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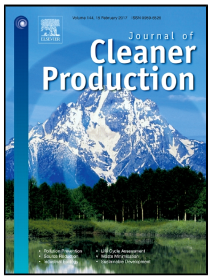

Systems Thinking: A Review of Sustainability Management Research

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Highlights:

- Research on systems thinking and sustainability management is synthesized.
- Number of articles published per year is found to be increasing.
- Core theoretical concepts and research themes are discussed.
- Conceptual basis for future research agenda using systems thinking is proposed.

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Systems Thinking: A Review of Sustainability Management Research

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Abstract
Scholars from a wide range of disciplines and perspectives have sought to unravel the high complexities of sustainability. A mature understanding of sustainability management requires studies to adopt a multidisciplinary systemic lens capable of appreciating the interconnectivity of economic, political, social and ecological issues across temporal and spatial dimensions. Yet the field of systems thinking in the context of sustainability management research is disparate and can benefit from a comprehensive review in order to assimilate the current fragmented body of research and to identify promising research directions. To address this gap, we conducted a review of the systems thinking and sustainability management literature from 1990 up to 2015 including 96 articles. In this review, we first present descriptives that show an emerging body of work rapidly growing since 2011. We found that 54 percent of articles were published in two transdisciplinary journals, demonstrating that a systemic approach is not yet prevalent in mainstream management journals. Second, we identify and describe the core theoretical concepts of systems thinking found in the literature including interconnections, feedbacks, adaptive capacity, emergence and self-organization. Third, findings show a number of research themes, including behavioral change, leadership, innovation, industrial ecology, social-ecological systems, transitions management, paradigm shifts and sustainability education. Finally we offer a cross-scale integrated framework of our findings, and conclude by identifying a number of promising research opportunities.

Keywords: systems thinking; sustainability management; literature review; multi-level

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1. Introduction

In order to effectively address pressing societal issues such as climate change, social inequality, unemployment, and ecological degradation, scholars and managers can benefit from an enhanced understanding of the dynamic interactions within and across interconnected systems (Whiteman et al., 2013). Numerous management scholars have long recognized that the complexity of highly interdependent systems necessitates a systems approach, viewing social systems nested within natural systems and recognizing the dependency of business on nature (Gladwin et al., 1995; Marcus et al., 2010; Roome, 2011; Starik and Rands, 1995; Whiteman et al., 2004). Gray (2010, p. 48) posits, "sustainability is a systems-based concept and, environmentally at least, only begins to make any sense at the level of ecosystems and is probably difficult to really conceptualize at anything below planetary and species levels." Despite these early and regular acknowledgments of the systemic character of sustainability, to date, a literature review of systems thinking as a theoretical lens to better understand sustainability management has not been conducted.

Reviews on sustainability research, of course, exist. However, these tend to focus on traditional management theories, such as the resource-based view, competitive strategy or institutional theory (Bansal and Gao, 2006; Berchicci and King, 2007; Etzion, 2007; Hoffman and Georg, 2012; Russo and Minto, 2012). While valuable, the theoretical perspectives covered in these reviews do not explicitly address the interactions of firms with the social-ecological systems in which they are embedded. In contrast to insights from other disciplines, the current body of literature on corporate sustainability is "linearly focused on firm and industry effects" (Whiteman et al., 2013, p. 310) and lacks radical new insights (Bansal and Gao, 2006). Yet, an understanding of corporate actions in isolation from social-ecological systems is unlikely to address interconnected sustainability challenges (Marcus et al., 2010; Starik and Kanashiro, 2013; Walker et al., 2009; Whiteman et al., 2013). Systems thinking provides an antidote to such silos, as it offers a more holistic lens to examine the role of corporations within social-ecological systems.

Strains of systems thinking prevail in diverse scientific fields. Our review integrates systems perspectives from organization theory on sustainability with insights from systems thinking within ecology. Systems thinking is a way to understand the complexity of economic, social and ecological systems (Holling, 2001). A complex system is a set of interacting variables that behave according to governing mechanisms or forces (Maguire et al., 2006, 2011; Walker and Salt, 2006). Through the application of systems thinking, sustainability management researchers may be able to "identify the points at which a system is capable of accepting positive change and the points where it is vulnerable" (Holling, 2001, p. 392).

Interdependence between organizations and the natural environment is central to a systemic sustainability management perspective given that organizations depend on the natural environment for inputs and organizational actions directly impact the natural environment through feedback loops (Starik and Kanashiro, 2013; Starik and Rands, 1995). This embedded view of organizations recognizes systemic limits to growth within the boundaries of the planet, finite resources and the dependency of organizations on society, economy and nature (Gladwin et al., 1995; Marcus et al., 2010; Meadows et al., 1972; Rockström et al., 2009; Whiteman et al., 2013; Winn and Pogutz, 2013). This leads us to ask the following question, "What do we know about sustainability management research which leverages a systems thinking theoretical lens?"

In this article, we present a systematic literature review addressing sustainability management from a systems thinking perspective to make sense of what is already known and provide directions for future research. First, we present the systematic review methodology. Second, we provide a descriptive analysis of the articles found in the review. Third, we give an overview of the core concepts and research themes. Fourth, we present an integrated framework of systems thinking and sustainability management. Finally, we discuss the implications for management research and provide directions for future research.

2. Research methods

To ensure the rigor and quality of our review, the synthesis of the existing research was conducted in a systematic manner with the aim of reducing bias while allowing for flexibility and creativity (Tranfield et al., 2003). We designed our methodological approach based on insights from the stages of a systematic review suggested by Tranfield et al. (2003) and from literature reviews published in peer-reviewed journals (i.e. Aguinis and Glavas, 2012; Crossan and Apaydin, 2010; Fulmer and Gelfand, 2012; Klewitz and Hansen, 2014; Lockett et al., 2006;

Morioka and de Carvalho, 2016). This 8-step process (see Table 1) resulted in an initial sample of 1,711 papers and a final collection of 96 articles.

Insert Table 1 about here

2.1 Search process: Steps 1 to 6

Step 1: First we determined the need for a review on systems thinking as a multi-disciplinary lens to understand the complexities of sustainability management. We conducted an extensive search using Google Scholar and the Web of Science, Social Sciences Citation Index (SSCI). Our search indicated that no previous reviews were published on systems thinking and sustainability management.

Step 2: Next we defined the temporal boundaries for the review. Our search included articles published from 1990 until the start of 2015. As with previous reviews, we selected to start our review in 1990 in accordance with significant events in the field. Etzion (2007) comments that following the Rio de Janeiro Earth Summit in 1992 environmental issues became more salient. Similarly, Hoffman and Georg (2012) traced the history of the field and found that Business and the Natural Environment research emerged around 1990 in parallel with an emerging focus on environmental issues and changing managerial trends aimed at considering the environment as a strategic issue. In 1990, management scholars met to form the Organizations and the Natural

Environment division at the Academy of Management and specialty journals such as *Business Strategy and the Environment* formed shortly afterwards (Hoffman and Georg, 2012).

Step 3: We further defined the search area by developing a list of top management, specialty and practitioner journals. The list of journals was determined by consulting published literature reviews in the field of management (i.e. Aguinis and Glavas, 2012) and prominent literature reviews on sustainability management (i.e. Bansal and Gao, 2006). We then compared this list with prominent journal rankings including the 4th Association of Business Schools journal list and Scientific Journal Rankings indicators. This resulted in 24 management journals, 11 specialty journals and 3 practitioner journals, thus constraining our search to the management literature. The final list of journals included in the review can be found in Table 2.

Insert Table 2 about here

Step 4: We developed two keyword search strings. The first string was developed to capture articles relating to sustainability. We based the first string on a review published by Adams et al. (2015) on the topic of sustainability-oriented innovation and incorporated insights from other sustainability reviews that published their search strings. The following search string was used in the topic field of SSCI: sustainab* OR environmen* OR green OR ecol* OR adapt* OR resilien* OR responsib* OR triple bottom line OR cradle OR soci* OR ethic*.

The second search string was developed to capture articles related to systems thinking. We read published articles relating to sustainability and systems thinking to identify fundamental concepts. Then we developed the keywords for this second string in discussions amongst the authors of this paper. This led to the following search string that was used in the topic field of SSCI: system* theory OR system* thinking OR complex* OR holis*.

