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How different forms of social capital created through project team assignments influence employee adoption of sustainability practices

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ABSTRACT

Can social capital created through project assignments increase the diffusion of sustainability practices, and if so, what types of social ties and conditions are likely to be most effective in doing so? We use a mixture of survey and qualitative evidence from a social network at a large organization, The Nature Conservancy, to help answer these questions. Our analysis supports the argument that cross-organizational unit ties promote adoption of complex practices by having the benefits of both external and internal ties (i.e., exposure to novel practices and on-the-job social learning experiences, respectively). Specifically, staff learned new sustainability practices from project teammates in other organizational units who were already employing sustainability evidence-based practices. Thus, a practical and cost-effective way to promote organizational learning for sustainability may be to strategically form cross-organizational unit project teams that include sustainability practice innovators. Internal fellowships and short-term assignments may be other effective ways to do this.

> *"Getting serious about sustainability needs to start with training.. ---providing employees with training on sustainability topics relevant to the company's goals, business strategy, operations and, ultimately, their own jobs"*
>
> - Ricketts 2013 GreenBiz.com

> *"Skill development is clearly a major priority for companies and managers these days. Enrollment in learning programs has surged over the last few years to generate a global executive education market of over $70 billion a year….. At some point, you have to stop listening to experts and start doing something real. That is why live business projects can be powerful vehicles for learning…"*

- Stearn 2015 Harvard Business Review

INTRODUCTION

Organizations are increasingly focused on employee skill development to adapt to new business conditions (Nahapiet & Ghoshal, 1998; Stearns, 2015). For many organizations, sustainability is at the top of the list of in-demand skills (Michaelis, 2003; Ortiz-de-Mandojana & Bansal, 2016; Ricketts, 2013; Seidel et al., 2010). But, simply hiring new employees or deploying traditional learning programs to fill this demand may not be possible (Glover et al., 2014; Fenwick, 2007; Matos & Silvestre, 2013; Thompson, 1967; Woodward, 1965), even though training has been shown to be effective (Sarkis, Gonzalez-Torre, & Adenso-Diaz, 2010; Vidal-Salazar, Cordón-Pozo & Ferrón-Vilchez, 2013). As an alternative or complement to hiring and training, locally adapted sustainability practices could spread through social networks (Epstein, 2018; Frank, Zhao, Penuel, Ellefson, & Porter, 2011; Pertusa-Ortega, López-Gamero, Pereira-Moliner, Tarí, & Molina-Azorín, 2018). In the context of inter-organizational networks, social capital has been shown to improve innovation, up to a point (Molinas-Morales & Martinez-Fernandez, 2009). Yet, there is less known about how this theory applies to networks within an organization and to spreading sustainability practices. Understanding these processes is particularly important for the increasing number of organizations who have sustainability-related missions or goals and globally dispersed organizational units (Lankoski & Smith, 2018; Sulkowski, Edwards, & Freeman, 2018).

Many studies have shown how relationships (i.e., social ties) outside an organization accelerate innovation by providing access to novel information (Burt, 2000; McEvily & Zaheer, 1999; Molina-Morales & Martinez-Fernandez, 2009; for examples related to sustainability practices, see Collins, Lawrence, Pavlovich, Ryan, 2007; Pretty & Ward, 2001; Sulkowski, Edwards, & Freeman, 2018). More generally, social network scholars have distinguished between weak ties and strong ties, arguing that weak ties provide access to novel information by forming ties across distinct social groups (Granovetter, 1973), whereas strong ties can provide the common language and social cohesion required to transfer information into practice (Hansen, 1999; Lin, 2017). Education and management scholars have also made distinctions between the types of learning experiences that are important for complex versus simple practices, arguing that complex practices involving tacit knowledge require adaptation to local contexts and benefit from social learning with close colleagues (i.e., strong ties) (Frank, Maroulis, Belman, & Kaplowitz, 2011; Frank, Zhao, Penuel, Ellefson, & Porter, 2011; Von Hippel, 1994). Hansen (1999) linked the research on weak ties and complex knowledge to explain why weak ties between organizational units—outside the project team—helped employees find novel information but did not improve the units' ability to transfer complex information back into the units' projects, suggesting that these weak ties lacked some of the value provided by strong ties within the unit's project teams.

