviews and Dissemination, University of York.	Cent*	Syst*		116	
	CRD	Syst*		22	
	Ctr*	Syst*		124	
Chalmers, I., & Altman, D. G. (1995). *Systematic reviews*. London: BMJ.	Chalmers*	Syst*		240	
Chalmers, I. (1996). *Systematic reviews and meta-analysis.* London: BMJ.	Chalmers*	Syst*		In above	
Cook, T. D., Cooper, H., Cordray, D. S., Hartmann, H., Hedges, L. V., Light, R. J., … Mosteller,F. (1992). *Meta-analysis for explanation: A casebook*. New York: Russell Sage.	Cook T*	Meta*		139	
Cooper, H. (1984). *The integrative research review: A systematic approach*. Beverly Hills & London: Sage.	Cooper H*	Integ*		185	
Cooper, H. (1989). *Integrating research: A guide for literature reviews* (2nd ed). Beverly Hills, CA: Sage.	Cooper H*	Integ*		280	
Cooper, H. (1998). *Synthesizing research: A guide for literature reviews* (3rd ed). Thousand Oaks, CA: Sage.	Cooper H*	Syn*		319	
Cooper, H. (2010). *Research synthesis and meta-analysis: A step-by-step approach* (4th ed.). Thousand Oaks, CA: Sage.	Cooper H*	Res*		25	
Cooper, H., & Hedges, L. V. (1994). *The handbook of research synthesis*. New York: Russell Sage Foundation.	Cooper H*	H*		1282	
Cooper, H., Hedges, L. V., & Valentine, J. C. (2009). *The handbook of research synthesis and meta-analysis* (2nd ed.). New York: Russell Sage Foundation.	Cooper H*	H*		78	
Egger, M., Smith, G.D., & Altman, D., Eds. (2001). *Systematic reviews in health care: Meta-analysis in context*. London: BMJ. DOI: 10.1002/9780470693926	Egger M*	Syst*		1386	
Farley, J. U., & Lehmann, D. R. (1986). *Meta-analysis in marketing: Generalization of response models.* Lexington, MA: Lexington Books.	Farley J*	Meta*		63	
Fink, A. (1998, 2005, 2010). *Conducting research literature reviews: From the Internet to paper* (1st, 2nd, & 3rd eds.). Thousand Oaks, CA: Sage.	Fink A*	Cond*		61	
Glass, G. V., McGaw, B., & Smith, M. L. (1981). *Meta-analysis in social research.* Beverly Hills, CA: Sage.	Glass G*	Meta*		16	
Glasziou, P. (2001). *Systematic reviews in health care: A practical guide*. New York: Cambridge University Press.	Glasziou P*	Syst*		106	

Seed Publications	Cited reference search Author	Work	Year	Records	Diverse Search
Hartung, J., Knapp, G., & Sinha, B. K. (2008). *Statistical meta-analysis with applications*. Hoboken, NJ: Wiley.	Hartung J*	Stat*		23	
Hedges, L. V., & Olkin, I. (1985). *Statistical methods for meta-analysis.* New York & London: Academic Press.	Heges L*	Stat*		1191	
Hedges, L. V., Shymansky, J. A., & Woodworth, G. (1989). *A practical guide to modern methods of meta-analysis*. Washington, DC: National Science Teachers Association.	Heges L*	Prac*		27	
Hunt, M. (1997). *How Science Takes Stock: The Story of Meta-Analysis.* New York: Russell Sage.	Hunt M*	How*		130	
Hunter, J. E., & Schmidt, F. L. (1990, 2004). *Methods of meta-analysis: Correcting error and bias in research findings*. London: Sage.	Hunter J*	Meth*		2350	
Hunter, J. E., Schmidt, F. L., & Jackson, G. B. (1982). *Meta-analysis: Cumulating research findings across studies*. Beverly Hills, CA: Sage.	Hunter J*	Meta*		985	
Khan, K. S., Kunz, R., Kleijnen, J., & Antes, G. (2003). *Systematic reviews to support evidence-based medicine: How to review and apply findings of healthcare research*. London: Royal Society of Medicine Press.	Khan K*	Syst*		91	
Light, R. J., & Pillemer, D. B. (1984). *Summing up: The science of reviewing research.* Harvard, MA: Harvard University Press.	Light R*	Sum*		918	Yes
Lipsey, M. W., & Wilson, D. B. (2001). *Practical meta-analysis*. Thousand Oaks, CA: Sage.	Lipsey M*	Pract*		1548	
Littell, J. H., Corcoran, J., & Pillai, V. K. (2008). *Systematic reviews and meta-analysis*. Oxford: Oxford University Press.	Littell J*	Syst*		42	
Major, C. H., & Savin-Baden, M. (2010). *Introduction to qualitative research synthesis: Managing the information explosion in social science research.* London & New York: Routledge.	Major C*	Intro*		5	Yes
Mosteller, F. (1994). *Meta analysis for medicine: Applications and methods*. Boston, MA: Harvard School of Public Health.	Mosteller*	Meta*		not found	
Mullen, B. (1989). Advanced BASIC meta-analysis. Hillsdale, NJ: Lawrence Erlbaum.	Mullen B*	Adv*		252	
Mulrow, C. D., & Cook, D. (1998). *Systematic reviews: Synthesis of best evidence for health care decisions*. Philadelphia: American College of Physicians.	Mulrow C*	Syst*		137	
Noblit, G., & Hare, R. D. (1988). *Meta-ethnography: Synthesizing qualitative studies* (Vol. 11). Newbury Park, CA & London: Sage.	Noblit	Meta*		288	Yes
Paterson, B. L., Thorne, S. E., Canam, C., & Jillings, C. R. (2001). *Meta-study of qualitative health research: A practical guide to meta-analysis and meta-synthesis.* Thousand Oaks, CA: Sage.	Paterson B*	Meta*		124	
Pawson, R. (2006). *Evidence-based policy: A realist perspective.* Thousand Oaks, CA: Sage.	Pawson R*	Evid*		153	Yes
Petitti, D. B. (2000). *Meta-analysis, decision analysis, and cost-effectiveness analysis: Methods for quantitative synthesis in medicine*. New York: Oxford University Press.	Petitti D*	Meta*		921	
Petticrew, M., & Roberts, H. (2006). *Systematic reviews in the social sciences: A practical guide.* Malden, MA: Blackwell.	Petticrew M*	Syst*		154	
Pope, C., Mays, N., & Popay, J. (2007). *Synthesizing qualitative and quantitative health evidence: A guide to methods*. Maidenhead, UK & New York: McGraw-Hill.	Pope C*	Synth*		50	Yes

Seed Publications	Cited reference search Author	Work	Year	Records	Diverse Search
Rosenberg, M. S. (2000). *MetaWin: statistical software for Meta-Analysis*. Sunderland, MA: Sinauer.	Rosenberg M*	Meta*		555	
Rosenthal, R. (1984, 1991). *Meta-analytic procedures for social research*. Beverly Hills & Newbury Park, CA: Sage.	Rosenthal R*	Meta*		2930	
Rutter, D., Francis, J., Coren, E., & Fisher, M. (2010). *SCIE Systematic Research Reviews: Guidelines* (2nd ed.). London, UK: Social Care Institute for Excellence.	Rutter D*	S*		not found	
Sandelowski, M., & Barroso, J. (2007). *Handbook for synthesizing qualitative research*. New York: Springer.	Sandelowski M*	H*		68	Yes
Schulze, R. (2004). *Meta-analysis: A comparison of approaches*. Cambridge, Mass.: Hogrefe & Huber.	Schulze R*	Meta*		66	
Sutton, A. J., Abrams, K.R., Jones, D.R., Sheldon, T., & Song, F. (2000). *Methods for meta-analysis in medical research*. Chichester, West Sussex, UK: Wiley.	Sutton A*	Meth*		660	
Wachter, K. W., Straf, M. L., (eds). (1990). *The Future of Meta-analysis*. Russel Sage Foundation.	Wachter K*	Meta*		53	
Whitehead, A. (2002). *Meta-analysis of conrolled clinical trials.* Chichester, UK: Wiley.	Whitehead A*	Meta*		275	
Wolf, F. M. (1986). *Meta-analysis: Quantitative methods for research synthesis*. Beverly Hills, CA: Sage.	Wolf F*	Meta*		746	
Cochrane Handbook		Cochr * Hdb*		5012	
Clarke, M., & Oxman, A. (2000). *Cochrane reviewers' handbook* (4.1.1. ed.). Oxford, England: Update Software.	Clarke M*	Coch*		338	
Higgins, J. P. T. (2008, 2009, 2010, 2011). *Cochrane handbook for systematic reviews of interventions*. Chichester, West Sussex: Wiley.	Higgins*	Coch*		5440	
Higgins, J. T. P., & Green, S. (2008, 2009). *Cochrane handbook for systematic reviews of interventions* (Reprinted with corrections. ed.). Chichester, West Sussex: Wiley.	Higgins*	Coch*		In above	
Oxman, A. (1996). *The Cochrane Collaboration handbook: Preparing and maintaining systematic reviews* (2nd ed.). Oxford, UK: Cochrane Collaboration.	Oxman A*	Coch*		146	
ONLINE RESOURCES					
Dixon-Woods, M., Agarwal, S., Young, B., Jones, D., & Sutton, A. J. (2005). *Integrative approaches to qualitative and quantitative evidence*. Health Development Agency Web site: http://www.hda.nhs.uk	Dixon*	Integ*		64	Yes
EPPI-Centre. (2001, February). *EPPI-Centre Review Group manual (Version 1.1)*. http://eppi.ioe.ac.uk/EPPIWebContent/downloads/RG_manual_version_1_1.pdf	Eppi*	Eppi*		15	
What Works Clearinghouse. (2003). *WWC study review standards.* Http://w-w-c.org/reviewprocess/study_standards_final.pdf	What works*	WWC*		5	Yes
ARTICLES: Primary					
Cooper, H. M. (1982). Scientific guidelines for conducting integrative research reviews. *Review of Educational Research, 52*(2), 291-302.	Cooper H*	Rev Ed*		172	

Seed Publications	Cited reference search Author	Work	Year	Records	Diverse Search
Dixon-Woods, M., Agarwal, S., Jones, D., Young, B., & Sutton, A. J. (2005). Synthesising qualitative and quantitative evidence: A review of possible methods. *Journal of Health Services Research and Policy, 10*(1), 45-53.	Dixon*	J H*		150	Yes
Glass, G. V. (1976). Primary, secondary, and meta-analysis of research. *Educational Researcher, 5*(10), 3-8.	Glass G*	Edu*		1218	
Jackson, G. B. (1980). Methods for integrative reviews. *Review of Educational Research, 50*(3), 438-460.	Jackson G*	Rev Ed*		173	
Light R. J., & Smith P. V. (1971). Accumulating evidence: procedures for resolving contradictions among different research studies. *Harvard Educational Review 41*, 429–471.	Light R*	Harv*		180	Yes
Mulrow, C. D. (1987). The medical review article: State of the science. *Annals of Internal Medicine, 106*, 485-488.	Mulrow C*	Ann*		436	
Mulrow, C. D. (1994). Systematic reviews: Rationale for systematic reviews. *British Medical Journal, 309*(6954), 597-599.	Mulrow C*	Brit* BMJ*		317 314	
Slavin, R. E. (1995). Best evidence synthesis: An intelligent alternative to metaanalysis. *Journal of Clinical Epidemiology, 48*(1), 9-18. doi: 10.1016/0895-4356(94)00097-a	Slavin R*	J Clin*		248	
PROCEEDINGS / CONFERENCE PAPERS					
Bair, C. R. (1999, November). Meta-synthesis.Paper presented at the 24th annual meeting of the Asociation for the Study of Higher Education, San Antonio, TX. (ERIC No. ED437866)	Bair C*		1999	9 Results off topic	
Noblit, G. W., & Hare, R. D. (1983, April). Meta-ethnography: Issue in the synthesis and replication of qualitative research. Paper presented at the 67th annual meeting of the American Educational Research Association, Montreal, Quebec, Canada. (ERIC No. ED231853)	Noblit G*		1983	4	Yes
CHAPTERS					
Glass, G. V. (2006). Meta-analysis: The quantitative synthesis of research findings. In J. L. Green & G. Camilli & P. B. Elmore (eds.), *Handbook of complementary methods in education research* (3rd ed., pp. 427-438). Washington, DC: American Educational Research Association.	Glass G*	Meta* OR Hand * OR HDB*	2006	3	
Gough, D. (2004). Systematic research synthesis. In G. Thomas & R. Pring (Eds.), *Evidence-based practice in education* (pp. 44-62). Buckingham, UK: Open University Press.	Gough D*	Syst* OR Evid*	2004	2	
Gurevitch J., & Hedges L. V. (1993). Meta-analysis: combining the results of independent studies in experimental ecology. In S. Scheiner and J. Gurevitch (Eds.), *The design and analysis of ecological experiments*. (pp. 378–398). New York: Chapman & Hall.	Gurevitch J*	Meta* OR Des*	1993	215	
Schmidt, F. L., & Hunter, J. E. (2003). Meta-analysis. In Handbook of Psychology. Vol. 2: Research Methods in Psychology. Editor in chief I. B. Weiner, volume editors J. A. Schinka and W. F. Velicer, (pp. 533– 554). New York: Wiley.	Schmidt F*	Meta* OR Hand * OR HDB*	2003	not found	

Appendix D. Search Strategy Development

The search strategies were developed based on an extensive literature review, a short bibliographic list (Cook et al., 1992), following reference trails, searches for research synthesis methods texts in OCLC (Table D1), consultation with an extensive bibliography (Hafdahl, 2011), and examination of terms used to identify systematic review guidelines in a cross-field study (Sander & Kitcher, 2006). Query terms were limited to those that authors use to describe the composite process of research synthesis. Titles and other content (e.g., abstracts, tables of contents) were reviewed as necessary to determine whether to include seed publications. The final collections of terms and seed publications represent a wide variety of research synthesis methods, from more traditional to interpretivist and realist approaches.