A first search using the term 'system*' returned a cumbersome 5,343 articles, largely falling outside the scope of this review. This was refined by adding the terms 'theory' and 'thinking' to 'system*' in order to capture articles making theoretical contributions and keep the boundaries of the review manageable. To be considered for further inclusion in the review, articles needed to contain one term from the first string and one term from the second string in the title or abstract.

Inclusion and exclusion criteria to decide which articles would be accepted in the review were also developed in this step in discussion between the authors of this paper. Articles with a focus on sustainability management and systems thinking were selected for the review. We now give examples of when search terms returned irrelevant articles. An article suggested for inclusion in the review because it contained the term 'responsible' in the abstract, referring to the responsibility of work teams would be removed for further consideration because it lacked a sustainability focus. Articles that included the term 'environment' in the abstract referring to general business environments (instead of environmental sustainability or the natural environment) were also removed. Considering the focus on systems thinking, articles that contained the term 'complex', such as complex problem solving, were removed due to a lack of use of complexity theory.

After removing articles without a clear focus on sustainability management and systems thinking, we noticed many articles that made a methodological contribution as opposed to a theoretical contribution. Given that literature reviews have already been published focusing on methods (i.e. Angelakoglou and Gaidajis, 2015; Chang et al., 2014; Ibanez-Fores et al., 2014) we decided to further refine our inclusion criteria. Articles that made a theoretical contribution to the field were included in the review, while articles that made a practical or methodological contribution were excluded from the review. For example, we removed articles that solely evaluated the environmental impact of a product or conducted a life cycle assessment (practical) or aimed to improve agent based modeling methods (methodological).

Step 5: We conducted our search using the SSCI. To ensure the quality of the articles in the review and to keep the review manageable, we limited our search to peer-reviewed journal articles and excluded non-peer reviewed options including book reviews, conference proceedings, editorial materials and notes. The keyword search strings we developed in Step 4 were run on titles and abstracts in SSCI. This search identified 1,711 potentially relevant articles for the review.

Step 6: We began to develop a database of articles by screening titles and abstracts. To ensure reliability of the review, 3 co-authors were involved in the screening of the articles. The first and second authors reviewed the title and abstract of each article coding either 'accept', 'reject' or 'further review' based on the inclusion criteria. The third author reviewed any articles coded 'further review' or in which the coding of the first and second co-author did not match e.g. articles that were coded as 'accept' by one author and 'further review' or 'reject' by the second.

Articles that were still considered for inclusion underwent full text analysis, conducted by the first and second authors, with the third co-author again reviewing any cases of disagreement. This process reduced the number of articles to be included in the review to 80.

Finally in this step, we consulted academics in the field to recommend any articles that had not been identified in the review. These consultations were held during presentations of the review and through the release of early drafts of this article. This procedure was undertaken to ensure that our keywords did not overlook any pertinent articles. This resulted in an additional 16 articles added to the review.

2.2 Descriptive and thematic analysis: Steps 7 to 8

Step 7: We then conducted a descriptive analysis of the papers covered in our review. The descriptives are found in Section 3.

Step 8: As a final step we conducted a thematic analysis. We abductively coded all articles, alternating between inductive and deductive coding. The general deductive codes included: level of analysis, contribution to what literature, empirical or conceptual, methods used and sources of data. The theoretical deductive codes derived from the literature included: conceptualization of business-society interface (Marcus et al. 2010), anthropocentrism versus ecocentrism (Purser, Park, and Montuori, 1995) the adaptive cycle, social-ecological systems (Gunderson and Holling, 2002) and systems thinking dimensions such as feedback loops, hierarchical systems, delays, flows, intervention, dynamic equilibrium and self-organization (Meadows, 2009). A list of these codes including definitions was developed by the co-authors and made available for reference during the coding.

In addition to these predetermined codes other relevant codes emerged such as industrial symbiosis, innovation, paradigm shifts, decision making and tools to enable a systemic understanding of sustainability. The coding of the articles was completed using Nvivo, a computer software for qualitative data analysis. The authors discussed different approaches for presenting the results of the review and presented the paper at three international conferences to receive feedback. This ultimately resulted in 5 core theoretical concepts and 8 research themes, which are presented in Section 4.

3. Descriptives

From 1990 until 2000, articles published pertaining to systems thinking and sustainability management were limited, averaging less than 1 article published per year (see Figure 1). Since 2000, the number of articles published per year has increased exponentially with 67 of our 96 reviewed articles becoming available from 2010.

Insert Figure 1 about here

Using citation statistics from SSCI, we present a list of the top 20 cited articles in the review (see Table 3). The top cited articles come from a variety of sources including *Academy of Management Review, Journal of Business Ethics, California Management Review, Accounting*

Organizations and Society, Research Policy, Journal of Cleaner Production, Journal of Industrial Ecology, Organization Science, Journal of Management Studies and Organization & Environment. *Journal of Cleaner Production* represents 7 of the top 20 cited articles.

Insert Table 3 about here

The *Journal of Cleaner Production* is highlighted in our review as the leading publication outlet for sustainability management research from a systems perspective (see Figure 1). From the *Journal of Cleaner Production*, 41 articles were identified, and another 11 from a fellow transdisciplinary journal, the *Journal of Industrial Ecology*. Despite the mainstream publication of early conceptual articles calling for a systemic or ecological paradigm (Gladwin et al., 1995; Starik and Rands, 1995), we found few articles in these types of management journals, such as *Journal of Business Ethics* (10), *Organization & Environment* (6), *Research Policy* (5), *Business Strategy and the Environment* (4), *Academy of Management Review* (4), *Organization Science* (2), *Journal of Management Studies* (1) and *Strategic Management Journal* (1). This distribution suggests that while a systems perspective on sustainability management is well accepted in the transdisciplinary journals, which include disciplines well versed in systems thinking such as environmental sciences and engineering, it is yet to be a regular feature in journals solely focused on mainstream management. In addition, we highlight that mainstream 'environmental management' journals such as *Organization & Environment* and *Business Strategy and the Environment* also appear to have few articles published with a systemic lens.

In terms of research themes (see Figure 2), we found most of the published articles addressed social-ecological systems (22), innovation systems (15), industrial ecology (14) and transitions management (12). Research themes with fewer articles include, paradigm shifts (10), education (10), leadership (8) and behavioral change (5).

Insert Figure 2 about here

We found that the majority of the articles, 53 percent, were conceptual, while 47 percent of the articles were empirical. The empirical articles used a variety of methods. Notably, 47 percent of the empirical articles used case study methodology, and 4 articles combined case study research with other approaches such as action research, cross-case comparison, survey research and grounded theory. Other methodologies adopted included statistical analysis, factor analysis, hypothesis testing, backcasting, agent based modeling and material flow analysis.

4. Research results

We begin by defining sustainability from a systems perspective. Sustainability is a normative concept referring to an ideal state of being in which humans are able to flourish within the ecological thresholds of the planet alongside other living entities for perpetuity (Ehrenfeld, 2012). Sustainability is not an end state that can be achieved, but a ‘moving target’ that is continuously changing and improving (Gaziulusoy et al., 2013). This dynamic state exists within thresholds, defined by the *planetary boundaries framework,* or the safe operating space for humanity (Rockström et al., 2009; Steffen et al., 2015). From a systems perspective, sustainability is the ability of systems to persist, adapt, transform or transition in the face of constantly changing conditions.

Systems thinking is a useful lens to understand change across scales. Scale is "the spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon," and levels of analysis are "the units of analysis that are located at different positions on a scale" (Cash et al., 2006, p. 2). A holistic understanding, including spatial and temporal conditions, is critical for advancing towards sustainability and avoiding tradeoffs that result in unintended consequences (Metson et al., 2012).

4.1. Core Concepts

In this section we provide an overview of the core theoretical concepts that have been used to understand sustainability from a systems thinking perspective. In Table 4, for each core concept, we have provided a short description from the literature, representative articles and future research questions.

4.1.1. Interconnections

Interconnected parts in systems determine the behavior of the system as a whole (Merali and Allen, 2011). The value of a systems thinking approach to sustainability issues springs from consideration of the dynamic interconnections between networks of actors across scales in social, economic and ecological systems (Davis et al., 2009; Freedman, 1992; Gladwin et al., 1995; Hoffman, 2003; Lozano, 2008; Valente, 2012). Sustainability managers are faced with balancing the relative autonomy and self-preserving tendencies of organizations, with recognizing their roles and responsibilities as part of wider systems (van Marrewijk, 2003). Organizations hold mutual relationships of impact and dependence with larger and smaller systems that offer services critical to their ability to create value, for example, human and material resources or supporting ecological services such as water cycling (Winn and Pogutz, 2013).