Here we focus on sustainability practices that are complex practices and network ties between individuals within an organization who are on the same project team, which may include members from the same or different organizational units. Research on adoption of sustainability practices in organizational contexts has often focused on relatively simple practices (Ellison et al., 2015) or on inter-organizational collaborations (e.g., Lang, Wiek, Bergmann, Stauffacher, Martens, Moll, et al., 2012). Hansen (1999) focused on intra-organizational ties but individuals were not necessarily working together on projects. Ryan, Mitchell & Daskou (2012) propose that "dyadic [two-person] relationships and the network organization" are important for developing sustainability solutions in organizations. Still, there is little empirical research on how the dynamics of internal organizational networks affect the spread of sustainability practices between individual employees.

This study contributes to the existing literature by applying social capital theory to the specific context of complex sustainability practices and internal organizational ties to ask 1) does exposure to sustainability practices through social ties promote adoption, and 2) which ties (cross-unit vs. within unit ties created through project team assignments) are most effective given their potentially differing roles (exposure to new practices vs. social learning with close colleagues, respectively)? We examine these questions using the case of an initiative at The Nature Conservancy (TNC)—the largest environmental non-governmental organization (NGO) by revenue (Kareiva, Groves, Mavier, 2014). We overcome the important methodological challenge of examining weak ties in a large network by using administrative data on project team assignments as an objective measure of ties (Granovetter, 1973**)**. Based on our results, we argue that building ties across units within an organization helps spread sustainability practices by providing both exposure to new practices and conditions that promote integration of these practices. From a management perspective, this study is important because it demonstrates how forming project teams across organizational units could be a practical, cost-effective way to promote sustainability practices that are intended to improve outcomes for people and the environment.

THEORY AND HYPOTHESES

Complex Sustainability Practices and Social Learning through Projects

Professionals need help adapting complex innovations to their own local situation, in coordination with other colleagues (Frank, Maroulis, Belman, & Kaplowitz, 2011; Frank, Zhao, Penuel, Ellefson, & Porter, 2011). Conventionally, professionals try to adapt innovations through trial and error, while formal leaders (e.g., supervisors, human resource managers, executives) facilitate coordination and provide formal professional development opportunities (e.g., self-paced learning, workshops, or online training). But learning through trial and error is slow (Thompson, 1967; Woodward, 1965), and leadership actions may work counter to professionals' efforts to coordinate amongst themselves and learn from one another (Frank, Maroulis, Belman, & Kaplowitz, 2011; Frank, Zhao, Penuel, Ellefson, & Porter, 2011). As an alternative to conventional approaches, in theory, organizations can leverage internal networks to create social learning opportunities that accelerate adoption of sustainability practices (Frank, Zhao, Penuel, Ellefson, & Porter, 2011). Social network connections can provide efficient access and exposure to colleagues who have already adopted an innovation (Hansen, 1999; Nonaka, 1994; Penuel, Frank, Sun, Kim, & Singleton, 2013; Schumpeter, 1934). Not surprisingly, the importance of one's network for social learning and diffusion of innovations is well established in other contexts (Valente, 2012). In the context of sustainability, social learning has gained recognition for its importance in water resource management, in particular, with scholars arguing that solutions require a "societal search and learning process" because "prediction and control" approaches are no longer viable (Pahl-Wostl, Mostert, & Tàbara, 2008). In this section, we will use the example of water resource management to develop the theory because it illustrates the complex challenges and practices that are the focus of our study.