For query-based searches, the topic index rather than the title index was chosen for search because it was expected to increase recall, and also because publication guidelines used in some fields but not others specify that type of review should be indicated in the title of a publication. Therefore, searching only on titles would have resulted in an uneven representation of fields.

Because there are many ways authors may combine words to express the concept "research synthesis", the query terms are not believed to exhaustively retrieve relevant papers. Instead, the goal was to maximize the ecological validity of how "research synthesis" was operationalized in this study within the range of ways this concept has been expressed by authors in publications and captured in records of the *SCI/SSCI*. In Stage I, all types of engagement with research synthesis (e.g., whether a publication reports a research synthesis, discusses the method, evaluates research syntheses, or develops research synthesis methods) were included.

Table D1. Search Worksheet for OCLC WorldCat

Database Title:	OCLC FirstSearch WorldCat
Platform:	First Search
Purpose of search	Identify books on research synthesis methods

Search terms or phrases, indexes searched, filters applied	**# Docs (Orig)**	**# Docs in review**	**Last date searched**
WorldCat results for: ((su= "research synthesis") or (su= "systematic review") or (su= "meta analysis") and la= "eng" and dt= "bks") not mt: mic and la= "eng" and dt= "bks" . (Save Search) Records found: 855 Rank by: Number of Libraries	855		20-Jan-12
WorldCat results for: ((((la= "eng" and (((yr: 1987-2013 and ((dt= "bks" and ((su= "Methodology" and su= "Qualitative research")))))) not mt: juv)) and dt= "bks")) not kw: thesis) not kw: theses) not mt: mic and la= "eng" and dt= "bks" . (Save Search) Records found: 805 Rank by: Number of Libraries	805		20-Jan-12
Total items included - need to recheck for citedness		32	1-Feb-12

Notes
In first pass, titles screened for relevance. Titles that indicated a study about a topic (primarily) rather than primarily a methods discussion were not marked/considered for further review. There appears to be many duplicate records in the 352 records of the original 855 that I marked. These will need to be reviewed/deduplicated. There also appears to be little related to qualitative research synthesis based on the titles that I am familiar with. Based on this observation, known works will be used as the basis for pearl growing (Sandelowski, Noblit, Major & Savin-Baden). Also, there appears to be a limited number of works related to systematic review - did not see Cooper's series of works. Will do a pearl search based on these. 78 dissertations / theses removed.
40 records of 805 checked for additional review related to qualitative methods
From the composite group of the two search strategies above, 68 duplicate references were found (not counting the ones I kept), 78 dissertations/theses, 116 did not meet inclusion criteria - for reasons such as breadth (too narrow or too broad) lack of relevance (especially in case of qualitative works for which titles / descriptions were not descriptive enough to know without further investigations), not used or only used a few times - though this is interesting in the context of diffusion, it does not make a good seed publication, some were special journal issues and conference publications. Journal articles were in sources that would be found via the search terms; conference publications reviewed were either off-scope or not cited very much or otherwise determined to be not usable. 32 references were found to be of use as seed publications. It would be good to see how much they are actually cited in more depth, especially in the case of more recent titles. Some items might be classified differently in different databases - for example meta-analysis in ecology, a book series chapter

Appendix E. Example Pandas Code

Extracting *Web of Science* category counts by publication year

```
# Includes
from pandas import *
from numpy import *

# read combined file, previously reduced & deduplicated, from csv:
df_all_dedup = read_csv('<path>/all_records_deduplicated.csv', sep='|')

# make an empty list for the set of all WOS WCs, which I named "research_field":
all_wcrf = []

# go through and create a list of all WCs (use try/except in case there are empty cells)
for x in df_all_dedup.research_field:
    try:
        all_wcrf.extend(x.split('| '))
    except:
        pass

# get the unique list of entries
unique_wcrf = np.unique(all_wcrf)

# create a new dataframe to put in the 1/0 values for each row (i.e., record)
# length is that of the original dataframe, width is that of unique_wcrf
# column names are unique_wcrf:
df_wcrf = DataFrame(np.zeros((len(df_all_dedup), len(unique_wcrf))), columns =
unique_wcrf)

# fill in the new data frame with 1's to indicate which subject areas are valid for each row
# all cells currently have 0's, so those not filled in with a 1 will have a 0
for i, gen in enumerate(df_all_dedup.research_field):
    try:
        df_wcrf.ix[i, gen.split('| ')] = 1
    except:
        pass

# look at sums for all the columns:
df_wcrf.sum()

# make a data frame with just the pub year
df_py = DataFrame({'pub-year': df_all_dedup.pub_year})

# combine the wcrf df with the df_py:
df_wcrfpy = df_py.join(df_wcrf, how="outer")

# sort the df by pub year
df_wcrfpy.sort_index(by='pub-year', ascending=False)
```

```
# have a look at one of WC's:
df_wcrfpy['Veterinary Sciences'].sum()

# group by pub year
py_wcrf = df_wcrfpy.groupby(df_wcrfpy['pub-year'])

# produce a matrix of sums for each year by WC:
py_wc_matrix_out = py_wcrf.agg(lambda x: x.sum())

# save the matrix to csv
py_wc_matrix_out.to_csv('<path>/wc_by_year.csv', sep = ';')
```

Appendix F. Search Strategy Yields By Year

Table F1. Number of records retrieved with search strategies by year.

Year	Union	Keyword	Cited Ref	Unique Key	Intersection	Unique Cited
1972	3	0	3	0	0	3
1973	0	0	0	0	0	0
1974	2	0	2	0	0	2
1975	2	0	2	0	0	2
1976	6	5	1	5	0	1
1977	10	5	5	5	0	5
1978	10	5	5	5	0	5
1979	22	10	13	9	1	12
1980	47	34	23	24	10	13
1981	39	24	24	15	9	15
1982	83	49	61	22	27	34
1983	138	75	106	32	43	63
1984	123	59	98	25	34	64
1985	164	85	140	24	61	79
1986	209	100	167	42	58	109
1987	229	105	191	38	67	124
1988	268	125	207	61	64	143
1989	318	163	231	87	76	155
1990	393	225	258	135	90	168
1991*	634	506	269	365	141	128
1992	744	623	287	457	166	121
1993	843	713	293	550	163	130
1994	1032	878	330	702	176	154
1995	1298	1131	425	873	258	167
1996	1548	1335	502	1046	289	213
1997	1909	1698	493	1416	282	211
1998	2291	2102	524	1767	335	189
1999	2595	2422	489	2106	316	173
2000	2893	2683	515	2378	305	210
2001	3328	3116	606	2722	394	212
2002	3797	3597	610	3187	410	200
2003	4385	4167	702	3683	484	218
2004	5353	5124	749	4604	520	229
2005	6886	6565	990	5896	669	321
2006	8217	7851	1189	7028	823	366
2007	10133	9719	1458	8675	1044	414
2008	12154	11665	1730	10424	1241	489
2009	14630	14036	2079	12551	1485	594
2010	17151	16426	2693	14458	1968	725
2011	19994	19187	3287	16707	2480	807

*Keyword yield increase due to availability of abstracts in the *S/SCI*.

Table F2. Proportional contributions of keyword versus cited reference searches

Year	Keyword	Cited Ref	Unique Key	Intersection	Unique Cited
1972	0.000	1.000	0.000	0.000	1.000
1973	NA	NA	NA	NA	NA
1974	0.000	1.000	0.000	0.000	1.000
1975	0.000	1.000	0.000	0.000	1.000
1976	0.833	0.167	0.833	0.000	0.167
1977	0.500	0.500	0.500	0.000	0.500
1978	0.500	0.500	0.500	0.000	0.500
1979	0.455	0.591	0.409	0.045	0.545
1980	0.723	0.489	0.511	0.213	0.277
1981	0.615	0.615	0.385	0.231	0.385
1982	0.590	0.735	0.265	0.325	0.410
1983	0.543	0.768	0.232	0.312	0.457
1984	0.480	0.797	0.203	0.276	0.520
1985	0.518	0.854	0.146	0.372	0.482
1986	0.478	0.799	0.201	0.278	0.522
1987	0.459	0.834	0.166	0.293	0.541
1988	0.466	0.772	0.228	0.239	0.534
1989	0.513	0.726	0.274	0.239	0.487
1990	0.573	0.656	0.344	0.229	0.427
1991*	0.798	0.424	0.576	0.222	0.202
1992	0.837	0.386	0.614	0.223	0.163
1993	0.846	0.348	0.652	0.193	0.154
1994	0.851	0.320	0.680	0.171	0.149
1995	0.871	0.327	0.673	0.199	0.129
1996	0.862	0.324	0.676	0.187	0.138
1997	0.889	0.258	0.742	0.148	0.111
1998	0.918	0.229	0.771	0.146	0.082
1999	0.933	0.188	0.812	0.122	0.067
2000	0.927	0.178	0.822	0.105	0.073
2001	0.936	0.182	0.818	0.118	0.064
2002	0.947	0.161	0.839	0.108	0.053
2003	0.950	0.160	0.840	0.110	0.050
2004	0.957	0.140	0.860	0.097	0.043
2005	0.953	0.144	0.856	0.097	0.047
2006	0.955	0.145	0.855	0.100	0.045
2007	0.959	0.144	0.856	0.103	0.041
2008	0.960	0.142	0.858	0.102	0.040
2009	0.959	0.142	0.858	0.102	0.041
2010	0.958	0.157	0.843	0.115	0.042
2011	0.960	0.164	0.836	0.124	0.040
all years	0.941	0.176	0.824	0.117	0.059

*Keyword yield increase due to availability of abstracts in the *S/SCI*.

Appendix G. Search Strategy Yields By Research Area

Table G1. Records retrieved by search strategy and by subject category

"RSM cont" is the year continuous use of research synthesis methods began.

Field Name	RSM cont	Union	Key word	Unique Key	Intersect	Unique Citing	Citing
SOCIAL SCIENCES							
Education Educational Research	1975	2431	1900	1356	544	531	1075
Psychology	1976	15044	12978	9776	3202	2066	5268
Business Economics	1979	4451	3925	2955	970	526	1496
Social Sciences Other Topics	1980	1152	966	744	222	186	408
Communication	1981	438	349	224	125	89	214
Sociology	1982	329	263	196	67	66	133
Social Work	1984	490	410	287	123	80	203
Family Studies	1987	532	476	383	93	56	149
Government Law	1987	488	412	320	92	76	168
Women S Studies	1987	301	286	253	33	15	48
Criminology Penology	1988	679	636	508	128	43	171
Linguistics	1989	209	171	116	55	38	93
Mathematical Methods In Social Sci	1990	216	174	103	71	42	113
Social Issues	1990	160	134	107	27	26	53
Public Administration	1991	219	156	118	38	63	101
Urban Studies	2000	53	45	30	15	8	23
Anthropology	2001	121	112	99	13	9	22
Demography	2002	41	35	28	7	6	13
Geography	2004	58	47	31	16	11	27
Ethnic Studies	2008	13	13	12	1	0	1
Area Studies	2010	8	6	5	1	2	3
Archaeology	2011	5	3	3	0	2	2
International Relations	NA	22	18	12	6	4	10
CLINICAL MEDICINE							
Neurosciences Neurology	1983	9016	8772	8023	749	244	993
General Internal Medicine	1984	15521	13965	11860	2105	1556	3661
Pharmacology Pharmacy	1985	5793	5693	5294	399	100	499
Cardiovascular System Cardiology	1986	9502	9428	9012	416	74	490
Oncology	1986	7077	6966	6569	397	111	508
Pediatrics	1986	2735	2647	2409	238	88	326
Surgery	1986	6452	6366	5915	451	86	537
Dermatology	1987	698	689	652	37	9	46
Gastroenterology Hepatology	1987	5339	5288	5008	280	51	331

Field Name	RSM cont	Union	Key word	Unique Key	Intersect	Unique Citing	Citing
Anesthesiology	1988	1583	1538	1392	146	45	191
Obstetrics Gynecology	1988	3902	3825	3505	320	77	397
Toxicology	1988	736	718	670	48	18	66
Dentistry Oral Surgery Medicine	1989	1427	1382	1174	208	45	253
Hematology	1989	2631	2609	2495	114	22	136
Radiology Nucl Med Med Imaging	1989	1579	1548	1475	73	31	104
Respiratory System	1989	2320	2288	2128	160	32	192
Rheumatology	1989	1794	1771	1624	147	23	170
Endocrinology Metabolism	1990	3336	3294	3078	216	42	258
Urology Nephrology	1990	2440	2407	2281	126	33	159
Orthopedics	1991	2185	2152	1929	223	33	256
Otorhinolaryngology	1991	736	723	674	49	13	62
Emergency Medicine	1992	675	659	609	50	16	66
Ophthalmology	1992	484	470	416	54	14	68
Transplantation	1992	729	722	680	42	7	49
Tropical Medicine	1994	287	281	253	28	6	34
OTHER HEALTH & MEDICAL SCIENCES							
Geriatrics Gerontology	1980	1681	1632	1493	139	49	188
Rehabilitation	1980	2060	1869	1524	345	191	536
Sport Sciences	1980	1600	1496	1280	216	104	320
Psychiatry	1981	8434	8128	7261	867	306	1173
Nursing	1982	2148	1985	1597	388	163	551
Public Environmental Occup Hlth	1982	7875	7511	6421	1090	364	1454
Research Experimental Medicine	1985	2049	1992	1767	225	57	282
Medical Informatics	1986	1070	990	804	186	80	266
Health Care Sciences Services	1988	3970	3723	3144	579	247	826
Infectious Diseases	1988	1922	1879	1700	179	43	222
Substance Abuse	1988	979	918	771	147	61	208
Immunology	1989	1863	1813	1643	170	50	220
Medical Laboratory Technology	1989	333	326	309	17	7	24
Nutrition Dietetics	1989	2176	2134	1934	200	42	242
Biomedical Social Sciences	1990	466	427	348	79	39	118
Allergy	1994	492	479	429	50	13	63
Integrative Complementary Med	1998	621	594	514	80	27	107
Legal Medicine	2000	64	59	52	7	5	12
Medical Ethics	2008	45	40	38	2	5	7
LIFE SCIENCES							
Behavioral Sciences	1986	659	557	436	121	102	223
Environmental Sciences Ecology	1986	2204	1944	1361	583	260	843
Life Sci Biomedicine Other Topics	1989	930	876	722	154	54	208