Understanding interconnections is important for leaders of organizations and for the management of complex systems in order to achieve sustainability (Metcalf and Benn, 2013). Understanding interconnections within industrial ecosystems can improve industrial symbiosis (Tsvetkova and Gustafsson, 2012) and closed-loop manufacturing processes (Ashton, 2009), while cross-scale impacts and systems transitions can occur when products are innovated with consideration of interconnections between product components and social-technical systems (Boons et al., 2013). However, determining the behavior of a system is complex due to interconnections between systems variables that manifest over time and space leading to difficulty in decision making (Kunz et al., 2013b). For instance, an ecosystem service may generate benefits far away from the source and long after the service is provisioned (Winn and Pogutz, 2013).

4.1.2. Feedback loops

Feedback loops are, "The secondary effects of a direct effect of one variable on another, they cause a change in the magnitude of that effect. A positive feedback enhances the effect; a negative feedback dampens it," (Walker and Salt, 2006, p. 163). Feedback loops cause systems to be interconnected (Kunz et al., 2013b) and when the consequences of feedbacks loops are not fully understood by managers, unpredictable system behavior can emerge (Allenby, 2009). In response to feedback from the external environment, systems adapt or transform (Folke et al., 2002; Holling, 2001) and have direct and indirect impacts on organizations (Winn et al., 2011).

Sterman (2001, p. 12) explains the implications of feedback loops for managers: "our decisions alter the state of the world, causing changes in nature and triggering others to act, thus giving rise to a new situation which then influences our next decision." Managers actively create and then react to feedback loops (Whiteman et al., 2004). As managers respond to improving indicators of sustainable progress, positive feedback loops are created, further advancing sustainability (Starik and Kanashiro, 2013). When managers fail to make sense of feedback loops and respond accordingly, the system may become vulnerable jeopardizing resilience (Whiteman et al., 2013). With an understanding of feedback loops, the consequences of decisions are evident and system behavior can be managed as opposed to reacting passively to system changing events (Sterman, 2001).

4.1.3. Adaptive capacity

The ability of actors in a system to maintain basic structure and manage resilience represents the adaptive capacity of the system (Ehrenfeld, 2007; Holling, 2001; Walker and Salt, 2006; Whiteman et al., 2004). Resilience is, "The amount of change a system can undergo (its capacity to absorb disturbance) and remain within the same regime—essentially retaining the same function, structure, and feedbacks" (Walker and Salt, 2006, p. 163). Adaptive capacity suggests that managers and complex systems continuously learn from their experience (Ferreira et al. 2006; Sterman, 2001; Valente, 2010). When managers adapt to these learnings, competitiveness, resilience and survival are improved (Valente, 2010). If an environmental crisis strikes, adaptive capacity is enabled to effectively manage the disruption (Beermann, 2011).

To build the adaptive capacity of a firm, managers can innovate new business models or ways of organizing to cope with change in complex systems (Beerman, 2011). Managers may also build adaptive capacity by engaging in transformative learning processes (Folke et al., 2002; Manring, 2014). Transformative learning processes include learning to deal with change, enhancing diversity, systems level learning and creating conditions for self-organization to emerge. However, firms may need to manage tensions between building adaptive capacity and considerations of efficiency that espouse the conflicting aims of low diversity and standardization (Hahn et al., 2015).

4.1.4. Emergence

Emergence occurs in complex systems when novel higher level structures and patterns arise due to interaction between systems variables (Rotmans and Loorbach, 2009). The constant adaption to complex feedback loops and co-evolution of organizations with their environments (Porter, 2006) without a central organizing agent, drives the emergence of systems dynamics, structures and self-organization (Batten, 2009; Dougherty and Dunne, 2011; Rotmans and Loorbach, 2009; Sterman, 2001). The emergent patterns, whether on a global, regional or local level, arise from interacting subsystems: the actions and decisions of companies and individuals alike (Huo and Chai, 2008; Kunz et al., 2013a).

The emergence of sustainable industrial systems may be facilitated by systems dynamics modeling and improved decision making (Romero and Carmen Ruiz, 2013). The emergence of sustainability oriented innovations can create opportunities for problem solving and information flows (Dougherty and Dunne, 2011). However, rigid organizational structures can also stifle the emergence of sustainability oriented innovations (Dougherty and Dunne, 2011) and constrain personal sustainability agendas of employees (Hahn et al., 2015). Considering individuals, the emergence of post-conventional consciousness in managers can foster corporate greening but the factors leading to this emergence are unknown (Boiral et al., 2014).

4.1.5. Self-organization

Self-organization is, "the ability of a system to structure itself, to create new structure, to learn, or diversify," (Meadows, 2009, p. 188). Complex adaptive systems are able to self-organize, learn from their experience and adapt to changes in the external environment (Ashton, 2009; Rotmans and Loorbach, 2009). Self-organization arises when dynamics, patterns and structures emerge within the internal structure of a system without outside management or control (Batten, 2009; Freedman, 1992; Rotmans and Loorbach, 2009; Sterman 2001). Patterns in systems at the global level emerge due to self-organizing dynamics of interacting lower level systems (Batten 2009). Self-organized emergence is enabled when the system is pushed out of equilibrium (Dougherty and Dunne, 2011).

Self-organization occurs internally in a system and is driven by external energy (Rotmans and Loorbach, 2009). Self-organizing processes requires patience and trust (Nevens et al., 2013).

Transformative learning can create opportunities for self-organizing processes towards sustainability (Manring, 2014).

Insert Table 4 about here

4.1.6. Summary of core concepts

We have presented the core concepts independently, however they are interrelated. System components are *interconnected* due to *feedback* loops (Kunz et al., 2013b). Understanding interconnected components of a systems allows the dynamics of the system as a whole to be understood (Merali and Allen, 2011). *Self-organization* drives higher level *emergent* structures and processes (Dougherty and Dunn, 2011; Rotmans and Loorbach, 2009). At the macro-level, *adaptation* of the whole system is determined by local-level processes of *self-organization* and *emergence* (Merali and Allen, 2011).

4.2. Research themes

We found 8 different research themes that apply a systems thinking lens to understand sustainability management (see Table 5). They are presented here in order of scale starting with the individual level.

4.2.1. Behavioral change

Scholars argue behavioral change and a revolution of mindsets is crucial to transforming business and society, taking concrete action (Marcus et al., 2010) and driving systemic change (Raivio, 2011). Behavioral change may be necessary because individual behavior aggregates to drive systems dynamics in business and society (Marcus et al., 2010). Studies at the local community level give insight into how individuals can be collectively engaged and how their behavior can be influenced based on their personal connection to local conditions (Nevens et al., 2013).

Scholars have used a cognitive framing lens to explore an integrative perspective of managerial processes that accounts for temporal and spatial dimensions of sustainability across multiple scales (Bansal and DesJardine, 2014; Hahn et al., 2015). From this logic of focusing on paradoxes and tensions in sustainability, managers are stimulated to understand interconnections between system elements and their decisions over time (Gao and Bansal, 2013). Furthermore scholars posit that cognitive diversity may play a role in large scale systemic change (Hahn et al. 2014).

Sustainable consumption patterns are dependent on the values and decisions of individual citizens (Raivio, 2011). Transformation of consumptions patterns is crucial given planetary limits (Vinkhuyzen and Karlsson-Vinkhuyzen, 2014) but current attempts are failing (Doyle and Davies, 2013). Behavioral incentives that may drive sustainable consumption remain fuzzy (Vinkhuyzen and Karlsson-Vinkhuyzen, 2014) and extant research has yet to give due consideration to how consumption patterns are embedded in social-cultural and technological systems (Doyle and Davies, 2013).

4.2.2. Leadership

Research suggests sustainability leadership presupposes extraordinary capabilities and a holistic perspective on the complexities of embedded organizations (Lozano, 2012; Metcalf and Benn, 2012, 2013; Painter-Morland, 2008). Taking a holistic perspective may require managing large amounts of complex information while avoiding the tendency to reduce and narrow data for decision-making (Metcalf and Benn, 2012). The ability of a leader to maintain a long-term focus (Boiral et al., 2014), incorporate different viewpoints and allow for decentralized decision making were also found to be important (Wong et al., 2011).