Water resource governance occurs at multiple scales and involves many stakeholders, including private and non-governmental organizations such as TNC. With "predict and control" no longer available, these actors and organizations are increasingly finding solutions through collaboration within and across organizations (Mostert, Pahl-Wostl, Rees, Searle, Tàbara, Tippet, 2007; Lang, Wiek, Bergmann, Stauffacher, Martens, Moll, et al., 2012). Lang et al. (2012) identified principles of successful transdisciplinary teams that created evidence-based strategies to solve sustainability problems. These principles emphasize the importance of developing a transdisciplinary team with a joint understanding of the problem and methodological framework, generating knowledge and integrating it into the creation of solutions, producing targeted products that advance the solutions, and evaluating whether the desired scientific and societal impacts were achieved (Table 1). We define the implementation of these principles as sustainability evidence-based practices (SEBPs), i.e., evidence-based practices applied to solving complex sustainability problems in transdisciplinary teams.

Insert Table 1 here

At TNC, the complexity of water resource management was an early driver of its shift in focus from biodiversity conservation problems toward broader sustainability problems. TNC's Water Funds strategy illustrates the need for SEBPs in this context. Water funds are governance and finance mechanisms that support watershed conservation projects. With support from TNC, local water users and stakeholders (e.g., businesses, municipal governments, charitable organizations) collectively create governance and finance mechanisms specific to their context. Typically, the watershed conservation projects supported by a water fund are designed to conserve habitat for biodiversity and enhance drinking water quality for people downstream (Richter, Abell, Bacha, et al., 2013; Game, Tallis, Olander, Alexander, Busch, Cartwright et al., 2018; Kroeger, Klemz, Boucher, Fisher, Acosta, Cavassani, et al., 2018). The nearly 20 year old water fund in Quito, Ecuador was one of the first examples. Since then, water funds have spread rapidly, first in Latin America and subsequently in North America, Africa, and Asia-Pacific.

Now, there are over 30 water funds in development or being implemented (Abell, Boccaletti, Bremer, Chapin, Erickson-Quiroz, et al. 2017), with potential for at least 27 more (Tellman, McDonald, Goldstein, Vogl, Flörke, Shemie, 2018). Underscoring the need for SEBPs, a recent analysis of water funds concluded that there is no "one-size-fits-all" model and that "a sustained commitment to an evidence-based approach [is needed] to increase the likelihood that programs will attain their goals" (Bremer, Auerbach, Goldstein, Vogl, Shemie, et al., 2016).

The first Water Fund was a project within TNC before it became a strategy with over 30 teams using SEBPs to develop and implement locally adapted Water Funds. Within organizations, projects are increasingly important modes of organization and centers for innovation (Sayles & Chandler, 1971; Drucker, 1993; Bresnen et al., 2003]. Forming project teams changes the social structure of an organization, which in turn should change knowledge creation, capture, and diffusion (Brown et al., 1991; 2001; Bresnen, Edelman, Newell, Scarbrough, Swan, 2001). While much research has focused on the difficulties of learning from projects (Gann & Salter, 2000; DeFillippi, 2001; Prencipe & Tell, 2001), social capital theory suggests that learning complex practices such as SEBPs could be enhanced through joining a project team. This leads us to our first hypothesis about the effect of network ties created through project teams.

> **Hypothesis 1**: Exposure to colleagues' sustainability evidence-based practices through project assignments increases employees' use of sustainability evidence-based practices over time.

Social Learning Advantages of Cross-Organizational Unit Project Teams

From a network perspective, social capital can be described as arising from ties between individuals (Burt, 2000). Ties between individuals within the same group are "bonding" ties, while ties across social groups are "bridging" ties (Adler & Kwon, 2002). Studies of bridging ties between different organizations show that these infrequent, weak ties are the most valuable for learning about innovations because they provide non-redundant information (Burt, 1992; Burt, 2000; McEvily & Zaheer, 1999; Molina-Morales & Martínez-Fernández 2009; Nahapiet & Ghoshal, 1998;). Employees that bridge "structural holes" (i.e., the space between groups) increase their potential exposure to innovators (Nonaka, 1994; Penuel, Frank, Sun, Kim, & Singleton, 2013; Schumpeter, 1934). Bridging ties therefore predict increases in creativity and learning (Ancona & Caldwell, 1992; Burt, 2000). Indeed, bridging structural holes has been correlated with organizational learning (Burt, 2000; Cohen & Levinthal, 1990). In contrast to bridging ties, bonding ties that contribute to "network closure" and increase social cohesion, solidarity, and cooperation have value in sustaining or improving performance of existing routines (Adler & Kwon, 2002; Coleman, 1988).