Field Name	RSM cont	Union	Key word	Unique Key	Intersect	Unique Citing	Citing
Microbiology	1989	851	830	780	50	21	71
Mathematical Computational Bio	1990	688	655	511	144	33	177
Zoology	1990	359	284	208	76	75	151
Biochemistry Molecular Biology	1991	1238	1213	1140	73	25	98
Pathology	1991	391	389	380	9	2	11
Physiology	1992	374	349	322	27	25	52
Reproductive Biology	1992	1018	1002	919	83	16	99
Cell Biology	1993	423	412	397	15	11	26
Genetics Heredity	1993	2086	2018	1892	126	68	194
Evolutionary Biology	1994	313	247	154	93	66	159
Biotechnology Applied Microbio	1995	473	464	429	35	9	44
Virology	1995	327	321	291	30	6	36
Audiology Speech Lang Pathology	1996	167	143	111	32	24	56
Biodiversity Conservation	1996	238	223	134	89	15	104
Marine Freshwater Biology	1997	282	255	208	47	27	74
Biophysics	1998	140	133	123	10	7	17
Plant Sciences	1998	324	313	244	69	11	80
Parasitology	2001	123	119	103	16	4	20
Paleontology	2002	21	21	20	1	0	1
Anatomy Morphology	2004	39	37	35	2	2	4
Developmental Biology	2005	74	70	62	8	4	12
Mycology	2006	19	19	18	1	0	1
AGRICULTURE							
Agriculture	1990	543	523	434	89	20	109
Entomology	1993	76	69	57	12	7	19
Forestry	1996	118	109	86	23	9	32
Fisheries	1997	113	101	84	17	12	29
Veterinary Sciences	1997	274	264	213	51	10	61
Food Science Technology	1998	352	342	312	30	10	40
PHYSICAL SCIENCES & MATH							
Mathematics	1985	1171	1030	721	309	141	450
Chemistry	1989	216	210	204	6	6	12
Oceanography	2000	96	85	72	13	11	24
Water Resources	2000	79	73	65	8	6	14
Meteorology Atmospheric Sciences	2001	60	55	43	12	5	17
Physical Geography	2001	54	50	37	13	4	17
Geology	2003	68	67	64	3	1	4
Physics	2004	47	45	45	0	2	2
Optics	2007	12	10	10	0	2	2

Field Name	RSM cont	Union	Key word	Unique Key	Intersect	Unique Citing	Citing
Geochemistry Geophysics	2010	10	10	10	0	0	0
Mining Mineral Processing	2011	1	1	1	0	0	0
Thermodynamics	2011	3	3	3	0	0	0
Astronomy Astrophysics	NA	12	11	11	0	1	1
Crystallography	NA	1	1	1	0	0	0
Electrochemistry	NA	10	10	10	0	0	0
Mineralogy	NA	1	1	1	0	0	0
Polymer Science	NA	4	4	4	0	0	0
TECHNOLOGY							
Science Technology Other Topics	1985	305	278	245	33	27	60
Computer Science	1986	717	627	499	128	90	218
Engineering	1988	762	697	596	101	65	166
Information Science Library Science	1991	408	343	249	94	65	159
Operations Research Mgmt Science	1994	112	98	73	25	14	39
Transportation	1994	152	142	106	36	10	46
Acoustics	2001	102	98	88	10	4	14
Materials Science	2004	53	53	49	4	0	4
Energy Fuels	2006	37	37	33	4	0	4
Instruments Instrumentation	2006	22	21	20	1	1	2
Nuclear Science Technology	2008	32	32	31	1	0	1
Metallurgy Metallurgical Eng	2010	7	7	6	1	0	1
Automation Control Systems	2011	11	9	9	0	2	2
Construction Building Technology	2011	15	12	10	2	3	5
Imaging Sci Photographic Tech	2011	5	5	4	1	0	1
Remote Sensing	2011	2	2	2	0	0	0
Robotics	2011	3	3	3	0	0	0
Spectroscopy	2011	6	5	5	0	1	1
Telecommunications	2011	4	3	3	0	1	1
Mechanics	NA	6	5	5	0	1	1
Microscopy	NA	0	0	0	0	0	0

Appendix H: 2012 *Journal Citation Reports* Title Lists

Journal title lists were downloaded from the 2012 *Journal Citation Reports* (*JCR*) on 13 September 2013 for each of the five fields selected for examination in Stages II and III. Lists are included here for convenience and because a later (24 February 2014) download of the 2012 *JCR* included an additional title in the Information Science & Library Science category: *Informacios Tarsadalom* (INF TARSAD, ISSN: 1587-8694, a Hungarian title).

Table H1. Evolutionary Biology journal titles

Abbreviated Title	ISSN	Abbreviated Title	ISSN
Am J Phys Anthropol	0002-9483	J Evol Biochem Phys+	0022-0930
Am Nat	0003-0147	J Evolution Biol	1010-061X
Annu Rev Ecol Evol S	1543-592X	J Exp Zool Part B	1552-5007
Anthropol Sci	0918-7960	J Hum Evol	0047-2484
Aust Syst Bot	1030-1887	J Mol Evol	0022-2844
Biochem Syst Ecol	0305-1978	J Syst Palaeontol	1477-2019
Biol J Linn Soc	0024-4066	J Zool Syst Evol Res	0947-5745
Biol Letters	1744-9561	Mol Biol Evol	0737-4038
BMC Evol Biol	1471-2148	Mol Ecol	0962-1083
Cladistics	0748-3007	Mol Ecol Resour	1755-098X
Dev Genes Evol	0949-944X	Mol Phylogenet Evol	1055-7903
Evodevo	2041-9139	Org Divers Evol	1439-6092
Evol Appl	1752-4571	P Roy Soc B-Biol Sci	0962-8452
Evol Bioinform	1176-9343	Paleobiology	0094-8373
Evol Biol	0071-3260	Plant Syst Evol	0378-2697
Evol Dev	1520-541X	Syst Biol	1063-5157
Evol Ecol	0269-7653	Syst Bot	0363-6445
Evol Ecol Res	1522-0613	Syst Entomol	0307-6970
Evolution	0014-3820	Taxon	0040-0262
Genome Biol Evol	1759-6653	Theor Popul Biol	0040-5809
Heredity	0018-067X	Trends Ecol Evol	0169-5347
Insect Syst Evol	1399-560X	Yearb Phys Anthropol	0096-848X
Invertebr Syst	1445-5226	Zool Scr	0300-3256
Isr J Ecol Evol	1565-9801		

Table H2. Biodiversity Conservation journal titles

Abbreviated Title	ISSN	Abbreviated Title	ISSN
Afr J Range For Sci	1022-0119	Ecography	0906-7590
Afr Nat Hist	1816-8396	Environ Conserv	0376-8929
Am Midl Nat	0003-0031	Global Change Biol	1354-1013
Am Mus Novit	0003-0082	J Fish Wildl Manag	1944-687X
Anim Biodiv Conserv	1578-665X	J Nat Conserv	1617-1381
Anim Conserv	1367-9430	J Nat Hist	0022-2933
Avian Conserv Ecol	1712-6568	Landsc Ecol Eng	1860-1871
B Am Mus Nat Hist	0003-0090	Nat Conservacao	1679-0073
B Peabody Mus Nat Hi	0079-032X	Northeast Nat	1092-6194
Biodivers Conserv	0960-3115	Oryx	0030-6053
Biol Conserv	0006-3207	Pachyderm	1026-2881
Biol Invasions	1387-3547	Paleobiology	0094-8373
Biota Neotrop	1676-0603	Polar Biol	0722-4060
Caribb J Sci	0008-6452	Rev Chil Hist Nat	0716-078X
Conserv Biol	0888-8892	Rev Mex Biodivers	1870-3453
Conserv Genet	1566-0621	Southeast Nat	1528-7092
Conserv Genet Resour	1877-7252	Southwest Nat	0038-4909
Conserv Lett	1755-263X	Syst Biodivers	1477-2000
Divers Distrib	1366-9516	Trop Conserv Sci	1940-0829
Eco Mont	2073-106X	West N Am Naturalist	1527-0904

Table H3. Social Work journal titles

Abbreviated Title	ISSN	Abbreviated Title	ISSN
Admin Soc Work	0364-3107	Int J Soc Welf	1369-6866
Affilia J Wom Soc Wo	0886-1099	Int Soc Work	0020-8728
Am J Commun Psychol	0091-0562	J Community Psychol	0090-4392
Asia Pac J Soc Work	0218-5385	J Soc Policy	0047-2794
Aust J Guid Couns	1037-2911	J Soc Serv Res	0148-8376
Aust Soc Work	0312-407X	J Soc Work	1468-0173
Brit J Soc Work	0045-3102	J Soc Work Educ	1043-7797
Child Abuse Neglect	0145-2134	J Soc Work Pract	0265-0533
Child Abuse Rev	0952-9136	Ljetop Soc Rada	1846-5412
Child Fam Soc Work	1356-7500	Res Social Work Prac	1049-7315
Child Maltreatment	1077-5595	Rev Cercet Interv So	1583-3410
Child Soc	0951-0605	Smith Coll Stud Soc	0037-7317
Child Youth Serv Rev	0190-7409	Soc Policy Admin	0144-5596
Clin Soc Work J	0091-1674	Soc Serv Rev	0037-7961
Eur J Soc Work	1369-1457	Soc Work	0037-8046
Fam Relat	0197-6664	Soc Work Health Care	0098-1389
Fam Soc	1044-3894	Soc Work Public Hlth	1937-1918
Health Soc Care Comm	0966-0410	Soc Work Res	1070-5309
Health Soc Work	0360-7283	Trauma Violence Abus	1524-8380

Table H4. Women's Studies journal titles

Abbreviated Title	ISSN	Abbreviated Title	ISSN
Affilia J Wom Soc Wo	0886-1099	Hypatia	0887-5367
Asian J Women Stud	1225-9276	Indian J Gend Stud	0971-5215
Asian Women	1225-925X	Int Fem J Polit	1461-6742
Aust Feminist Stud	0816-4649	J Gender Stud	0958-9236
Differences	1040-7391	J Women Aging	0895-2841
Eur J Womens Stud	1350-5068	J Women Polit Policy	1554-477X
Fem Econ	1354-5701	J Womens Health	1540-9996
Fem Legal Stud	0966-3622	Polit Gender	1743-923X
Fem Psychol	0959-3535	Psychol Women Quart	0361-6843
Fem Theor	1464-7001	Radical Philos	0300-211X
Feminist Rev	0141-7789	Sex Roles	0360-0025
Feminist Stud	0046-3663	Signs	0097-9740
Feministische Stud	0723-5186	Soc Polit	1072-4745
Frontiers	0160-9009	Trav Genre Soc	1294-6303
Gender Lang	1747-6321	Violence Against Wom	1077-8012
Gender Place Cult	0966-369X	Women Health	0363-0242
Gender Soc	0891-2432	Women Health Iss	1049-3867
Gender Work Organ	0968-6673	Women Stud Int Forum	0277-5395
Health Care Women In	0739-9332	Women Ther	0270-3149

Table H5. Information Science Library Science journal titles

Abbreviated Title	ISSN	Abbreviated Title	ISSN
Afr J Libr Arch Info	0795-4778	J Inf Technol	0268-3962
Annu Rev Inform Sci	0066-4200	J Informetr	1751-1577
Aslib Proc	0001-253X	J Knowl Manag	1367-3270
Aust Acad Res Libr	0004-8623	J Libr Inf Sci	0961-0006
Aust Libr J	0004-9670	J Manage Inform Syst	0742-1222
Can J Inform Lib Sci	1195-096X	J Med Libr Assoc	1536-5050
Coll Res Libr	0010-0870	J Organ End User Com	1546-2234
Data Base Adv Inf Sy	0095-0033	J Scholarly Publ	1198-9742
Econtent	1525-2531	J Strategic Inf Syst	0963-8687
Electron Libr	0264-0473	Knowl Man Res Pract	1477-8238
Ethics Inf Technol	1388-1957	Knowl Organ	0943-7444
Eur J Inform Syst	0960-085X	Learn Publ	0953-1513
Gov Inform Q	0740-624X	Libr Collect Acquis	1464-9055
Health Info Libr J	1471-1834	Libr Cult Rec	1932-4855
Inform Dev	0266-6669	Libr Hi Tech	0737-8831
Inform Manage-Amster	0378-7206	Libr Inform Sc	0373-4447
Inform Organ-Uk	1471-7727	Libr Inform Sci Res	0740-8188
Inform Process Manag	0306-4573	Libr J	0363-0277
Inform Res	1368-1613	Libr Quart	0024-2519
Inform Soc	0197-2243	Libr Resour Tech Ser	0024-2527

Abbreviated Title	ISSN	Abbreviated Title	ISSN
Inform Soc-Estud	0104-0146	Libr Trends	0024-2594
Inform Syst J	1350-1917	Libri	0024-2667
Inform Syst Res	1047-7047	Malays J Libr Inf Sc	1394-6234
Inform Technol Dev	0268-1102	Mis Q Exec	1540-1960
Inform Technol Libr	0730-9295	Mis Quart	0276-7783
Inform Technol Manag	1385-951X	Online	0146-5422
Inform Technol Peopl	0959-3845	Online Inform Rev	1468-4527
Int J Comp-Supp Coll	1556-1607	Perspect Cienc Inf	1413-9936
Int J Geogr Inf Sci	1365-8816	Portal-Libr Acad	1531-2542
Int J Inform Manage	0268-4012	Prof Inform	1386-6710
Interlend Doc Supply	0264-1615	Program-Electron Lib	0033-0337
Investig Bibliotecol	0187-358X	Res Evaluat	0958-2029
J Acad Libr	0099-1333	Restaurator	0034-5806
J Am Med Inform Assn	1067-5027	Rev Esp Doc Cient	0210-0614
J Am Soc Inf Sci Tec	1532-2882	Scientist	0890-3670
J Assoc Inf Syst	1536-9323	Scientometrics	0138-9130
J Comput-Mediat Comm	1083-6101	Serials Rev	0098-7913
J Doc	0022-0418	Soc Sci Comput Rev	0894-4393
J Glob Inf Manag	1062-7375	Soc Sci Inform	0539-0184
J Glob Inf Tech Man	1097-198X	Telecommun Policy	0308-5961
J Health Commun	1081-0730	Transinformacao	0103-3786
J Inf Sci	0165-5515	Z Bibl Bibl	0044-2380

Appendix I. Financial Support For Research Syntheses

Though authors are often criticized for omitting references to research support in publications, funding information extracted from publications is available from indexes such as the *Web of Science* and *Scopus*. Funding data indicated in *Web of Science* records was cleaned to identify levels of support from organizations overall and, where applicable, geographically. Support data is summarized for each field by journal, organization, and region.