While traditional leadership theories rest on concepts of intentional influence, control and direction by a leader towards a predefined organizational goal (Yukl, 2008), research on complex systems and leadership stresses unpredictability, emergence and resilience, and the need to integrate and reconcile multiple conflicting goals (Boiral et al., 2014). A systems approach suggests that responsibility is shared among all members and the aim of leaders is to build value-driven organizations (Painter-Morland, 2008).

4.2.3. Innovation

To address systemic challenges and enable transformative change, scholars of this research theme posit that radical innovation in education, products, services, production systems, logistic systems and business models is needed (Boons et al., 2013; Boons and Lüdeke-Freund, 2013;

Jänicke, 2008; Loorbach and Wijsman, 2013; Winn et al., 2011). Innovating for sustainability is a systemic, dynamic and nonlinear process that faces many uncertainties (Foxon and Pearson, 2008).

Considering the implications of sustainability oriented innovations for the firm, extant literature shows managers must understand the relationship between sustainable process, product and organizational innovation to manage business performance (Cheng et al., 2014). For example, interactions between production innovation and process innovation in energy efficiency must be understood to improve the sustainability practices of a firm (Gerstberger et al., 2014).

Innovations of new sustainability oriented products and services are viewed as the result of complex interactions between many firms (Dougherty and Dunne, 2011). Knowledge and resources for innovation can be dispersed among industry actors (Dougherty and Dunne, 2011), and their success depends on prior efforts of technical advancement and unlocking changes in the marketplace. Organizational networks should be formed to encourage interactions between firms and connect disparate ideas (Dougherty and Dunne, 2011). Jänicke (2008) explains how a complex networks of firms can also serve to increase pressure on firms with poor sustainability performance to innovate as they face growing insecurity over societal and governmental governance risks. Developing a systems understanding of supply chains can also provide great opportunity for sustainability oriented innovations and enhance business performance (Isaksson et al., 2010). Tools such as life cycle analysis may improve sustainable product development between firms (Gmelin and Seuring, 2014; Luthe et al., 2013).

Firm innovations, such as innovative business models, seek to go beyond the techno-fix approaches to sustainability and offer opportunities to significantly change the way a business creates, delivers and captures value (Bocken et al., 2014). An emerging literature stream is considering how changes in business models may lead to changes in the interconnected larger production and consumption systems (Boons et al., 2013). Such interconnections between micro-level product innovation and macro-level societal transformation can be understood using double-flow scenario methods or explorative backcasting scenarios (Gaziulusoy et al., 2013).

4.2.4. Industrial Ecology

Industrial Ecology research examines the flows of energy and materials within industrial systems with the aim of understanding systemic emergent behavior of integrated human-natural systems such as eco-industrial parks. Eco-industrial parks aim to increase productivity while simultaneously providing collective solutions to environmental problems through geographical clustering of organizations and coordination of material, energy and information flows (Allenby, 2009; Behera et al., 2012; Huo and Chai, 2008). Eco-industrial parks may also have wider impact to promote and be used as levers for implementing sustainable policies at the regional level (Cerceau et al., 2014).

Scholars view modelling of eco-industrial parks as critical to improving decision making and fostering industrial symbiosis (Despeisse et al., 2012; Huo and Chai, 2008; Romero and Carmen Ruiz, 2013). Yet, a more holistic approach to industrial ecology could benefit the field (Ashton, 2009; Hoffman, 2003; Metson et al., 2012). Ashton (2009) found that the recognition of interconnections between human and natural systems introduces new institutional variables to the analysis of industrial ecosystems. A more holistic approach to industrial ecology can expand the field from a set of tools to understand material and energy flows to address more profound challenges in social-technical landscapes (Allenby, 2009).

To better understand the social-technical landscape, a combination of insights from industrial ecology and complexity science can help managers make decisions and address complex sustainability problems (DeLaurentis and Ayyalasomayajula, 2009; Ehrenfeld, 2007). Integrative research and interdisciplinary learning is also needed to develop frameworks of interconnected industrial-social-ecological systems (Ramaswami et al., 2012).

4.2.5. Social-ecological systems

The social-ecological systems perspective recognizes the interconnections between business and society, which are both nested in natural systems defined by biospheric limits (Marcus et al., 2010; Whiteman et al., 2013). A social-ecological system is an, "integrated system of ecosystems and human society with reciprocal feedbacks and interdependence" (Folke, et al., 2010, p. 3). Studies within this research theme seek to deepen understanding of organizational dependency on social-ecological foundations (Winn and Pogutz, 2013) and posit that when managers understand the complex dynamics of social-ecological systems, its management may be improved (Kunz et al., 2013a). New partnership models and collaborative solutions are seen to drive systemic solutions for complex sustainability problems (Hodge, 2014; Mahoney et al., 2009; Nidumolu et al., 2014).

Organizations adapt to changes in social-ecological systems, such as environmental crises driven by climate change which has been given special attention by scholars (Linnenluecke and Griffiths, 2010; Paschen and Ison, 2014; Winn et al., 2011). Direct and indirect impacts of climate change create an uncertain environment for managers (Beermann, 2011). Organizations may apply resilience thinking to help manage the impacts of climate change by identifying climate risks and opportunities (Beerman, 2011; Ortiz-de-Mandojana and Bansal, 2015; Winn et al., 2011). While research has focused on considering the impact of social-ecological system changes on organizational resilience, few studies explore the impact of firms on ecological systems and the services they provide organizations (Whiteman et al., 2013; Winn and Pogutz, 2013).

4.2.6. Transitions management

When systems fail or become path dependent different actors may choose to intervene (Foxon and Pearson, 2008; Mahoney et al., 2009; Vanloqueren and Baret, 2009) to initiate systems change towards sustainability (Doyle and Davies, 2013). Research on transitions management (Vries and Riele, 2006), seeks to understand long-term systems change processes of niche sub-systems (Rotmans and Lorbach, 2009) and societal systems (Loorbach et al., 2009). Policy interventions are shaped by the dynamics of social-technical systems (Hoppmann et al., 2014) and policy tools can help facilitate transitions to low-carbon energy economics (Konnola et al., 2007).

Cities, when viewed as complex adaptive systems can undergo urban transitions towards sustainability stimulated by entrepreneurial change agents (Block and Paredis, 2013; Uyarra and

Gee, 2013). Network governance may help improve decision making in city level transitions (Khan, 2013). Creating public urban spaces for entrepreneurial activity provides a low-risk common space for social and environmental innovations to develop (Radywyl and Biggs, 2013). During the collaborative innovation process, learning processes occur to support the firms in effective action (Nevens et al., 2013). The alignment of principles across scales can lead to higher-order systemic change (Perey, 2014).

4.2.7. Paradigm shifts

Scholars posit that a change in worldview is essential to sustainable development progress (Seiffert and Loch, 2005; Shin et al., 2008). Paradigm shifts in the field of management can be seen as the result of larger shifts at the societal level (Valente, 2010). Criticism from society about the role of business in society has also driven paradigm changes towards sustainability (Valente, 2012). Management scholars demonstrate a change in worldviews, values and paradigms from a reductionist to an integrative perspective (Gladwin et al., 1995; Shrivastava et al., 2013) or from a neoclassical mechanistic to a systemic perspective (Seiffert and Loch, 2005; Stormer, 2003).

4.2.8. Education

Research found in the education theme suggests that scientific paradigm shifts challenge the conceptual foundations of educational systems and call for the integration of sustainability into curricula for all ages (Raivio, 2011). Lozano (2010) found that university leaders in sustainability education lack a holistic transdisciplinary approach. Adoption rates of sustainability curricula may be increased if the contribution to sustainable progress is demonstrated (Watson et al., 2013). Yet, Dlouha et al. (2013) suggest it is difficult to demonstrate success because the social and political impacts of educational transformations are difficult to measure due to the fluid nature of transformation processes.

Research could consider pedagogical approaches for driving changes towards sustainability in organizations or society. Developing skills for holistic thinking was found to be important in most research (Ferreira et al., 2006; Gombert-Courvoisier et al., 2014; Lozano, 2010). Other pedagogical approaches include ‘hands-on’, ‘on-the-job’ training (Ferreira et al., 2006), providing decision making tools (Lozano and Lozano, 2014), interdisciplinary approaches (Gombert-Courvoisier et al., 2014; Shrivastava et al., 2013), skills for managing uncertainty, encouraging collaboration (Gombert-Courvoisier et al., 2014) and developmental approaches (Pappas et al., 2013).