While much of the research on social capital and organizational innovation has focused on external bridging ties, bridging within organizations has also been shown to increase innovation (Burt, 2000; Hansen, 1999; Levin & Cross, 2004). In large organizations, units may develop or adopt different innovations based on their specific business or function; geographic, socioeconomic, or political context; as well as their particular capabilities. This local innovation and experimentation is especially likely to occur for sustainability practices because environmental sustainability challenges, such as drought, pollution, sea level rise, fires, or deforestation and land conversion, vary across geographies. At TNC, Water Funds first arose in the Ecuador program as a result of a team innovating to develop a solution that fit their local context. Watershed conservation (e.g., restoring or protecting forests) is particularly effective for improving water quality in subtropical environments such as in Quito, Ecuador and there was a substantial governance and financing capacity gap that could be filled for watershed conservation in Quito (Bremer, Auerbach, Goldstein, Vogl, Shemie, et al., 2016).

The problem is that employees in any one unit may find it extremely difficult and time-consuming to learn about potentially useful innovations in other units. Bridging ties with employees in other organizational units, however, can speed up this process (Burt, 1992; Hansen, 1999) and foster novel learning across a variety of environmental, social, economic, and political contexts (as illustrated in Pretty & Ward, 2001). Yet, bridging has been shown to have limitations. Bridging may help transfer explicit knowledge, but it may be less helpful for transferring tacit knowledge. Complex innovations, such the sustainability practices that are the focus of this study, are distinguished by tacit knowledge, or knowledge that cannot easily be written down (Von Hippel, 1994). This type of knowledge is more easily shared when there is a high level of shared purpose, trust, and cohesion, which is promoted by bonding ties (Saxenian, 1994). Too many bridging ties and not enough bonding ties can erode the conditions that are important for learning complex practices and inhibit the assimilation of new innovations (Hansen, 1999; Meyer & Goes 1988).

In the spirit of Alder & Kwon (2002) who did not want to bifurcate research on ties, we propose that internal ties (bonding within units, bridging across units) and external ties (bridging across organizations) should be on a spectrum (Fig. 1). These ties have different values in terms of exposure to new practices and social conditions that promote integration and local adaptation of practices. Cross-unit ties (i.e., internal bridging ties) may have advantages by providing moderate levels of both of these values that are important for adopting new complex practices, such as

SEBPs. Advancing the research of Hansen (1999) who demonstrated the value of bridging across organizational units for finding innovations but not for transferring innovations, we focus on a specific type of bridging ties that results from cross-unit project teams.

Project teams formed across organizational units may have social learning advantages that promote innovation because the relationships amongst team members have attributes of both bridging and bonding ties. From the perspective of the organizational unit, joining the team forms a bridging tie to another group who may be a source of innovation, similar to bridging outside of the organization. From the perspective of the project team, the team member will form bonding ties within this new group, enhancing conditions that promote transfer of tacit knowledge. Moreover, while the group would be new to the team member(s), it is still part of the same organization with the same mission, values, and leadership. The organizational social capital should be reflected in shared goals and trust even across employees from different organizational units (Leana & Van Buren, 1999). This leads us to our next set of hypotheses about the effect of different types of network ties.

Hypothesis 2a. Bridging Effect: Exposure to colleagues' sustainability evidence-based practices from different organizational units (bridging) through project assignments increases employees' use of sustainability evidence-based practices.

Hypothesis 2b. Bonding Effect: Exposure to colleagues' sustainability evidence-based practices in the same organizational unit (bonding) through project assignments has no effect on employees' use of sustainability evidence-based practices.