Evolutionary Biology

Financial support was identified in sixty-six of 255 publications (2008-2011) judged related to research synthesis methods. Publication venues and years (Table I1) and support by organizations (Table I2) are presented.

Table I1. Publication venues of supported projects in Evolutionary Biology

Journal Title	2008	2009	2010	2011	All Years
American Journal of Physical Anthropology	0	0	0	1	1
American Naturalist	0	4	2	2	8
Annual Review of Ecol, Evol & Systematics	0	1	0	0	1
Biological Journal of the Linnean Society	0	0	0	1	1
Biology Letters	1	0	1	1	3
BMC Evolutionary Biology	0	0	1	3	4
Evolution	0	1	3	2	6
Evolutionary Applications	0	0	1	0	1
Evolutionary Bioinformatics	1	0	0	0	1
Evolutionary Ecology Research	0	0	1	0	1
Heredity	0	0	0	2	2
Israel Journal of Ecology & Evolution	0	0	3	0	3
Journal of Evolutionary Biology	0	4	5	4	13
Molecular Ecology	1	1	2	2	6
Proc of the Royal Society B-Biol Sciences	0	5	3	4	12
Taxon	0	0	1	0	1
Trends in Ecology & Evolution	0	0	1	1	2
All Journals	3	16	24	22	66

Table I2. Organizations recognized in funding text and years of publications

Country and Funding Organization	Publication Year
Australia	
Australian Research Council (ARC)	2009, 2009, 2010, 2011, 2011
Australian National Wildlife Collection (ANWC) Foundation	2009
Australian National University (A.N.U.)	2011
Invasive Animals Cooperative Research Center	2011
Ecological Society of Australia	2010
Australian Geographic Society	2010
Linnean Society of New South Wales	2010
Canada	
Natural Sciences and Engineering Research Council of Canada (NSERC)	2009, 2009, 2010, 2010, 2010, 2010, 2010, 2011, 2011, 2011
NSERC Fonds Quebecois de la Recherche sur la Nature et les Technologies	2011
Killam Trust	2011
Alberta Heritage Foundation for Science and Engineering Research - Alberta Ingenuity	2009, 2010
Ontario Graduate Scholarship	2010
Canadian Foundation for Innovation/Ontario Innovation Trust	2010
University of Alberta	2009, 2010
USA	
Environmental Protection Agency (EPA)	2010
National Institutes of Health (NIH)…	2011, 2011
National Institute of Environmental Health Sciences (NIEHS)	2011
National Institute of Allergy and Infectious Diseases (NIAID)	2010
National Science Foundation (NSF)	2009, 2009, 2009, 2009, 2010, 2010, 2010, 2010, 2010, 2010, 2011, 2011
National Evolutionary Synthesis Center (NESCent)	2010
National Center for Ecological Analysis and Synthesis (NCEAS)	2009, 2010
Mycological Society of America	2010
Lilly Endowment, Inc (USA)	2010
Ira C. Darling Marine Laboratory of the University of Maine	2011
PADI Foundation	2011
California State University, Northridge (CSUN) (from several university departments and programs)	2011
Indiana University (METACyt Initiative)	2010
University of California, Santa Barbara	2010
Georgia Tech	2009

Country and Funding Organization	Publication Year
University of Wisconsin-Madison	2010
National Geographic Society	2009
University of California, Santa Cruz UCSC Academic Senate Committee; Department of Environmental Studies	2009
Department of Botany at the University of Hawaii at Manoa	2011
University of Kentucky Agricultural Experiment Station	2011
United States Department of Agriculture USDA-NRI	2009
Fulbright Fellowship	2009
University of North Carolina (UNC) Interdisciplinary Obesity Center, Center for Environmental Health and Susceptibility	2011
Berry College	2011
University of Utal (Energy and Geoscience Institute: EGI)	2009
UK	
Biotechnology and Biological Sciences Research Council (BBSRC)	2011, 2011
Leverhulme Trust	2010
Natural Environment Research Council (NERC)	2010, 2010, 2010, 2010, 2010, 2011, 2011
Royal Society	2009, 2009, 2010, 2011
Imperial College, London	2010
University Royal Society (University of Exeter)	2010
Europe	
Academy of Sciences of the Czech Republic	2011
Czech Ministry of Education	2011, 2011
Grant Agency of the Czech Republic	2011
Czech Republic Ministry of Education, Youth and Sports (MSMT)	2011
Science Foundation of the Czech Republic	2011
Czech Republic [AVOZ 60050516]	2011
Danish Natural Science Research Council	2011
Danish National Research Foundation (Danmarks Grundforskningsfond)	2010
Estonian Science Foundation	2011
French-Estonian Hubert Curien (G.F. Parrot) partnership	2011
L'Action Concertée Incitative (ACI) Jeunes Chercheurs (France)	2010
Water Agency Adour-Garonne Agence de l'Eau Adour-Garonne (France, Regional)	2010
Agence Nationale de la Recherche (ANR) Freshwater Fish Diversity (France)	2009
Centre National de la Recherche Scientifique (France)	2011
Alexander von Humboldt Foundation (Germany)	2011
Helmholtz Association (Germany)	2011
German Ministry of Research and Education (BMBF)	2011
Biodiversity and Climate Research Centre (BIK-F) (Germany)	2011
German Science Foundation (DFG)	2010, 2011, 2011, 2011
Hesse's Ministry of Higher Education, Research, and the Arts (Germany, 'Bundesland' (Regional State))	2011
Doctorate of Computational Biology and Bioinformatics, University Federico II,	2010

Country and Funding Organization	Publication Year
Naples	
Netherlands Organisation for Scientific Research (NWO) Innovational Research Incentives Scheme Vici NWO-VICI	2008
Portuguese Foundation for Science and Technology	2008
Spanish Ministry of Science and Innovation	2011
Ministry of Education, Culture, and Sport (MEC) Spain	2009
Swedish Research Council for Environment, Agricultural Sciences and Spatial planning (FORMAS)	2010
Swiss National Science Foundation	2009, 2010
Zoological Institute of the University of Zurich	2009
European Union	2010, 2010, 2010, 2010, 2011
European Commission	2009, 2009, 2009, 2009, 2010
European Research Council (ERC)	2009
European Social Fund (ESF)	2010
Israel	
Ancell Teicher Foundation of Genetics and Molecular Evolution, University of Haifa	2010
Israel Science Foundation	2010
New Zealand	
Marsden Fund Council (http://www.royalsociety.org.nz/programmes/funds/marsden/)	2008, 2011, 2011
Landcare Research; New Zealand Department of Conservation; New Zealand Ministry of Education (NZIDRS)	2011
Tertiary Education Commission of New Zealand (JRC)	2009, 2011
University of Otago	2011
Latin America (with co-supporting organizations)	
Comision Nacional de Investigacion Cientifica y Tecnologica of the Government of Chile; Le Fonds Quebecois de la Recherche stir la Nature et les Technologies; Roche Research; Stiefel-Zangger Foundation; Secretaria Nacional de Ciencia y Tecnologia de Panama	2010
Consejo Nacional de Ciencia y Tecnologia (CONACyT) Mexico	2008
Direccion General de Asuntos del Personal Academico at the Universidad Nacional Autonoma de Mexico	2008
Inter-American Institute for Global Change Research	2008
Agencia Nacional de Promocion Cientifica y Tecnologica, Argentina	2008
Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)	2009
SeCyT-UNC (Universidad Nacional de Cordoba), Argentina	2009
Undetermined:	
FRST [MAUX0905]	2011

Conservation Biology

Financial support was identified for sixty-eight of 101 publications (2008-2011) judged to have a primary or secondary relationship to research synthesis methods. Publication venue by year (Table I3) and organizations across geographical regions (Table I4) was identified.

Table I3. Publication venues of supported projects in Conservation Biology

	Publication Year				
Journal Title	**2008**	**2009**	**2010**	**2011**	**All Years**
Animal Conservation				1	1
Avian Conservation and Ecology	1				1
Biodiversity and Conservation	1	1	1		3
Biological Conservation	1	2	4	5	12
Biological Invasions			1	1	2
Conservation Biology	1	2	10	3	16
Conservation Letters		1			1
Diversity and Distributions		1			1
Ecography				2	2
Ecohealth			1		1
Ecological Indicators				1	1
Global Change Biology	2	3	4	7	16
Human and Ecological Risk Assessment	1			1	2
Insect Conservation and Diversity		1			1
Journal for Nature Conservation	2		1	2	5
Natureza & Conservacao				1	1
Oryx			1		1
Western North American Naturalist				1	1
All Journals	9	11	23	24	67

Table I4. Organizations recognized in funding text and years of publications

Country and Funding Organization	**Publication Year**
THE AMERICAS	
Canada	
Ministry of the Environment, Ontario	2008
Natural Science and Engineering Research Council (NSERC) of Canada	2008, 2008, 2009, 2010, 2011, 2011

Country and Funding Organization	Publication Year
NSERC with Corner Brook Pulp and Paper, Ltd.	2008
University of British Columbia	2011
Fonds Quebecois de la Recherche sur la Nature et les Technologies (FQRNT)	2010
Canadian Forest Service - Laurentian Forestry Centre	2010
Agriculture and Agri-Food Canada - Soils and Crops Research and Development Centre	2010
Canada Foundation for Innovation	2011
Western Newfoundland and Labrador Field Unit of Parks Canada	2008
Memorial University Humber River Basin Project	2008
Latin America	
Capes Foundation, Ministry of Education - Brazil	2011
Fondecyt National Fund for Scientific and Technological Development (Chile)	2011
Universidad de Chile	2011
CONACYT (National Council of Science and Technology: Consejo Nacional de Ciencia y Tecnologia, Mexico)	2011, 2011
Foundation Banco Bilbao Vizcaya Argentaria	2010
AGCI (Agencia de Cooperaci on Internacional de Chile)	2010
USA	
National Science Foundation	2008, 2009, 2009, 2010, 2011, 2011
National Center for Ecological Analysis and Synthesis (NCEAS)	2008
Canada-U.S. Fulbright Chair position at University of Washington	2011
Department of Energy (DOE)...	
Office of Biological and Environmental Research (BER)	2009, 2001
Global Change Education Program	2009
National Institute of Health	2010
Utah Division of Wildlife Resources	2011
Science Foundation Arizona	2011
Brigham Young University (BYU)	2011
University of Connecticut (UConn)	2010
Utah State University Ecology Center	2010
University of Massachusetts, Amherst	2008
Wildlife Conservation Society	2011
Conserved Forest Ecosystems: Outreach and Research (CFEOR)	2011
Wenner-Gren Foundation for Anthropological Research, Inc.	2010
Conservation International	2010
American Bird Conservancy	2010
USAID	2009
Asia	
Japan Society for Promotion of Science	2011
Sumitomo Foundation (Japan)	2011
Ministry of Environment and Forests, Government of India, through Nature	2010