Insert Table 5 about here

4.2.9. Summary of research themes

We have presented the research themes separately, however overlaps in the research themes do exist and two or more research themes can be found in the same article. For instance, the role of *innovation* in social-technical *transitions* is highlighted in the literature (Foxon and Pearson, 2008; Gaziulusoy et al., 2013). Unpredicted technological innovations may lead to changes in policy and shape social-technical systems (Hoppmann et al., 2014). Product *innovations* can have drastic impacts on macro-level consumptions trends in *social-ecological systems* (Vries and Riele, 2006).

Research suggests that *paradigm* shifts are dependent on successful shifts in social systems in turn creating new opportunities to sustain *social-ecological systems* long-term (Valente, 2010). *Paradigm* shifts are also dependent on changes in *individual behavior* (Stormer, 2003) and call for changes towards sustainability *education* (Raivio, 2011). The work on *education* highlights the role of sustainability education in preparing future *leaders* in sustainability (Lozano and Lozano, 2014; Lozano et al., 2013). A challenge facing sustainability *education* is preparing *leaders* that can understand the complexities of *social-ecological systems* and the impact of their work (Raivio, 2011; Watson et al., 2013). *Leaders* can take a holistic approach to adapt to *social-ecological systems* and recognize their role as change agents (Metcalf, 2012, 2013).

5. Integrated framework

We developed an integrated framework to give an overview of the research themes presented in the previous section. The contribution of the framework is to demonstrate to what extent each research theme has addressed cross-scale interactions and where gaps still exist. The bidirectional arrows represents conceptual interdependence between the two levels, or that the higher level system influences the lower level system and vice versa. The article per theme that discusses the broadest bidirectional impacts is depicted in Figure 3. In this section, we examine the cross-scale interactions found in the literature by each research theme.

Insert Figure 3 about here

5.1. Behavioral change

We found five articles dedicated to understanding behavioral change. Zhang et al. (2013) test the impact of decision making tools on the strategy of firms in the textile industry, or the impact of individual behavior change on organizational level concepts. Zollo et al. (2013) propose a conceptual framework for understanding change initiatives starting from the individual to organizational level. Their model points to the inter-connections between cross-scale change initiatives and organizational adaptive capacity.

Expanding beyond organizational boundaries, our review also identifies an emerging group of articles using a cognitive framing perspective, that are aimed at understanding how an integrative or paradoxical logic may affect managerial decision making (Gao and Bansal, 2013; Hahn et al., 2015). Hahn et al. (2014) consider the implications of cognitive managerial frames offering that a pragmatic frame may lead to workable solutions and large scale change. Represented in the integrated framework (Figure 3), the work on managing tensions in corporate sustainability demonstrates that firms affect and are affected by social-ecological systems and also considers the tensions between individual and firm level sustainability (Hahn et al., 2015). The systematic framework for managing tensions in corporate sustainability paves the way for future empirical research to consider cross-scale interactions (Hahn et al., 2015, p. 301).

5.2. Leadership

Studies on leadership seek to understand how leaders transform organizations and society. The integrative complexity and decentralization of decision making in top management teams influences corporate social performance (Wong et al., 2011). When understood holistically, leadership initiatives influence company systems such as operations, strategy and communication and therefore the sustainability dimensions of the firm (Boiral, 2014; Lozano and Huisingh, 2011). Leadership that promotes ethical behavior may drive transformational change of sustainable production and consumption systems (Vinkhuyzen and Karlsson-Vinkhuyzen, 2014) and consciousness development may resolve the global economic crisis (Boiral et al., 2014).

As depicted in the integrated framework (Figure 3), Painter-Morland (2008) suggests that complex interactions between individuals and groups shapes shared organizational institutions. Sustainability requires leaders to predict complex systems dynamics, quickly adapt and implement organizational change (Metcalf and Benn 2012, 2013). Factors of community systems may influence which type of leadership emerges and the leader's ability to facilitate sustainable community development (Harley et al., 2014). While this research examines the interdependence between leaders and their organizational environments, research could examine feedback loops with higher level social-ecological systems.

5.3. Innovation

Sustainability oriented innovation articles in the review cover all levels of analysis from individual to social-ecological systems. Yet, we did not find a study that explores innovation for adaptive capacity nor research that holistically examines feedback loops at all levels. Most articles identified sought to understand the implications of firm level innovations (technological, social and organizational) to value chains (Boons and Lüdeke-Freund, 2013) and social-ecological systems (Bocken et al., 2014; Boons et al., 2013; Gaziulusoy et al., 2013), or examined the influence of social-ecological systems on innovations (Luthe et al., 2013; Vries and Riele, 2006). Hoppmann et al. (2014) draw attention to the ongoing dynamics between technological change, social-technical systems and policy, which is represented in the integrated framework (Figure 3).

Foxon and Pearson (2008) focus on the social-ecological system level by giving an understanding of the co-evolution of innovation systems of new technology and public sustainability policy systems. We identified two articles that focused on organizational level innovation and implications for the firm (Chang et al., 2014; Gerstlberger et al., 2014). Another two articles examined the connection between inter-organizational networks and organizational innovation (Dougherty and Dunne, 2014; Isakssoon et al., 2010). We identified one article that considered individual behavior change. In their study of Irish households, Doyle and Davis (2013) use backcasting of social-technical innovation scenarios including aspects such as regulations, user practices and cultural meanings to stimulate individual self-reflection.

5.4. Industrial Ecology

Most articles in the review focusing on industrial ecology connect the organizational level or inter-organizational level to industrial and social-ecological systems (i.e. Batten, 2009; Behera et al. 2012; Cerceau, 2014; Romero and Carmen Ruiz, 2013; Tsvetkova and Gustafsson, 2012).

For example, Despeisse et al. (2012) develop a model for improved environmental performance taking the factory as the unit of analysis and linking manufacturing processes to technical and ecological systems. We identified one paper that is represented in Figure 3 (Ramaswami et al., 2012) which conceptually embeds industrial systems in social-ecological systems and considers the role of individual actors. In this study Ramaswami et al. (2012) consider the sustainability of cities in an integrated manner by considering the role of individual actors in social-ecological infrastructural systems. Industrial ecology scholars have called for research to continue in this integrated direction (Ashton, 2009; Hoffman, 2003; Metson et al., 2012).

5.5. Social-ecological systems

As shown in Figure 3, Starik and Rands (1995) and Starik and Kanashiro (2013) provide conceptual foundations for considering dynamic interactions across-all scales. We suggest that there is an opportunity to advance this research empirically. Other research explores the role of bottom-up action on systemic change (Gray, 2010; Perey, 2014). Gray (2010) suggests that sustainability of social-ecological systems will be the result of individual, organizational, political, and collective outcomes, but does not explicitly consider the role of feedback loops across scales.

A group of articles considers the adaptation of organizations or individuals to social-ecological systems such as disasters related to climate change (Beermann, 2011; King, 1995; Linnenluecke and Griffiths, 2010; Ortiz-de-Mandojana and Bansal, 2015; Paschen and Ison, 2014; Sterman, 2011; Winn et al., 2011). A second set has considered the feedback relationships, the transformation of social-ecological systems or the role of business in society without attention to the role of individual agency or firm level effects (Kunz et al., 2013a, 2013b; Manring, 2014; Marcus et al., 2010). A third set considers the role of firms in social-ecological systems or as co-evolving with their environment (Hodge, 2014; Porter, 2006; Whiteman et al., 2004; Whiteman et al., 2013; Winn and Pogutz, 2013). For instance, Winn and Pogutz (2013) offer a theoretical model of organizational ecosystem embeddedness, representing the mutual relationship of impact and dependence between organizations and ecosystems.

5.6. Transitions management

Articles in the transitions management theme have addressed directional change at all scales. However we found just one model in the review that considers interconnections across all levels. Rotmans and Loorbach (2009) present a holistic transitions management framework for addressing complex social problems (see Figure 3). The framework considers individual learning experiences, mobilization of actors and selection of experiments that can be scaled to drive change.