Effect of Different Types of Ties at Different Stages of the Innovation Process

Burt (2000) observed that bridging helps access “sources of value,” while bonding ties “can be essential to realizing the value” (i.e., adopting a practice or innovation). This observation emphasizes the importance of these different ties in different stages of the innovation process. If exposure is a prerequisite to adoption and bridging increases exposure to innovations, this could explain the results suggesting that individuals without bridging ties are less likely to adopt innovations (McEvily & Zaheer, 1999).

Although cross-unit bridging ties have attributes of both internal bonding ties and external bridging ties, Fig 1 shows that they should be superior to bonding ties for exposure to new practices. This has implications for the benefits of these ties for employees at different stages of the innovation process. As shown by Hansen (1999), when an employee is not yet using an innovation, cross-unit bridging ties help employees find the innovation, but they do not help with transfer and integration. In the context of this case study, if an employee has zero or low levels of adoption of SEBPs, they have likely had little to no exposure to SEBPs of other employees. Therefore, bridging could increase their exposure to SEBPs and subsequent adoption of these practices. Put another way, without first being exposed to SEBPs, an employee cannot “realize the value” of these innovative practices through bonding ties. This leads us to our last set of hypotheses about the moderating effect of the starting level of practices on the effect of network ties.

Hypothesis 3a: The effect of exposure to colleagues’ sustainability evidence-based practices from different organizational units (bridging) through project assignments is higher for employees whose starting level of sustainability evidence-based practices is low than for employees whose starting level is not low.

Hypothesis 3b: The effect of exposure to colleagues' sustainability evidence-based practices in the same organizational units (bonding) through project assignments is no different for employees whose starting level of sustainability practices is low than for employees whose starting level is not low.

METHODS

Case Study Background

TNC is an increasingly large actor in sustainability (Kareiva, Groves, Marvier, 2014). Historically, TNC's core strategy and brand has been defined by its collaborative, science-based approach to conserving biodiversity through land acquisitions and conservation easements. The framework and methodology for this approach, called Conservation by Design (CbD), was first captured in a policy document in 1996 (Fisher & Dills, 2012; Groves, Jensen, Valutis, Redford, Shaffer, et al., 2002; Kareiva, Groves, Marvier, 2014; Poiani, Baumgartner, Buttrick, Green, Hopkins, Ivey, et al., 1998). Since then, CbD has been adapted and used by many other conservation organizations and natural resource agencies (Fisher, Montambault, Burford, Gopalakrishna, Masuda, et al., 2018). In 2012, TNC updated its mission and focused its strategies on addressing challenges for nature and people, i.e., sustainability challenges (Tallis, Hawthorne, Polasky, Reid, Beck, et al., 2018).

CbD was updated in 2015 (version 2.0) in order to support the shift toward broader sustainability problems (TNC, 2015), such as providing food and water sustainably, tackling climate change, and building healthy cities. A key innovation in CbD 2.0 is the increased use of SEBPs. SEBPs in CbD 2.0 have three features that distinguish them from evidence-based practices (EBPs) in previous versions of CbD (Table 1). First, they focus on solving interlinked challenges for nature and people. Second, they involve drawing on and generating evidence from multiple disciplines and sources to support theories of change and impact evaluation. Third, they address underlying systemic drivers of problems rather than proximate threats.

SEBPs are complex practices that require tacit knowledge and local adaptation, which can be accelerated by exposure to colleagues who are already adopting the practices. SEBPs are complex, even in comparison to previous EBPs promoted by earlier versions of CbD. In the earlier versions of CbD, TNC's methodology focused on mapping biodiversity and its threats, and then developing conservation action plans for protection. In contrast, the methodology for developing plans related to the sustainability challenges cannot be as prescriptive as the previous methodology for conserving biodiversity through protection (Game, Tallis, Olander, Alexander, Busch, Cartwright et al., 2018; Mostert, Pahl-Wostl, Rees, Searle, Tàbara, Tippet, 2007).