Country and Funding Organization	Publication Year
Conservation Foundation, Mysore;	
National Centre for Biological Sciences (India)	2010
Ministry of the Environment, Japan	2008, 2010
Bio-oriented Technology Research Advancement Institution, Japan	2010
National Natural Science Foundation of China	2010
National Science Foundation of China	2009
Chinese Scholarship Council	2009
Center for International Forestry Research CIFOR (Headqtr. in Indonesia)	2009
Indonesian Ministry of Forestry	2009
Environment Agency of Japan	2008
Australia	
Commonwealth Environmental Research Facilities - Applied Environmental Decision Analysis (AEDA)	2011
B. Macfie Family Foundation	2011
Flinders University	2010
Winifred Violet Scott Trust	2010
Royal Zoological Society of South Australia	2010
Australian Federation of University Women (SA)	2010
Australian Department of Environment, Heritage Arts	2010
Australian Antarctic Division	2009
Europe	
European Union	2010, 2011
IN-TERREG (European Union: European Regional Development Fund (ERDF))	2010
EU-Commission…	2008, 2008, 2009, 2010, 2010
COST (European Cooperation in Science and Technology) Action	2011
FP7 GHG-Europe (Greenhouse Gas mgmt in European land use systems)	2011
FP7 Seventh Framework Programme	2011
Alter-Net European Network of Excellence	2010
France	
Centre national de la recherche scientifique CNRS (National Center for Scientific Research)	2009, 2011
MEDAD (French Minister of the Environment: Ministère de l'écologie, du développement et de l'aménagement durables)	2011
French Environment and Energy Management Agency (ADEME)	2011
CR PACA (Regional Counsel: Provence-Alpes-Côte d'Azur)	2011
DIREN PACA (France)	2011
Conseils generaux de Gironde et du Gers et des Landes (France - Regional)	2011
Germany	
Federal Ministry of Education and Research (BMBF)	2011, 2011
Max Planck Institute for Biogeochemistry (Jena)	2011
Johann Heinrich von Thunen Institute (Braunschweig)	2011

Country and Funding Organization	Publication Year
Institute for Advanced Study, Berlin	2010
Spain	
Spanish Ministry of Science and Education	2011, 2011
Spanish Ministry of Science and Innovation	2011, 2011
Spanish Government	2011
Parco Agricolo Sud Milano - University of Milano-Bicocca	2011
UK	
Natural Environment Research Council (NERC)	2008, 2009, 2009, 2009, 2009, 2010, 2010, 2010, 2010, 2010, 2010, 2011
Biotechnology and Biological Sciences Research Council (BBSRC)	2010
UK Department of Health Evidence Synthesis	2008
Economic and Social Research Council	2010, 2010
Countryside Council for Wales	2010
Department for Environment, Food and Rural Affairs (DEFRA)	2010
Forestry Commission of Great Britain	2010
Forestry Commission and the Scottish Forestry Trust	2009
Northern Ireland Environment Agency	2010
Joint Nature Conservation Committee (JNCC)	2010
British Trust for Ornithology and the Joint Nature Conservation Committee (JNCC/BTO partership)	2010
Arcadia Fund (UK)	2010, 2011
Lawes Agricultural Trust	2010
Natural England…	2008, 2010
w. UK Environment Agency	2009
Scottish Natural Heritage	2010
British Ecological Society	2009
Royal Society	2010
University of Exeter	2010
Centre for Integrated Research in the Rural Environment (CIRRE: Aberystwyth University and Bangor University Research & Enterprise Partnership)	2008
Netherlands	
Netherlands Organization for Scientific Research (NWO)	2009, 2011
Wetlands International Central Kalimantan Peatlands Project (Netherlands)	2010
Tropenbos International (Headquarters in the Netherlands)	2009
Elsewhere in Europe	
Ministry for University and Scientific and Technological Research (MURST, Italy)	2010
Swedish Research Council	2010
Foundation for Polish Science	2010
Hungarian Science Foundation (OTKA)	2010

Country and Funding Organization	Publication Year
Government of Catalunya (AGAUR, Catalonia)	2011
Academy of Finland	2011
Finnish Ministry of the Environment (Ymparistoklusterin tutkimusohjelma)	2011
Cogito Foundation (Switzerland)	2011
Berne University Research Foundation (Switzerland)	2011
Cross-Regional	
UK-India Education and Research Initiative	2010
Undetermined	
PLOTNET	2009
STREK	2009

Social Work

Financial support was recognized in one (Koster, 2009) of the 145 social work publications (2008-2011) judged to have a primary or secondary relationship with research synthesis. The paper, published in the *International Journal of Social Welfare*, reported a research synthesis. Koster was financially supported by Stichting Instituut GAK (Netherlands: http://www.sigv.nl/).

Women's Studies

Fifteen of 47 publications (2008-2011) judged to be related to research synthesis identified funding. All of these papers were published in the *Journal of Women's Health* from 2009 to 2011. Organizations from the USA and Canada were prevalent (Table I5).

Table I5. Organizations recognized in funding text and years of publications

Country and Funding Organization	Publication Year
Canada	
Canadian Institute of Health Research (CIHR) …	
Knowledge Synthesis/Translation	2010
Institute of Gender and Health	2010
(W. Ontario Women's Health Council) New Investigator Award	2009
Health Canada	2010
Social Sciences and Humanities Research Council of Canada	2010

Country and Funding Organization	Publication Year
United States	
National Institute of Health...	
Multidisciplinary Clinical Research Career Develop. Program	2010
National Center for Advancing Translational Sciences	2009
National Center for Research Resources	2009, 2010
National Institute for Nursing Research	2010
National Institute of Mental Health	2011
National Institute of Neurological Disorders and Stroke	2010
National Institute on Alcohol Abuse and Alcoholism	2011
Office of Research on Women's Health	2011, 2011
Ruth L. Kirschstein National Research Service Award (NRSA)	2010
U.S. Department of Health and Human Services...	
Agency for Healthcare Research and Quality	2009, 2010
Health Resources and Services Administration (HRSA)	2010
Boehringer Ingelheim Pharmaceuticals	2010
Johns Hopkins University	2010
Robert Wood Johnson Foundation	2010
Elsewhere	
Netherlands Organisation for Health Research and Development (ZonMw)	2011
Fondazione IRCCS Policlinico, Ospedale Maggiore, Magiagalli, Regina Elena (Italy)	2010
Swedish Council of Technology Assessment in Health Care	2009
Karolinska Institutet, Stockholm (Sweden)	2009

Information and Library Science

Financial support was recognized in fourteen of the 111 Information and Library Science publications (2008-2011) judged to be related to research synthesis. Support from Australian and Canadian organizations was prevalent, followed by the USA and UK (Table I6).

Table I6. Organizations recognized in funding text and years of publications

Country and Funding Organization	Publication Year
Australia	
Australian Department of Health and Ageing	2010
Australian Research Council	2009, 2011, 2011
National Health & Medical Research Council	2009
Canada	
Canadian Institutes for Health Research	2010

Country and Funding Organization	Publication Year
Canada Health Infoway	2010
College of Pharmacists of British Columbia	2010
Precarn/Ontario Centres of Excellence Partnership	2010
Natural Sciences and Engineering Research Council of Canada	2010
United Kingdom	
Arts and Humanities Research Council	2011
Engineering and Physical Sciences Research Council (EPSRC)	2011
UK Joint Information Systems Committee (JISC)	2009
United States	
Agency for Healthcare Research and Quality (AHRQ)	2010
National Library of Medicine	2009, 2009, 2010
Elsewhere	
Japan Society for the Promotion of Science	2011
Royal Society of New Zealand	2011
National Science Council, Taiwan	2011
Instituto Colombiano para el desarrollo de la Ciencia y la Tecnologia-Colciencias	2009
Asociacion Universitaria Iberoamericana de Postgrado	2009

Appendix J. Topic Model Terms

The twenty most frequently occurring terms in each topic for each field are presented in Tables J1 to J5. Only Information and Library Science topics are assigned labels. These labels were assigned using personal judgment after review of topic terms and documents that were primarily assigned to the given topic. Topics for other fields are labeled using the most frequently occurring word stems associated with the topic. Topics were described in the text with reference to the most commonly occurring terms and most closely associated documents. The number of terms assigned to each topic overall is presented in the top row of the term frequency count column. These numbers are greater than the sum of terms frequencies included in the table due to long-tail distributions.

Table J1. Evolutionary Biology topics

Evolutionary Biology topics 1-4

Topic 1	2353.08	Topic 2	1867.54	Topic 3	1926.49	Topic 4	1185.70
Model	99.24	rate	48.94	select	216.60	speciat	81.98
Phylogenet	68.61	chang	40.70	sexual	131.83	genet	31.28
Data	53.78	differ	38.20	male	81.73	diverg	26.13
Phylogeni	33.88	scale	33.79	trait	50.23	isol	24.10
Analys	31.60	bodi	28.99	differ	43.64	flow	19.53
sequenc	29.99	between	28.92	femal	38.56	rang	19.06
distribut	26.33	time	28.15	morpholog	37.42	geograph	15.27
set	26.30	variabl	28.04	natur	32.65	structur	15.15
pattern	25.93	hypothesi	28.03	direct	30.43	area	14.11
differ	23.40	global	25.60	call	30.35	island	14.06
across	22.77	gradient	25.31	between	25.79	allopatr	13.94
analysi	22.66	predict	24.34	mate	25.77	mai	13.67
estim	21.96	latitud	24.25	correl	24.61	gene	13.64
meta-analysi	20.04	pattern	24.24	mai	22.38	among	13.29
tree	19.74	latitudin	23.95	pattern	20.49	select	13.09
new	19.46	region	23.21	suggest	18.02	reproduct	12.97
statist	19.25	factor	22.06	dimorph	17.40	howev	12.89
histori	18.96	flexibl	19.71	phenotyp	17.17	mani	12.34
result	17.36	adapt	19.35	attract	16.07	adapt	12.14
within	17.29	mass	18.73	signal	15.98	model	11.68

Evolutionary Biology topics 5-8

Topic 5	2181.08	Topic 6	1604.87	Topic 7	1540.76	Topic 8	2064.25
meta-analysi	57.85	predat	94.93	seed	61.86	divers	47.13
method	56.83	trophic	34.99	dispers	61.55	ecolog	35.21
public	50.93	invas	28.76	limit	59.33	conserv	32.00
test	47.45	experi	28.20	plastic	46.94	meta-analysi	31.96
data	47.24	cascad	28.00	fragment	41.91	research	28.37
bia	44.14	prei	24.97	habitat	27.97	test	23.86
statist	39.13	recruit	23.36	chang	25.56	increas	23.77
weight	36.20	nativ	22.98	respons	24.65	result	23.55
gener	34.46	plant	22.68	pollen	22.98	complex	23.21
publish	34.19	food	22.41	phenotyp	22.93	empir	22.58
power	31.61	commun	22.32	area	22.10	field	22.13
combin	31.43	carnivor	20.98	plant	21.91	gener	21.72
research	31.40	respons	20.80	densiti	20.09	function	19.80
ecolog	31.40	releas	19.48	establish	18.73	factor	19.36
result	29.94	increas	19.42	fish	18.30	review	19.16
number	24.25	terrestri	18.63	evolut	17.12	need	18.14
hypothesi	20.59	level	18.43	forest	16.98	abund	17.79
paradigm	19.37	impact	16.74	ecolog	16.56	approach	17.72
independ	19.09	meta-analysi	16.58	rate	16.39	laboratori	17.16
when	18.48	divers	16.46	affect	15.61	whether	17.02

Evolutionary Biology topics 9-12

Topic 9	1424.93	Topic 10	2014.13	Topic 11	1386.77	Topic 12	2068.67
competit	114.32	sex	126.15	host	89.96	genet	144.55
sperm	107.99	femal	77.80	parasit	70.96	fit	92.15
rule	41.96	ratio	67.97	local	65.21	inbreed	76.94
temperatur	40.09	offspr	47.76	adapt	62.55	trait	70.03
increas	31.97	condit	40.29	infect	37.97	variat	41.12
taxa	27.58	male	34.77	transmiss	25.99	varianc	39.57
bergmann'	26.00	reproduct	32.08	interact	21.71	environment	37.47
bodi	23.47	matern	31.55	meta-analysi	21.14	depress	35.98
fertil	22.98	adjust	29.96	treatment	19.86	purg	32.99
variat	19.47	mate	29.01	coevolut	15.56	growth	28.32
across	16.25	success	28.63	result	15.10	addit	27.86
differ	16.19	alloc	28.51	diseas	14.01	condit	27.08
organ	15.85	benefit	24.19	preval	13.60	stress	26.76
signific	15.85	when	23.70	time	13.27	result	24.73
result	15.47	result	23.02	predict	12.92	gener	22.41
influenc	14.73	predict	23.01	across	12.81	chang	22.39
among	14.45	between	20.19	among	12.30	increas	22.34
cline	13.97	relationship	19.19	influenc	12.19	measur	21.36
length	13.94	differ	18.18	virul	11.99	herit	20.30
meta-analysi	13.77	support	16.94	vector	11.94	between	18.12

Evolutionary Biology topics 13-15

Topic 13	2210.21	Topic 14	1723.17	Topic 15	1777.35
asymmetri	75.98	Genet	71.31	plant	99.25
development	71.82	Gene	51.57	mate	62.83
report	53.11	Quantit	34.83	cost	44.51
individu	50.82	Select	30.67	associ	37.22
fluctuat	49.97	Variat	30.09	defens	34.94
herit	48.56	Trait	29.55	between	27.69
between	48.33	Bird	29.47	within	25.77
differ	46.69	Differ	28.44	resist	25.29
sampl	46.17	extra-pair	27.93	mai	25.25
stabil	41.90	Rate	27.19	trait	24.80
relationship	40.77	Result	25.07	pattern	24.65
correl	35.29	Marker	24.94	increas	23.22
mean	32.57	differenti	24.45	among	21.60
meta-analysi	32.38	Show	24.24	life	21.44
estim	31.70	molecular	21.22	system	20.89
measur	27.49	Compar	20.78	form	20.16
suggest	24.35	Between	19.90	pathogen	18.75
signific	22.90	Suggest	19.15	type	18.48
onli	21.12	Base	16.80	herbivor	18.35
neg	20.95	Loci	16.64	meta-analysi	18.31