Other articles have focused on the macro-level. For example, the role of geography in sustainability transitions (Coenen et al., 2012) or the role of business in proactively driving sustainability and public space creation to leverage disruptive change (Radywyl and Biggs, 2013). Another group of articles consider unidirectional change such as the role of political entrepreneurship in driving sustainability transitions (Block and Paredis, 2013). Transitions frameworks are based on multi-level, multi-phase dynamics of change (Geels, 2002). Our review highlights that research does not consistently leverage all levels over time.

5.7. Paradigm shifts

In the paradigm shifts research theme, we find the articles focus on a maximum of two levels of analysis and as represented in the integrated framework we did not find any cross-scale interactions (Figure 3). Most articles focus on how pressures from social-ecological systems can create field level paradigm shifts but the management paradigm has yet to shift from neoclassical and technocentric roots (Seiffert and Loch, 2005; Shin et al., 2008; Stormer, 2003; Valente, 2010). Other articles focus on how individual level management practices are changing as a result of growing complexity in external environments (Freedman, 1992; Lozano, 2008), and how organizations may respond to a sustain-centric paradigm (Gladwin et al., 1995). While Gladwin et al. (1995) suggests that management theory may have encouraged a techno-centric paradigm, our framework highlights that research has ignored the role of change agents in creating cross-scale impacts.

5.8. Education

A sustainability oriented transformation of higher education considers different viewpoints from ethical decision making to policy issues (Dlouha et al., 2013). Three articles consider the unidirectional downward adoption trends of sustainability education (Lozano, 2010; Raivio, 2011; Watson et al., 2013). Most articles consider the upward unidirectional effectiveness of pedagogical approaches in driving changes towards sustainability in organizations or society (Ferreira et al., 2006; Gombert-Courvoisier et al., 2014; Lozano, 2010; Lozano and Lozano, 2014; Pappas et al., 2013; Shrivastava et al., 2013). In this review, as shown in the integrated framework (Figure 3), we did not find any empirical evidence of cross-scale interconnections in the research with regards to sustainability education.

6. Future Research

Systems thinking is increasingly being used to understand sustainability issues in management but remains peripheral to mainstream organizational journals. We hope that the conceptual foundations identified in this review, such as the emerging field using a paradox lens (Hahn et al., 2015; Ven der Byl and Slawinski, 2015) among others, will encourage more scholars in the field of management to understand the complexities of sustainability with systems thinking. Overall, a key implication of our review of systems thinking is for future studies to explicitly recognize social-ecological embeddedness beyond the boundaries of the firm, industry, and product/process level, as well as the interconnections across multi-level, nested social-ecological systems. We conceptualize this in Figure 4. In Tables 4 and 5 we offer specific research questions derived from the representative articles to help guide management scholars and stimulate future research.

Insert Figure 4 about here

For example, the organizational adaptation literature has mainly focused on building organizational resilience in the face of changing climate conditions (Linnenluecke and Griffiths, 2010). This work has already provided new insights into risk management and we encourage future research to consider the impact of other social-ecological systems, such as biodiversity, nitrogen/phosphorus use, and ozone depletion on organizational adaptation strategies (Whiteman et al., 2013). We also invite organizational scholars to move beyond the notion of building organizational resilience, and to consider the implications of building social-ecological resilience (Whiteman et al., 2004; Winn and Pogutz, 2013).

Similarly, findings from the innovation research theme show that studies remain focused at the organizational level and on the development of new sustainable processes and products. However, these studies tend to ignore broader systemic feedback loops, and to address specific processes or products in isolation of other developments, both in the technological and ecological spheres. Therefore, future research on sustainability oriented innovation should take a broader scope and examine the implications of developing innovations, including new business models, intended to transform entire systems (Adams et al., 2015).

Another research theme that has been given limited attention by systems thinkers is organizational sustainability reporting. Studies are needed to provide insight into how temporal and spatial interlinkages can be taken into account within organizational sustainability reporting to give a holistic perspective (Lozano, 2013). Integrated reporting has emerged as an innovative topic within sustainability reporting that offers organizations the opportunity to better understand and manage how its business activities affect social-ecological systems. Integrated reporting stimulates 'integrated thinking' within companies - understanding the relationship between the business model and the capitals it depends on (social, ecological and financial) - in order to identify risks and opportunities in the short, medium and long term. Yet the field of integrated reporting remains nascent and little is known about how it can effectively act as a mechanism for internal organizational change (Perego et al., 2016), or how it may effectively improve the resilience of social-ecological systems. We invite scholars to investigate questions such as '*what* *is driving and inhibiting the diffusion of integrated reporting as a field of management practice?*' and, '*how is integrated reporting reconstructing the ways in which companies, industries and value chains operate in order to effectively enhance the resilience of social-ecological systems?'*

We were surprised to find that systems thinking has yet to be fully leveraged as a frame for understanding collaboration for sustainability, although collaboration is acknowledged to be important for achieving sustainability goals (Lozano, 2008). Clarke and Fuller (2010) found that stages of collaborative strategic management are driven by feedback loops and adaptation to feedback loops drives emergent strategies. Future research questions could address, '*does collaborative action help to understand complex interactions between social-ecological systems?'* and '*how can systems thinking be used to understand multi-stakeholder platforms driving action across scales?"*

Finally, we suggest that a further integration between research themes is needed to advance the field of sustainability management. For instance, our review highlights that industrial ecology gives much insight on how to build production systems while minimizing environmental impact. If connected with the work on social-ecological systems (Whiteman et al., 2013), we would have a better understanding of what is needed to achieve global sustainability within the limits of the planet (Rockström et al., 2009).

7. Conclusion

In 1995, Gladwin et al. called on management scholars to develop theories that reintegrate organizations with the social and ecological systems in which they are embedded. In the same early special issue on sustainability management, Starik and Rands (1995) invited studies that explore the linkages between organizations and all system levels and give insight into the strategies that may lead to overall systemic sustainability.

Our review indicates that many organizational scholars have endeavored to take up this challenge, applying core concepts of systems thinking in sustainability management research and advancing understanding through a number of research themes. Our results illustrate the exponential increase in publications on systemic dimensions to sustainability management, with the *Journal of Cleaner Production* clearly in a leadership position as the primary publication outlet for systems thinkers. We also observe that extant research is largely fragmented and marginal to the mainstream management journals.

Furthermore, the results of our review illustrate the field could benefit from more transdisciplinary research in order to better understand sustainability from a holistic systems perspective. Considering the interconnectedness of social-ecological systems and determining meaningful transition pathways requires multi-disciplinary work based on systems thinking originating in both management studies and ecology (Starik and Rands, 1995; Whiteman et al., 2013).

Our study has the following main limitations. First, the review is constrained by its selected time period excluding any early contributions to the field (pre-1990) and through its selection of academic journals. Future reviews may find manageable ways to broaden their searches to capture contributions from books, conference papers, articles written in languages other than

English and literature from sources other than journals should be given consideration. Second, our process of article identification through a keyword-based search and academic expert review may not have captured all relevant contributions to the field. Third, only the database SSCI was used for the review. Future reviews may consider the dual use of databases to give greater reliability to the results.

Despite these limitations, we believe that this review draws greater attention to the potential of systems thinking and encourages other management journals to expand their integration of such ideas. In order to facilitate the uptake of systems thinking, we also provide guidance on future research questions. In the words of recognized systems thinker and leader of corporate sustainability, Paul Polman, CEO of Unilever, "I truly believe that future leaders will be systems thinkers. It is inconceivable that anyone will successfully steer companies, or countries, through our volatile world without understanding the interdependencies between the systems on which we depend" (Polman, 2014).