Our qualitative research showed that SEBPs arose in different organizational units that found it necessary to address sustainability challenges such as water resource management, in addition to the more traditional and relatively simpler nature conservation challenges (Galey, 2015). Therefore, bridging ties across organizational units was hypothesized to be important for first learning about these practices. The fact that these bridging ties were formed because of project team assignments suggests that they also have attributes of bonding ties that would be beneficial for adapting these complex practices.

Although TNC endorsed SEBPs when it published CbD 2.0 in 2015, it is unclear whether and how CbD 2.0 will lead to the consistent use of SEBPs across TNC (Masuda, Liu, Reddy, Frank, Burford, et al., 2018). CbD 2.0 was communicated to staff primarily through the release of the CbD 2.0 overview document on March 17, 2015 and the technical guidance on March 23, 2016. Aspects of earlier versions of CbD (e.g., ecoregional plans, conservation action plans) were required for some business processes (e.g., approval for use of internal funds for land acquisition); however, adoption of CbD 2.0 remains voluntary at this time.

TNC was an ideal context to test these hypotheses for two main reasons. The SEBPs TNC is promoting are a good example of complex sustainability practices that are increasingly important to organizations and more elusive than simpler environmental practices such as recycling or saving energy (Michaelis, 2003; Ortiz-de-Mandojana & Bansal, 2016; Ricketts, 2013; Seidel, Recker, Pimmer, & vom Brocke, 2010). TNC's organizational structure and use of cross-organization unit project teams allowed for an examination of project team ties that have benefits similar to external ties while still having the benefits of internal ties (Fig. 1). TNC state and country "chapters" or organizational units have some resemblance to a federation (i.e., they are centrally controlled but have some internal autonomy). While to the contribute to the same mission and global priorities, each unit faces local sustainability and conservation challenges that shape its contribution to global priorities and its own local priorities (Masuda, Liu, Reddy, Frank, Burford, et al., 2018). Forming ties with employees in other organizational units might have value in terms of exposure to new practices, just as an external tie might; however, because the tie is within the same organization, it also might have value in terms of integrating practices, due to a shared mission, priorities, values, and culture.

TNC had at least three other attributes that make it a good context for studying internal organizational network processes and sustainability practices. First, it has a robust enterprise communications system where organizational knowledge can be distributed (Ellison, Gibbs & Weber, 2015). Second, as a not-for-profit organization, we can expect that individual employees are typically motivated by aspects of job satisfaction other than monetary compensation (Benz, 2005) and we thus expect social capital to exert a strong influence. Third, the organization has made its brand around being "science-based" (e.g., Kiesecker, Comendant, Grandmason, Gray, Hall, et al., 2007), and was thus amendable to empirical study of its organizational knowledge transfer and uptake of sustainability practices.

Data

We used multiple data sources to evaluate how staff's exposure to SEBPs through their internal social networks affected subsequent adoption of SEBPs. The study population was eligible staff in TNC's North America Region (NAR). We considered staff eligible if they were full-time employees with jobs in the executive, conservation, and science job families because CbD 2.0 is an explicit guiding framework for these employees' practices. Employees in all other job families where CbD 2.0 only implicitly guides their practices (external affairs, finance, human resources, legal, marketing, operations, philanthropy, and technology and information systems) were excluded from the study. Data sources for the study population included survey data, administrative network data, and digital records of interactions with CbD 2.0 materials and professional development opportunities (i.e., conventional learning opportunities).

Survey

We conducted a survey to assess changes in SEBPs over a one-year period around the release of CbD 2.0. The baseline survey was conducted May 12-June 26, 2015 (time 1) and the follow-up survey was conducted approximately a year later, May 5-June 9, 2016 (time 2).

Eight survey items measured respondents' use of SEBPs (Table 1). These survey items reflect principles of sustainability problem-solving, as described by Lang et al. (2012). As such, they represent best practices for implementing these principles. For example, the principle of "develop joint understanding" is embodied by the practice "identify conservation opportunities by conducting or participating in developing theory of change linked and informed by data." As illustrated by this example, these practices involve tacit knowledge. The survey also included questions about demographics and education, current position and professional experience, and the sources and frequency with which staff acquire and share information.