Table J2. Conservation Biology topics

Conservation Biology topics 1-4

Topic 1	1431.90	Topic 2	1792.51	Topic 3	1742.07	Topic 4	1295.39
Plant	109.10	popul	98.61	fragment	89.93	surviv	32.68
Graze	59.98	distanc	38.23	predat	75.95	declin	32.66
Exot	38.88	spatial	36.91	landscap	64.56	increas	27.28
Density	32.96	genet	35.01	edg	61.95	time	25.03
Herbivore	28.27	Size	31.10	habitat	59.21	rate	23.79
Veget	26.65	Scale	28.99	bird	46.28	popul	21.86
nativ	25.91	sampl	28.04	nest	44.80	risk	20.91
site	20.79	similar	27.61	forest	39.46	survei	20.70
experi	19.11	among	26.04	increas	33.04	cover	19.85
test	17.71	individu	25.28	popul	32.35	amphibian	18.94
greater	17.14	abund	22.86	patch	30.96	trend	18.37
cover	16.44	between	21.34	result	30.63	demograph	18.22
impact	15.87	Rare	20.87	size	27.30	mortal	16.78
hypothesi	14.97	signific	20.08	success	25.69	median	15.91
competit	14.94	measur	19.80	area	24.75	associ	15.44
restor	14.85	Rang	18.76	review	22.27	result	15.12
variabl	14.64	common	18.23	corridor	21.97	indic	14.65
growth	14.55	differ	17.89	remov	19.78	reduc	14.04
treatment	13.35	conserv	17.28	sensit	19.22	loss	13.79
exclus	13.12	within	16.50	whether	18.15	wildlif	13.61

Conservation Biology topics 5-8

Topic 5	1401.48	Topic 6	1167.31	Topic 7	1756.49	Topic 8	1691.65
biodivers	58.76	soil	59.05	forest	113.11	disturb	84.92
marin	40.91	chang	54.76	rich	89.26	divers	59.13
protect	39.29	carbon	48.47	biodivers	58.58	human	29.56
reserv	32.83	soc	43.00	abund	55.37	correl	27.57
monitor	30.04	stock	33.96	bird	55.25	respons	24.96
fish	28.63	forest	33.24	manag	43.95	commun	24.49
conserv	26.64	land	26.74	plantat	41.17	habitat	23.52
area	25.07	emiss	22.99	taxonom	34.55	size	22.33
plan	23.50	tropic	21.46	mammal	31.71	impact	22.10
design	18.72	land-us	20.69	land	27.88	bodi	20.28
larg	18.10	organ	16.55	between	27.23	ecolog	20.07
recoveri	17.76	after	15.92	conserv	23.80	natur	19.79
develop	16.75	grassland	15.86	differ	23.61	pattern	18.82
mediterranean	15.89	agricultur	14.24	higher	23.20	show	17.78
result	15.21	co(2	13.96	complex	21.83	e.g	17.74
data	15.01	deforest	12.70	group	21.83	select	17.59
assess	13.43	asia	12.09	invertebr	20.90	examin	16.74
evalu	12.53	plantat	11.83	habitat	18.82	composit	16.18
zone	12.16	becaus	10.83	tree	16.96	gradient	15.93
consid	11.85	year	10.76	loss	16.12	environment	15.91

Conservation Biology topics 9-12

Topic 9	1843.55	Topic 10	1359.85	Topic 11	1506.96	Topic 12	1267.75
chang	108.57	site	75.47	invas	71.67	soil	49.96
climat	69.49	tree	55.95	popul	70.76	temperatur	41.11
respons	57.86	harvest	26.41	genet	50.97	ecosystem	35.43
region	28.57	between	24.81	inbreed	37.00	warm	34.02
differ	26.62	distribut	20.76	variat	33.51	ratio	22.02
global	24.73	condit	20.51	divers	31.93	global	21.97
ecosystem	22.06	data	20.06	introduc	27.89	experi	21.94
lake	21.65	refer	19.73	trait	26.42	increas	20.10
phenolog	20.99	commun	19.41	depress	25.98	chang	19.62
show	20.09	test	19.24	success	25.10	differ	19.25
pattern	19.26	level	18.22	fit	24.71	respons	18.44
across	18.78	hunt	17.93	island	23.96	precipit	17.97
import	18.02	area	17.61	extinct	23.22	experiment	16.13
impact	17.93	differ	16.09	introduct	22.93	climat	15.19
time	16.89	three	15.05	impact	20.52	consist	15.11
observ	16.69	predict	14.95	plant	18.01	between	13.99
commun	16.38	posit	14.52	gener	16.88	mean	13.99
caus	15.63	where	14.25	size	16.71	result	13.79
result	15.55	africa	12.94	conserv	16.63	cycl	12.85
temperatur	15.52	respons	12.59	affect	15.22	limit	12.35

Conservation Biology topics 13-15

Topic 13	2193.71	Topic 14	1814.47	Topic 15	1698.93
conserv	137.20	estim	73.52	elev	116.11
review	101.99	model	66.62	co2	81.00
manag	82.61	assess	52.05	concentr	65.21
evid	75.68	data	49.97	increas	63.76
systemat	73.86	risk	44.98	plant	49.08
intervent	30.99	method	32.76	leaf	33.74
evidence-bas	28.98	uncertainti	26.74	biomass	29.70
literatur	28.87	water	22.56	respons	28.87
practic	26.65	provid	20.68	growth	27.07
environment	26.40	statist	19.55	decreas	25.40
scientif	26.35	approach	19.16	yield	23.05
base	21.06	predict	18.34	tree	22.39
outcom	20.27	level	18.24	carbon	21.18
data	19.24	base	17.12	reduc	18.32
assess	18.60	current	16.91	ozon	18.00
evalu	17.98	control	16.54	chang	17.67
inform	17.73	result	15.74	when	17.06
polici	17.24	publish	14.63	type	16.44
avail	17.03	when	14.15	signific	16.43
decis	16.50	develop	13.73	aboveground	15.75

Table J3. Social Work topics

Social Work topics 1-4

Topic 1	2673.87	Topic 2	1816.74	Topic 3	3013.71	Topic 4	2090.28
effect	211.25	support	71.69	intervent	214.73	meta-analysi	55.53
size	149.75	educ	63.99	treatment	179.34	design	44.50
meta-analysi	119.97	inform	34.41	effect	161.51	result	40.05
outcom	66.52	survei	30.72	outcom	86.42	method	30.80
result	59.73	polici	30.27	therapi	67.03	publish	30.53
differ	54.32	relationship	29.52	group	62.13	statist	27.07
behavior	52.41	intervent	24.95	control	52.30	data	24.50
measur	52.38	patient	23.29	problem	43.51	field	23.53
meta-analyt	39.05	behaviour	19.11	adolesc	43.27	valid	23.36
between	38.20	receiv	18.94	evalu	37.63	effect	23.03
problem	34.69	find	17.87	client	37.47	approach	21.94
examin	31.31	initi	17.61	empir	31.01	meta-analys	20.63
indic	28.14	role	17.44	suicid	30.07	analysi	20.53
subject	28.10	practic	17.21	clinic	29.48	recent	19.83
signific	28.07	evid	16.62	who	29.01	problem	19.53
sampl	27.73	report	16.61	depress	28.92	synthesi	19.40
show	27.53	student	15.65	efficaci	28.66	decis	18.73
moder	27.47	potenti	15.49	meta-analysi	28.15	report	18.50
conduct	27.20	increas	15.37	trial	27.66	journal	17.90
across	23.54	mother	14.97	behavior	26.62	includ	17.74

Social Work topics 5-8

Topic 5	1580.69	Topic 6	2129.85	Topic 7	1869.98	Topic 8	2170.16
violenc	62.96	systemat	111.67	health	196.22	program	234.83
women	39.96	search	81.65	mental	77.76	prevent	169.99
partner	30.95	databas	74.78	care	64.77	effect	66.13
variabl	30.20	care	57.10	peopl	54.61	intervent	52.86
ipv	28.00	articl	50.95	cultur	44.84	evalu	49.65
systemat	27.58	qualiti	45.66	youth	39.14	primari	38.79
drug	25.67	evid	45.41	servic	36.97	children	36.39
among	23.33	identifi	37.74	commun	34.07	meta-analysi	34.14
between	22.65	relev	28.61	intervent	30.51	particip	30.34
screen	21.00	literatur	25.91	american	29.00	adolesc	29.34
literatur	20.32	paper	22.68	popul	27.96	well	25.66
criteria	20.21	practic	21.85	ethnic	25.94	youth	23.24
depend	19.42	apprais	21.44	minor	23.96	develop	22.36
associ	19.22	provid	21.39	systemat	22.97	outcom	22.00
measur	18.14	requir	19.47	literatur	22.29	provid	20.33
particip	18.11	assess	19.06	among	20.40	specif	18.91
relationship	17.05	critic	18.35	ill	19.56	posit	18.82
intim	16.99	need	17.93	need	17.52	approach	18.73
identifi	15.97	healthcar	16.08	provid	17.13	enhanc	17.99
list	14.91	servic	15.58	hous	16.86	earli	16.31

Social Work topics 9-12

Topic 9	2993.04	Topic 10	2337.25	Topic 11	1505.62	Topic 12	1715.02
practic	287.56	Service	79.25	abus	190.56	child	91.76
evidence-bas	133.89	inform	58.38	sexual	176.98	factor	68.19
articl	87.13	what	56.76	child	95.53	famili	60.98
systemat	73.17	client	52.45	offend	43.98	maltreat	49.21
evid	64.01	process	44.02	sex	32.86	system	38.53
ebp	59.31	view	34.53	preval	32.21	risk	35.38
empir	50.99	need	33.61	children	27.32	model	34.70
practition	49.25	profession	33.00	adult	26.83	welfar	34.56
develop	36.69	how	28.10	physic	24.05	protect	30.72
support	34.83	question	27.80	sampl	22.30	chang	28.74
clinic	34.52	effect	26.79	rate	22.08	econom	25.90
base	33.21	ethic	25.98	includ	20.81	intervent	25.29
author	32.98	worker	24.71	estim	20.34	identifi	25.16
challeng	31.64	practic	22.93	risk	19.85	polici	24.44
set	28.85	agenc	22.71	csa	18.98	develop	21.08
knowledg	28.52	thei	22.67	assess	18.93	resili	20.98
implement	28.09	valu	21.50	against	14.07	strategi	20.02
therapi	27.79	describ	19.69	factor	13.97	neglect	19.98
guidelin	27.17	origin	19.26	childhood	11.88	servic	19.49
discuss	26.69	decis	18.94	who	11.86	data	16.65

Social Work topic 13

Topic 13	1581.78
children	148.36
parent	133.88
family	105.88
care	57.43
foster	48.96
train	37.77
placement	27.97
child	26.57
outcome	20.65
young	19.19
residenti	18.99
children'	18.62
neglect	15.34
compar	15.32
behavior	14.97
development	14.53
evid	13.52
youth	13.36
interact	13.29
involve	13.14

Table J4. Women's Studies Topics

Women's Studies topics 1-4

Topic 1	410.51	Topic 2	588.14	Topic 3	362.44	Topic 4	511.38
physic	25.69	diseas	35.62	work	35.72	mammographi	33.98
measure	24.44	review	31.61	role	21.92	new	16.77
masculine	18.96	trial	21.36	leadership	20.96	public	15.18
postpartum	14.70	systemat	20.14	model	13.65	year	15.15
children	11.54	cardiovascular	19.96	behavior	12.96	inform	14.63
depress	10.77	treatment	18.76	femal	12.94	result	14.14
support	10.45	clinic	18.14	leader	11.72	controversi	10.95
review	10.16	gender	15.16	qualit	9.94	who	10.67
mother	9.92	men	13.76	synthesi	9.76	screen	10.66
preval	9.38	analysi	13.08	social	9.10	state	10.29
model	8.82	report	12.64	influenc	8.48	thei	9.53
activ	7.99	cvd	12.33	show	8.15	research	8.58
three	7.98	sex	12.30	report	7.88	publish	8.21
orient	7.86	inclus	12.01	manag	7.83	breast	8.01
experi	7.31	patient	11.95	organ	7.63	like	7.15
young	6.96	includ	11.84	organiz	6.98	assess	7.06
popul	6.63	examin	11.35	educ	6.53	rate	6.76
includ	6.38	cochran	10.56	gender	6.19	import	6.43
target	5.97	evid	10.44	relat	5.53	level	6.38
continu	5.45	differ	8.98	find	5.43	includ	6.30

Women's Studies topics 5-8

Topic 5	745.12	Topic 6	589.10	Topic 7	616.64	Topic 8	472.07
health	54.36	effect	28.64	sexual	43.412	function	19.08
review	48.04	trial	24.53	attitud	38.984	sampl	16.88
articl	23.98	control	23.59	effect	28.393	activ	15.52
systemat	23.48	review	18.43	toward	23.295	benefit	15.09
guidelin	22.87	exercis	16.81	size	23.167	improv	14.18
address	17.79	increas	16.60	meta-analysi	19.565	observ	11.53
literatur	16.62	random	14.02	behavior	17.140	like	11.21
research	15.00	includ	11.22	sampl	15.604	perform	10.25
condit	14.93	blood	10.70	colleg	13.946	examin	9.90
develop	13.31	search	10.58	conduct	13.558	appear	9.49
evid	12.56	signific	10.58	associ	12.691	moder	9.26
search	12.42	pressur	9.98	moder	12.452	receiv	8.94
number	11.55	refer	9.86	particip	11.564	statu	8.91
identifi	10.61	result	9.44	between	11.401	outcom	8.86
issu	10.40	group	8.48	men	11.298	whether	8.35
publish	10.07	meta-analysi	8.24	gender	11.156	level	8.22
standard	9.62	decreas	7.27	signific	10.290	physic	7.86
problem	8.91	statist	6.78	relationship	10.228	year	7.82
affect	8.24	reduct	6.70	examin	9.831	dure	7.25
factor	8.16	interv	6.57	relat	7.404	analyz	7.09