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Table 1: Systematic Review Method

Step 1 Determine relevance of the review	• Establish need for the systematic review • Extensive search using Google Scholar and SSCI for past reviews
Step 2 Definition of temporal boundaries	• Include only articles published from 1990 up to 2015 • Use boundaries of previous reviews and salient events as a basis
Step 3 Definition of the search area	• Develop list of peer-reviewed top management, specialty and practitioner journals • Identify relevant journals from previously published literature reviews in the field of management and prominent literature reviews published on sustainability management
Step 4 Development of search strings and inclusion/ exclusion criteria	• Develop two strings of keywords based on insights from previous systematic reviews on sustainability • Develop inclusion and exclusion criteria including relevance to sustainability management and theoretical contribution to systems thinking
Step 5 Choice of database and search mode	• Search using the Web of Science's Science Citation Index (SSCI) • Exclude book reviews, proceedings, editorial materials and notes • Limit search to titles and abstracts of the papers
Step 6 Develop article database	• First and second authors read the title and abstract of each paper and remove articles without a clear sustainability and systems thinking focus • Third author reviews the articles the first and second author did not agree on • Consult academic experts in the field to identify pertinent articles not captured by the keyword search
Step 7 Descriptive analysis	• Conduct a descriptive analysis to identify patterns and trends
Step 8 Thematic analysis	• Abductively code entire article texts according to systems thinking concepts and general article attributes using computer qualitative analysis software Nvivo • Identify organizational scholar use of core theoretical concepts of systems thinking and primary research themes

Table 2: Targeted Journals

Category	Journals
Management Journals	*Academy of Management Annals, Academy of Management Journal, Academy of Management Perspectives, Academy of Management Review, Administrative Science Quarterly, British Journal of Management, European Management Review, International Organization, Journal of Applied Psychology, Journal of International Business Studies, Journal of Management, Journal of Management Studies, Journal of Organizational Behavior, Long Range Planning, Management and Organization Review, Management Science, Organization Science, Organization Studies, Organizational Behavior and Human Decision Processes, Organizational Research Methods, Personnel Psychology, Research Policy, Strategic Management Journal, Strategic Organization*
Specialty Journals	*Accounting, Auditing & Accountability Journal, Accounting Organizations and Society, Business & Society, Business Ethics Quarterly, Business Strategy and the Environment, Corporate Governance, Journal of Business Ethics, Journal of Cleaner Production, Journal of Industrial Ecology, Leadership Quarterly, Organization & Environment*
Practitioner Journals	*California Management Review, Harvard Business Review, Sloan Management Review*

Table 3: Top Cited Articles

Authors, Year	Journal	Total Citations*	Average Citations / Year*	Journal Impact Factor 2015**
Geels, 2002	Research Policy	828	51.75	3.470
Gladwin et al., 1995	Academy of Management Review	442	19.22	7.288
van Marrewijk, 2003	Journal of Business Ethics	321	21.40	1.837
Starik and Rands, 1995	Academy of Management Review	234	10.17	7.288
Sterman, 2001	California Management Review	162	9.53	1.109
Gray, 2010	Accounting Organizations & Society	150	18.75	2.464
Lozano, 2008	Journal of Cleaner Production	109	10.9	4.959
Jänicke, 2008	Journal of Cleaner Production	107	10.7	4.959
Vanloqueren and Baret, 2009	Research Policy	104	11.56	3.470
Coenen et al., 2012	Research Policy	102	17	3.470
Bocken et al., 2014	Journal of Cleaner Production	100	25	4.959
Lozano, 2012	Journal of Cleaner Production	90	15	4.959
Lozano et al., 2013	Journal of Cleaner Production	89	17.8	4.959
Lozano, 2010	Journal of Cleaner Production	81	10.12	4.959
Rotmans and Loorbach, 2009	Journal of Industrial Ecology	75	8.33	3.265
Boons et al., 2013	Journal of Cleaner Production	69	13.8	4.959
Mahoney et al., 2009	Organization Science	63	7	3.360
Whiteman et al. 2013	Journal of Management Studies	59	11.8	4.131
King, 1995	Academy of Management Review	51	2.22	7.288
Starik and Kanashiro, 2013	Organization & Environment	51	10.20	2.650

*retrieved from SSCI, January 16 2017
**retrieved from Journal Citation Reports, February 2 2017

Table 4: Core concepts

Short Description	Representative Articles	Future Research Questions
Interconnectedness Organizations are agents in interconnected social, economic and ecological systems. Recognition of the complexity of interconnected social and ecological problems is critical for achieving sustainability.	Davis et al., 2009 Metcalf and Benn, 2013 Sterman, 2001 Valente, 2010; 2012	Develop conceptual models to understand connections What tools can help leaders identify interconnections that close loops in industrial networks?
Feedbacks Interaction with and reaction to feedbacks causes nonlinear dynamics and the emergence of complex behaviors overtime. Understanding feedbacks as underlying governance mechanisms can inform decision making.	Sterman, 2001 Valente, 2010 Whiteman et al., 2004	Develop methods to understand the impact of long term social-ecological feedbacks Analyze the impacts of indirect social-ecological feedbacks on the resilience of the firm
Adaptive Capacity/ Resilience Adaptive capacity ensures the survival of the system when agents learn from their experience and act accordingly. Organizations must adapt to changing environmental conditions such as climate change.	Ashton, 2009 Beerman, 2011 Valente, 2010 Winn et al., 2011	Determine the thresholds between adaptive capacity and transformation Examine the costs and benefits of building long term resilience
Self- Organization Self-organizing systems develop their own structure and behavior spontaneously without being guided from the top-down. Self-organization leads to emergence in complex adaptive systems.	Batten, 2009 Sterman, 2001 Rotmans and Loorbach, 2009 Whiteman et al., 2013	Identify what micro-processes underlie self-organization in social systems Determine the cross-scale impacts of self-organization
Emergence Emergence is the result of lower level interactions when the system is pushed out of equilibrium. Existing structures can hinder future emergence.	Dougherty and Dunne, 2011 Ehrenfeld, 2007 Huo and Chai, 2008 Rotmans and Loorbach, 2009	Understand what conditions lead to a emergence enabling disequilibrium When does self-organization lead to the emergence of sustainable innovations?

Table 5: Research themes

Research Themes	Subthemes	Representative Article(s)	Future Research Questions
Behavioral Change	Decision Making	Raivio, 2011	What variables moderate sustainability decision making?
	Discourse	Paschen and Ison, 2014	How can discourse analysis inform policy?
	Social Norms & Values	Ramaswami et al., 2012; Marcus et al., 2010; Shrivastava et al., 2013	What is the process by which individuals learn new values?
	Cognitive Frames	Hahn et al., 2014	How do cognitive frames vary over time?
Leadership	Complex Systems Leadership	Metcalf and Benn, 2012; Harley et al., 2014; Painter-Morland, 2008	Does complexity leadership improve adaptability?
	Decentralized Decision Making	Wong, et al., 2011	How does sustainability performance influence top management teams?
	Moral Leadership	Vinkhuyzen and Karlsson-Vinkhuyzen, 2014	What are the impacts of leadership training on society?
	Consciousness Development	Boiral et al., 2014	What conditions foster consciousness development?
	Leadership Emergence	Harley et al., 2014	Use of quantitative methods to validate success in terms of sustainability
Innovation	Product & Process Innovation	Gaziulusoy et al., 2013; Jänicke, 2008; Vries and Riele, 2006	How can undesirable effects of product innovation be anticipated and avoided?
	Supply Chain	Isaksson et al., 2010	How can systems thinking unlock new opportunities for supply chain innovation?
	Sustainable Business Models	Boons et al., 2013	What is the role of social-ecological materiality in business model innovation?
Industrial Ecology	Complexity Theory	Ashton, 2009; Ehrenfeld, 2007	What tools can help managers improve both organizational and industrial system sustainability performance?
	Eco-Industrial Parks	Behera et al., 2012; Huo and Chai, 2008	How can theories of eco-industrial parks account for their dynamic nature to predict and support their growth evolution?