Women's Studies topics 9-12

Topic 9	539.83	Topic 10	651.65	Topic 11	784.19	Topic 12	550.74
research	35.48	risk	83.47	gender	125.31	pregnanc	31.97
literatur	27.24	among	33.02	differ	66.92	birth	27.97
review	26.30	associ	28.93	stereotyp	27.94	dure	21.67
older	16.56	between	21.65	result	19.97	weight	16.00
violenc	12.87	increas	17.50	social	18.91	associ	14.85
separ	11.80	meta-analysi	16.33	small	18.21	summari	13.56
although	11.30	outcom	14.61	effect	18.10	review	12.88
context	10.65	cohort	13.96	research	16.12	adjust	12.86
includ	10.58	heart	13.90	theori	13.67	systemat	12.13
impact	9.82	mortal	13.10	men	12.77	violenc	12.11
assault	9.60	diseas	11.34	when	12.65	less	11.06
sexual	9.55	compar	11.00	size	10.13	factor	9.41
how	9.23	reduct	10.21	compar	10.04	outcom	9.29
empir	8.81	signific	10.18	influenc	10.04	alcohol	8.91
issu	8.74	interv	9.18	evalu	9.59	low	8.90
articl	8.66	exposur	8.72	suggest	9.39	between	8.74
futur	8.51	howev	8.70	measur	9.38	assess	8.27
need	7.22	higher	8.55	meta-analys	8.82	exposur	8.27
feminist	7.20	men	8.45	behavior	8.63	includ	8.05
girl	6.76	estim	8.45	group	8.39	increas	7.89

Women's Studies topics 13 - 16

Topic 13	346.70	Topic 14	365.55	Topic 15	566.14	Topic 16	434.23
qualiti	16.94	intervent	33.44	differ	76.44	test	23.81
screen	14.31	primari	16.75	sex	39.21	hypothesi	14.23
test	12.88	care	14.50	abil	20.48	measur	13.40
sensit	11.05	recommend	12.68	spatial	19.95	feminist	12.60
characterist	10.62	outcom	11.90	mathemat	17.99	languag	12.42
type	10.16	health	11.27	male	16.54	sex	12.37
refer	9.20	prevent	11.07	femal	15.16	meta-analysi	12.23
data	8.95	behavior	10.14	gender	13.06	femal	12.03
detect	8.80	program	10.11	score	11.94	effect	10.07
databas	8.03	mai	10.03	chang	11.85	sensit	8.59
specif	7.22	factor	9.93	time	11.76	male	7.91
standard	7.22	effect	9.90	achiev	9.52	discuss	6.54
evalu	7.20	healthi	8.87	psycholog	8.55	particip	6.19
report	7.02	deliveri	7.25	test	8.26	impact	5.97
life	6.91	evid	7.24	gener	7.83	explain	5.85
perform	6.91	promot	6.93	mean	7.79	experi	5.68
pool	6.80	systemat	6.72	varianc	7.56	differ	5.27
cancer	6.69	system	5.80	consist	7.52	Leader	5.22
gestat	6.65	provid	5.35	found	7.43	Subject	5.21
approach	5.78	aim	4.78	children	7.41	Abil	5.16

Women's Studies topic 17

Topic 17	525.59
cancer	72.01
breast	43.94
effect	22.13
hormone	18.98
therapy	16.40
protect	13.47
between	9.73
who	8.77
risk	8.52
menopaus	7.97
data	7.64
postmenopaus	6.95
onli	6.94
publish	6.91
potenti	6.55
associ	6.42
control	6.22
overall	6.15
meta-analys	6.08
type	6.03

Table J5. Information and Library Science Topics

Information and Library Science Topics 1-4

Theories & Models		Text Classificat		Search Eval & Filters		Info Systems	
	1989.00		1258.86		1520.95		2010.04
research	158.22	perform	59.38	filter	78.95	model	98.56
method	62.24	system	48.72	sensit	67.93	system	92.06
approach	56.86	topic	30.56	medlin	65.56	support	59.57
theori	51.01	time	29.81	strategi	64.37	Effect	57.51
model	50.30	measur	25.75	precis	53.88	technolog	48.89
knowledg	35.27	data	25.30	term	50.54	success	44.15
analysi	30.29	classif	24.72	identifi	44.91	implement	43.42
techniqu	24.86	articl	22.89	trial	39.22	accept	42.67
develop	23.31	work	21.97	retriev	36.77	meta-analysi	39.74
behaviour	22.03	classifi	19.23	record	31.59	user	38.83
present	21.69	autom	18.97	rct	30.92	task	35.11
concept	21.61	evalu	17.91	specif	30.12	moder	33.55
meta-synthesi	20.99	factor	15.65	control	29.17	factor	32.71
analys	20.55	train	15.12	test	25.30	manag	30.45
common	20.05	approach	15.01	random	22.43	result	29.20
theme	18.57	prior	14.76	effect	20.34	between	27.20
stage	17.86	improv	13.65	set	19.58	empir	27.00
perspect	15.92	effici	13.37	combin	19.01	find	26.84
mai	15.74	text	13.06	pubm	18.47	group	24.25
propos	15.50	valid	12.08	embas	18.24	tam	23.99

Information and Library Science Topics 5-8

Librar* & Services		Med Lit		Patients, Participants		DBs, search, retrieval	
	1725.26		1588.52		1228.17		1921.15
health	152.58	medic	75.28	patient	49.89	databas	122.22
servic	75.62	literatur	62.73	particip	39.63	citat	57.39
librarian	58.05	evalu	49.42	user	36.68	refer	45.98
librari	45.66	design	41.54	onlin	25.37	effect	44.59
librarianship	32.85	sourc	38.82	effect	24.56	identifi	42.57
provid	32.55	research	37.14	internet	23.93	retriev	40.84
scienc	30.50	tool	31.55	need	23.86	includ	38.95
literatur	27.32	qualiti	26.21	develop	22.95	sourc	36.58
skill	26.62	includ	22.31	thei	17.82	method	36.44
evid	25.21	author	21.24	outcom	15.82	cochran	27.71
literaci	23.92	checklist	20.98	gender	15.72	record	27.21
develop	22.15	develop	20.36	research	15.51	relev	26.48
need	20.69	abstract	20.32	find	14.45	literatur	25.79
research	20.07	select	20.01	cancer	14.40	strategi	23.58
evidence-bas	19.39	help	18.40	treatment	14.17	evalu	22.00
profession	19.17	structur	17.80	symptom	13.95	abstract	21.10
evalu	16.03	method	17.44	differ	13.17	electron	21.02
e-learn	15.98	purpos	16.65	involv	13.07	evid	20.02
describ	15.94	informat	16.20	mean	12.46	index	19.81
student	15.68	intervent	15.26	educ	12.45	differ	18.83

Information and Library Science Topics 9-12

Meta-analysis, stats, measures	1612.29	Research, Issues	1776.66	Meta-research	2301.59	Critiquing syntheses	1774.85
meta-analysi	84.10	research	92.35	research	144.170	case	46.02
statist	51.13	issu	45.50	librari	65.93	paper	36.51
result	42.11	process	34.31	scienc	65.85	strategi	32.63
index	41.12	develop	32.14	literatur	62.20	includ	31.46
report	31.47	paper	27.13	journal	46.32	onli	29.23
articl	29.88	impact	22.67	articl	34.29	report	27.83
data	29.75	reflect	22.61	collabor	26.15	articl	25.44
journal	25.48	potenti	21.58	publish	26.11	like	25.27
analysi	24.74	larg	21.27	public	25.91	result	25.11
differ	24.70	number	20.77	digit	24.63	need	23.46
valid	23.59	import	19.61	analysi	24.29	differ	21.91
find	22.16	conduct	19.36	work	24.23	document	20.79
sampl	22.07	tool	19.34	practic	23.08	author	20.47
size	19.09	address	18.93	field	21.76	year	20.02
variabl	18.86	applic	18.86	relat	21.17	first	19.80
research	18.44	decis	18.63	educ	21.06	literatur	19.62
publish	18.11	level	18.07	synthesi	20.95	book	18.96
power	17.11	practic	18.06	report	20.45	refer	18.00
public	16.70	role	17.68	find	19.91	whether	17.87
correl	15.02	expert	17.55	disciplin	19.04	provid	17.29

Information and Library Science Topics 13 - 15

Clinics & Patient Care	2323.48	EBM / EBP	1833.11	Diffusion (Health Comm)	1331.07
patient	91.23	evid	125.11	behavior	55.84
clinic	74.67	question	103.59	health	42.17
care	72.43	clinic	103.20	campaign	35.00
effect	53.50	care	64.45	effect	34.97
system	53.09	medicin	60.50	commun	28.44
impact	50.62	answer	52.92	technolog	24.90
trial	43.73	practic	51.34	adopt	24.21
outcom	42.81	evidence-bas	50.37	articl	18.95
improv	41.77	articl	37.72	diseas	18.59
decis	35.36	primari	25.54	examin	17.17
evid	32.93	physician	24.83	risk	16.87
prevent	31.33	retriev	24.41	public	16.76
health	30.51	resourc	22.31	chang	14.96
control	28.96	level	19.87	diffus	14.84
evalu	26.52	guidelin	19.05	prevent	14.25
report	26.39	gener	18.16	messag	13.95
remind	25.99	base	17.99	impact	13.95
medic	24.83	manag	17.51	ill	13.90
clinician	23.66	type	16.58	gain	12.95
error	22.88	author	16.07	factor	12.51

Appendix K. Alternative Stage III Data Collection Strategy

S/SCI review classifications were determined to be too inclusive for the purposes of this analysis. Therefore, *Scopus* document type categorizations were used to identify reviews (Table K1 and Table K2). *Scopus* identifies publications as 'reviews' based on publisher records (personal correspondence with *Scopus* representatives). In order to collect records matching other criteria used to select records for this study, first *WOS* was consulted to identify the outermost perimeter of records to be considered. A subset of records identified as review publications were identified via *Scopus*, and citation reports downloaded from *Web of Science* through the following procedure: *S/SCI* bibliographic records associated with items published 2006 – 2011 and labeled document type (DT) 'Review' were downloaded for each given *Web of Science* category (WC) corresponding to one of the selected subject fields. The remaining *S/SCI* review records were sorted by DOI. Where available, DOI's were converted to a search string, and *Scopus* was searched using this search string. *Scopus* records were downloaded, and items indicated as a 'Review' in *Scopus* were identified. *Scopus* records were matched to *S/SCI* identifiers on the review list and on the research synthesis list based on DOI. Records identified as reviews in *Scopus* that were not included on the research synthesis list were allocated to the 'review' comparison group. For each set, research synthesis and review, *Web of Science* was then searched, citation reports generated, and citation data for years 2005 to present downloaded.

Data was arranged to identify the number of citations per year, each year beginning with the year of publication. Any citations attributed before year of publication were added to first year publication counts. Descriptive statistics and Wilcoxon sum rank tests were run in R using the base package and 'psych'. Subsequently, van Elteren tests were performed using SAS software system 9.3 for Windows to detect differences in times cited and number of collaborating authors, accounting for differences in publication date.

Table K1. Record processing yields (Reviews, 2006-2011)

Field	EB	BC	SW	WS	ILS
WOS reviews	2251	824	264	195	578
DOIs available from *WOS*, searched in *Scopus*	2145	734	231	156	425
Records located in *Scopus*	2114	704	227	136	371
Reviews in *Scopus* matched to RS	7	31	26	5	11
RS not matched to reviews in *Scopus*	93	91	76	43	79
Reviews in *Scopus* allocated to review group	830	348	84	53	90
Total *Scopus* reviews	837	379	110	58	101

ILS Missing: *ARIST* 2008 (No DOIs in *WOS*)
Across all fields, earlier Springer items published not labeled as review – document type not labeled at all in at least some cases

Table K2. Comparison group publication counts

Field	EB	BC	SW	WS	ILS
RS not matched to reviews in *Scopus*	93	91	76	43	79
Total RS	100	122	102	48	90
Total Reviews	830	348	84	53	90

Data was first described descriptively. Per group (research syntheses and reviews), median and interquartile values for authors and times cited at two and five years, publication year distributions were identified.

Data from all years were used in tests for differences in the number of collaborating authors per publication.

Tests for differences in citedness were run on all publications using data for publication year plus two additional years (times cited at 2), and publications from 2006 to 2008 using publication year plus five additional years (times cited at 5).

Evolutionary Biology

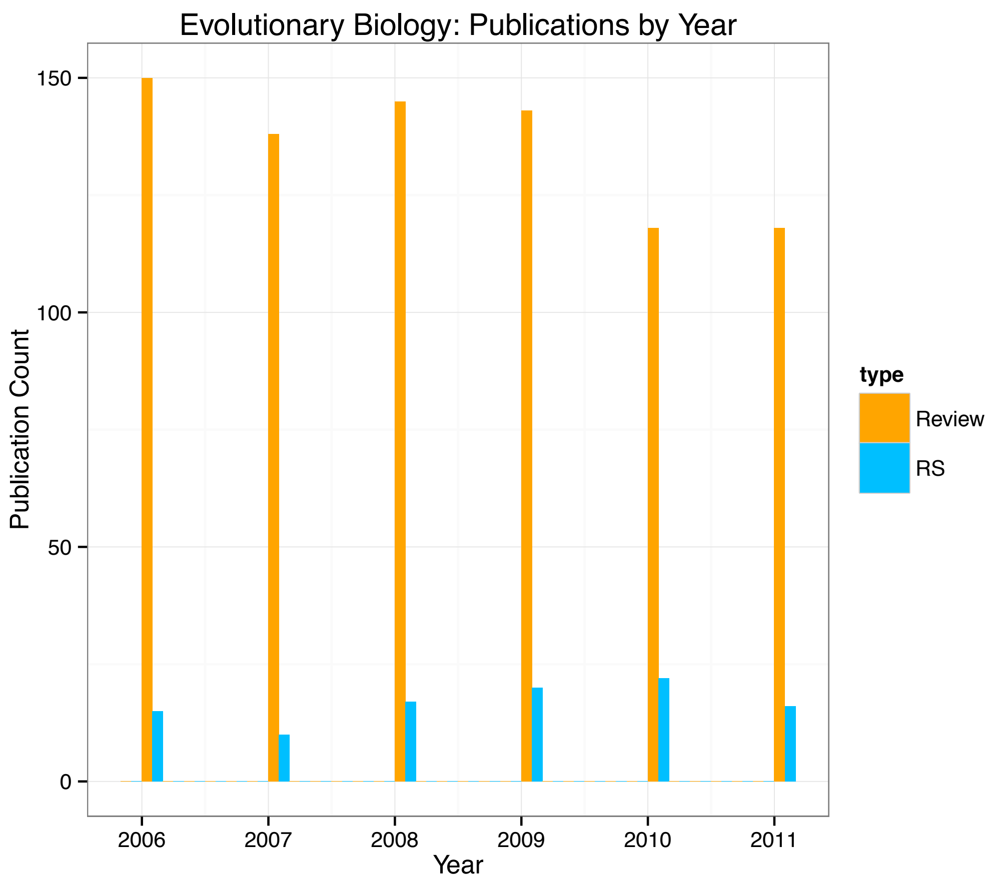


Figure K1. Scopus approach: Evolutionary biology publications by year

Table K3. Evolutionary Biology reviews and syntheses by year

Year	2006	2007	2008	2009	2010	2011	Total
Research syntheses	15	10	17	20	22	16	100
Reviews	150	138	145	143	118	118	812
Totals	165	148	162	163	140	134	912

Authors
EB RS MEDIAN (IQR): 3 (2:4)
EB Review Median (IQR): 2 (2:3)

TC at 2
EB RS MEDIAN (IQR): 11 (6:22.25)
EB Review MEDIAN (IQR): 18 (8:30.25)

TC at 5
EB RS MEDIAN (IQR): 33.5 (19.25:57.75)
EB Review Median (IQR): 52 (24:93)

Conservation Biology

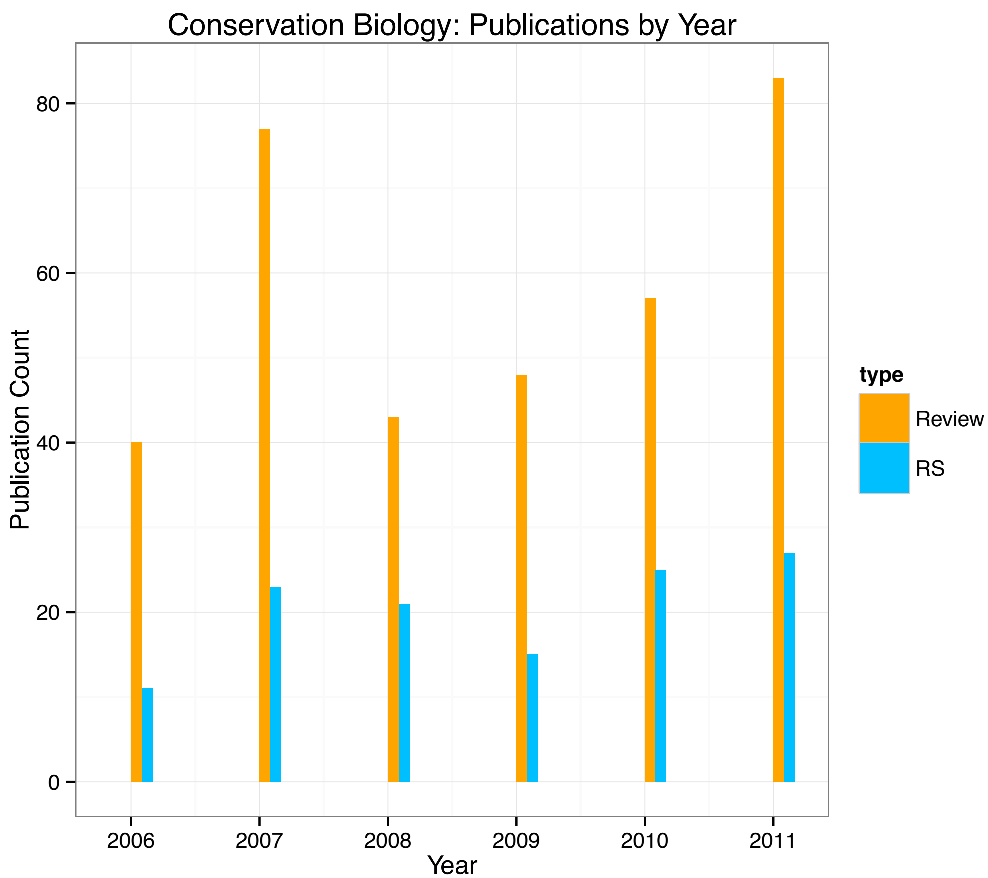


Figure K2. Scopus approach: Conservation Biology publications by year

Table K4. Conservation biology reviews and syntheses by year

Year	2006	2007	2008	2009	2010	2011	Total
Research syntheses	11	23	21	15	25	27	122
Reviews	40	77	43	48	57	83	348
Totals	51	100	64	63	82	110	470

Authors
CB RS MEDIAN (IQR): 3 (2:5)
CB Review Median (IQR): 3 (2:5)
TC at 2
CB RS MEDIAN (IQR): 11 (5:21.75)
CB Review MEDIAN (IQR): 9 (4:19)

TC at 5
CB RS MEDIAN (IQR): 42 (24.5:79. 5)
CB Review Median (IQR): 26 (12:48.25)

Social Work

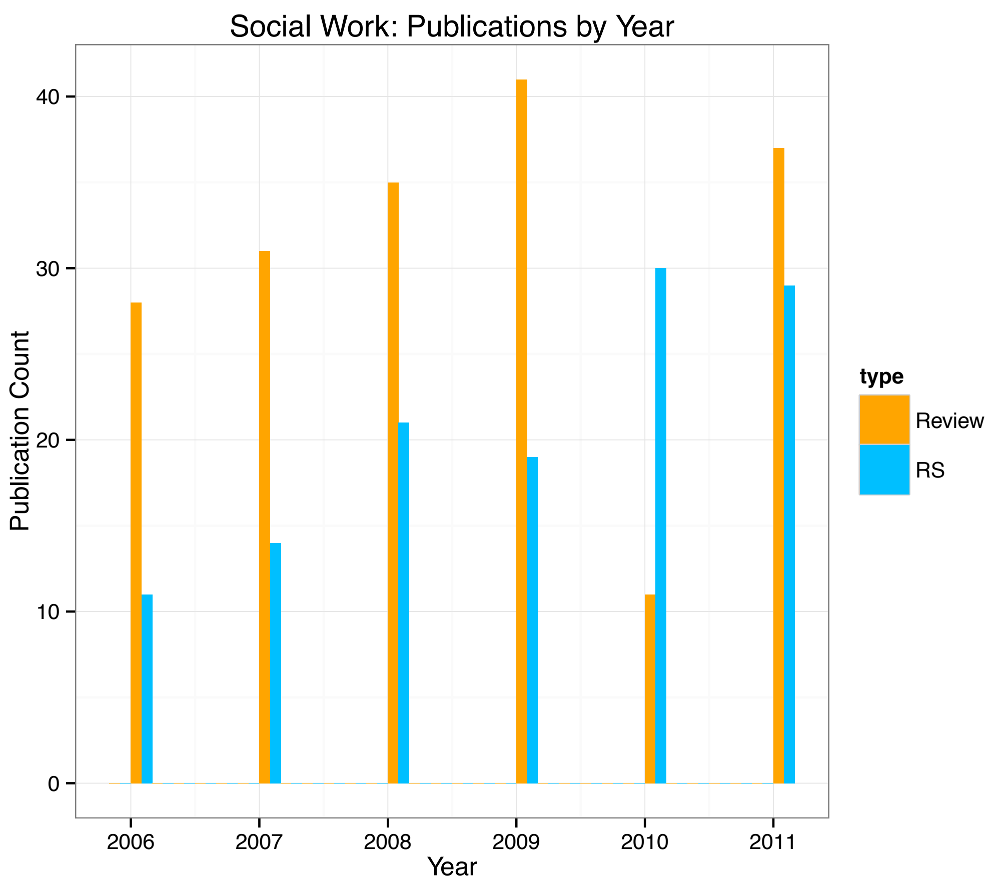


Figure K1. Scopus approach: Social Work publications by year

Table K5. Social work reviews and syntheses by year

Year	2006	2007	2008	2009	2010	2011	Total
Research syntheses	11	14	21	19	30	29	124
Reviews	28	31	35	41	11	37	183
Totals	39	45	56	60	41	66	307

Authors
SW RS MEDIAN (IQR): 3 (2:4)
SW Review Median (IQR): 2 (1:3)

TC at 2
SW RS MEDIAN (IQR): 4 (1:7)
SW Review MEDIAN (IQR): 2 (1:5.5)

TC at 5
SW RS MEDIAN (IQR): 13 (5:25.75)
SW Review Median (IQR): 8 (4:21. 5)

Women's studies

Figure K1. Scopus approach: Evolutionary biology publications by year

Table K6. Women's studies reviews and syntheses by year

Year	2006	2007	2008	2009	2010	2011	Total
Research syntheses	5	3	5	10	11	14	48
Reviews	14	8	9	4	8	10	53
Totals	19	11	14	14	19	24	101

Authors
WS RS MEDIAN (IQR): 3 (2:4)
WS Review Median (IQR): 1 (1:2)

TC at 2
WS RS MEDIAN (IQR): 3.5 (1:5.25)
WS Review MEDIAN (IQR): 3 (1:7)

TC at 5
WS RS MEDIAN (IQR): 13 (10:16)
WS Review Median (IQR): 10 (4:20)

Information and library science

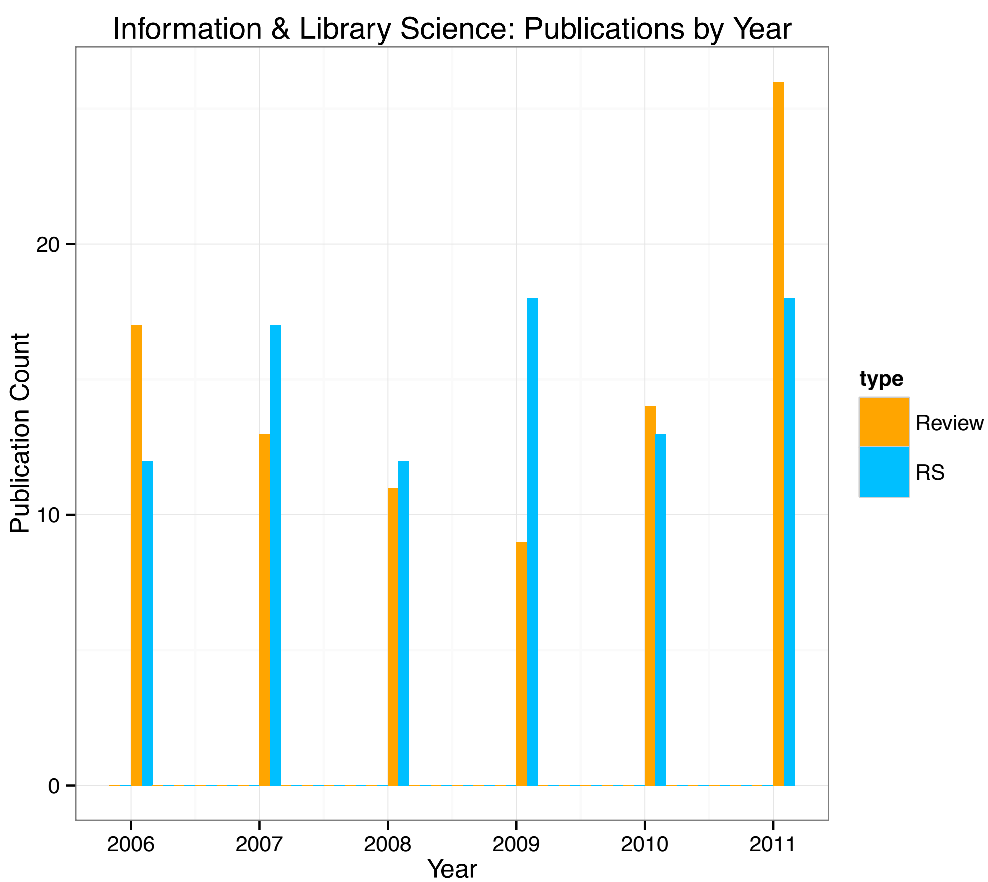


Figure K5. Scopus approach: Information and Library Science publications by year

Table K7. Information and Library Science reviews and syntheses by year

Year	2006	2007	2008	2009	2010	2011	Total
Research syntheses	12	17	12	18	13	18	90
Reviews	17	13	11	9	14	26	90
Total	29	30	23	27	27	44	180

Authors
ILS RS MEDIAN (IQR): 3 (2:4)
ILS Review Median (IQR): 2 (1:3)

TC at 2
ILS RS MEDIAN (IQR): 6 (2:12)
ILS Review MEDIAN (IQR): 2.5 (1:7.75)

TC at 5
ILS RS MEDIAN (IQR): 21 (9:52)
ILS Review Median (IQR): 9 (6:27)

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