	Modular Business Models	Tsvetkova and Gustafsson, 2012	How can modularity be applied to reduce system complexity and solve coordination problems within industrial ecosystems?
	Sociotechnical Landscapes	Allenby, 2009; Ashton, 2009	How can structures of industrial ecologies maintain flexibility to adapt in a world of rapid technological change?
Social-Ecological Systems	Collaboration	Mahoney et al., 2009; Nidumolu et al., 2014	Identify antecedents of org. resilience that enhance social-ecological resilience
	Organizational Climate	Beermann, 2011; Paschen and Ison, 2014	What solutions can build short term and long term resilience?
	Adaptation	Winn et al., 2011	What tools can researchers provide managers to build adaptive capacity?
	Planetary Boundaries	Whiteman et al., 2013	How can understanding of socio-ecological materiality be used for organizational sustainability strategy setting purposes?
Transitions Management	Co-evolution	Loorbach and Wijsman, 2013	What is the role of business in transitions?
	Complex Systems Theory	Rotmans and Loorbach, 2009	Provide empirical verification of transitions management frameworks
	Policy	Foxon and Pearson, 2008	Develop analytical models for policy makers
	Spatial Perspectives	Coenen et al., 2012	Empirical investigation of spatial scales
	Sustainable Consumption and Production	Mickwitz et al., 2011	Identify solutions for reduction of resources for consumption and production
	Urban Transformations	Nevens et al., 2013	Gain understanding of complex city dynamics
Paradigm Shifts	Educational Shifts	Ferreira et al., 2006; Manring, 2014	Determine best of practice methods for teaching students systems thinking
	Management as a Profession & Science	Bleicher, 1994; Valente, 2010; Freedman, 1992	What drives the paradigm shift in the management profession?
	Societal Shifts	Seiffert and Loch, 2005; Shin et al., 2008	Develop integrated knowledge approach to build sustainable societies

Figure 1: Distribution of Publications on Sustainability Management from a Systems Thinking Perspective (per year)

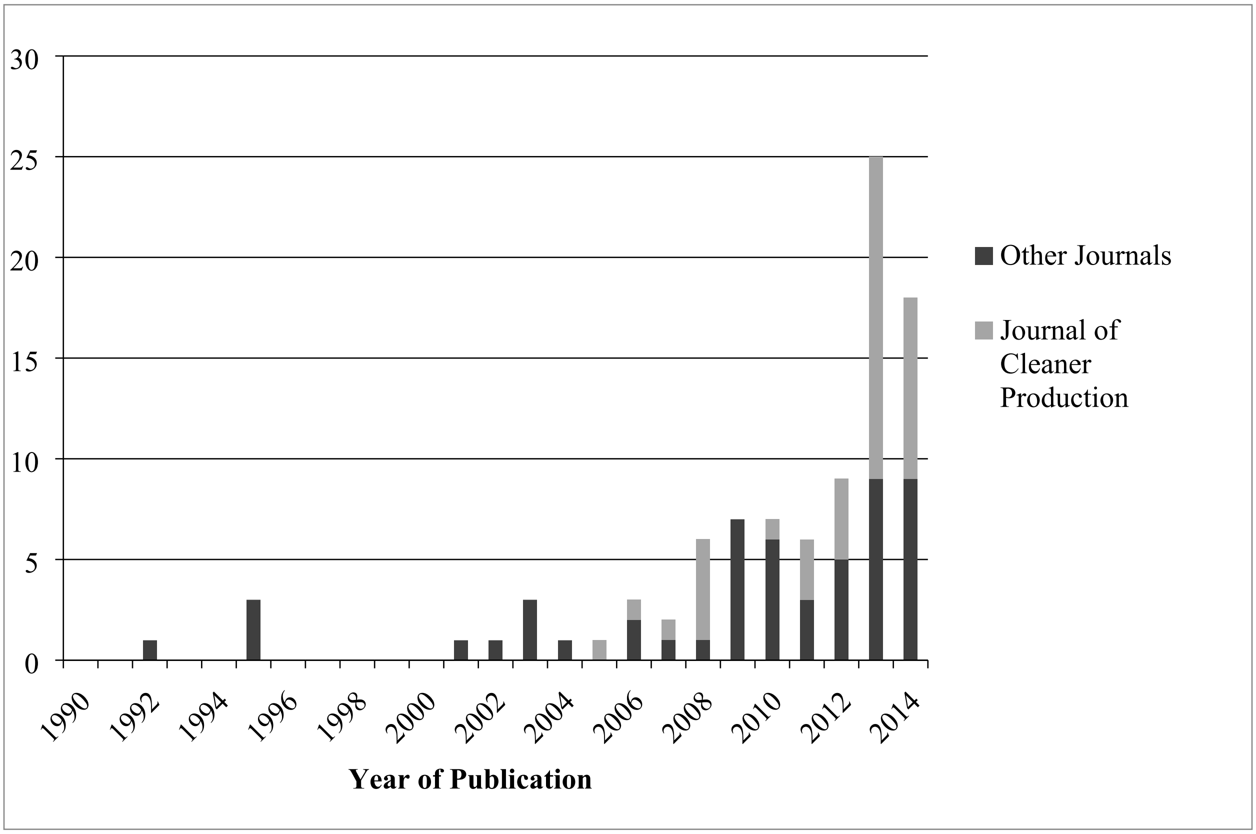

Figure 2: Distribution of Publications per Research Theme

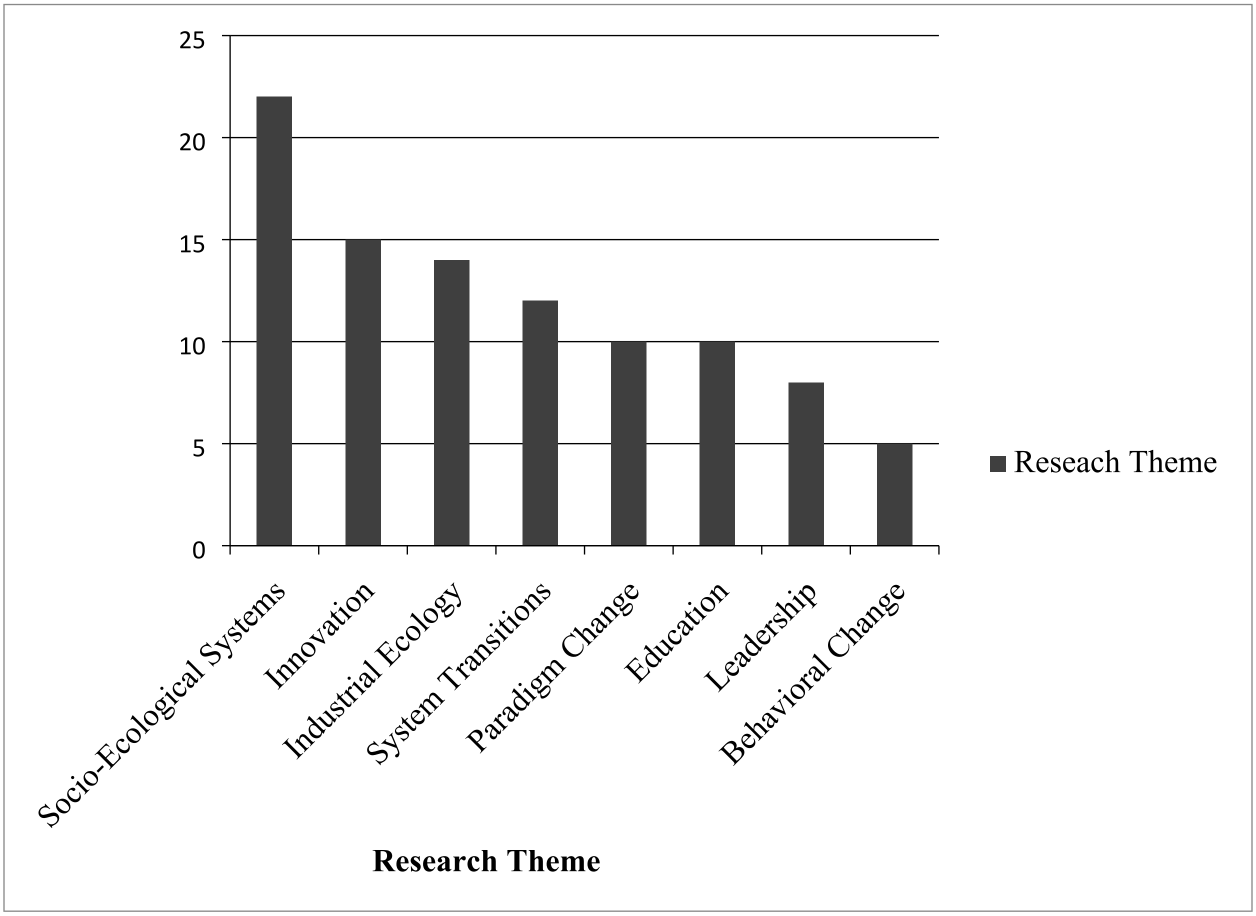

Figure 3: Integrated Framework

Research Theme	Individual	Organizational	Inter-organizational	Social-ecological
Behavioral Change	◄	—	—	►
Leadership	◄	►		
Innovation		◄	—	►
Industrial Ecology	◄	—	—	►
Social-ecological systems	◄	—	—	►
Transitions Management	◄	—	—	►
Paradigm Shifts	*No bi-directional dynamics considered*			
Education	*No bi-directional dynamics considered*			

Figure 4: Future research agenda