The SEBPs measured in the survey represent new innovations embodied in CbD 2.0. Although the practices were new for CbD, some innovators in the organization were already practicing SEBPs. In addition, some EBPs had been applied at TNC prior to CbD 2.0.

The survey was developed based on semi-structured interviews with the CbD 2.0 Steering Committee Members. These members are TNC staff with various job functions ranging from science to executive jobs. These staff were excluded from the study population. The survey was piloted multiple times with 15 staff and refined based on pilot testers' feedback.

The number of staff receiving the baseline and follow-up survey was 1,256 and 1,536, respectively. The baseline survey was completed by 586 staff (46.7%), while 691 staff completed the follow-up survey (45.0%). Survey responses included 317 staff who completed both the baseline and follow-up survey (Table 2). Using a difference of means test, we compared the staff that entered into final analysis with staff composing the entire studied population. Staff in the sample have a higher job grade (M=6.90, SD=1.90), and higher service years (M=12.06, SD=7.92) than staff in the population ($t(316)=11.24$, $p<.001$; $t(316)=6.86$, $p<.001$). There are more scientists and more executives, but slightly fewer conservationists in the sample than in the population ($\chi^2(2, N=317)=14.33$, $p<.001$). These differences between the sample and the population are not surprising given that the survey was voluntary. The attributes of our sample relative to the population indicate that our sample has a higher representation of staff that are responsible for implementing innovation, which is a bias that favors our study given its focus on adoption of innovations.

Insert Table 2 here

Network Exposure and Administrative Data

We used timesheet and human resource (HR) data retrieved in June 2016 to estimate exposure to SEBPs through the social network and to quantify employee characteristics. The timesheet data included information on the number of hours and the respective projects billed for a two-week time period. The HR data included information on an individual's location, department, operating unit (OU, a state or regional business unit), job family (conservation, science, or executive), and job grade. All timesheet and HR data were anonymized to ensure confidentiality.

We defined social network ties based on staff participation in common projects during a period between the baseline and follow-up survey (July 3, 2015 to April 22, 2016). This period between the surveys is when network interactions could contribute to an individual's change in practices (as reported on the time 2 survey) relative to their prior practices (as reported on the time 1 survey). We collapsed the person-to-project network data to person-to-person network data. We assumed that the strength of the person-to-person connection (i.e., the tie) was not affected by the number of staff on a project; staff had the same level of exposure to other's norms and information across projects. Instead, we assumed that exposure varied by the number of projects shared between two employees. To represent these assumptions, we did not differentiate person-to-person connections by project size and we weighted the connections by the number of projects the two people shared. So, if, for example, Employee A works on four projects with Employee B and on three projects with Employee C then the strength of the connection between Employee A and Employee B will be four and between Employee A and Employee C will be three, regardless of the sizes of the projects. But we did take the log of the number of ties representing our assumption that each additional project contributes less to the tie than the previous shared projects.

The final person-to-person network data contains 2,868 pairs of people who shared at least one project. We limited individuals in the analysis to those who responded to both surveys and had no other missing data (N=317, see section on missing data). This was necessary because we used individual's time 2 practices as the dependent variable and time 1 practices as a key independent variable. Similarly, we defined colleagues (in network terminology, "alters") as those who shared projects with the individual and responded to the time 1 survey (N=500). This is because we used colleagues' time 1 practices to calculate each individual's exposure to colleagues' prior practice.

Direct Exposure and Professional Development Data

To compare the effect of network exposure to conventional exposure, we also developed measures of conventional learning opportunities. We assumed that network exposure provided social learning opportunities, while direct exposure to CbD materials and professional development programs represented conventional learning opportunities.

Direct Exposure. Staff could be directly exposed to CbD 2.0 through digital or in-person interactions with CbD 2.0 materials. We compiled data on which individuals had direct exposure to CbD 2.0 materials. All staff were potentially exposed to the material via all-staff emails and had an opportunity to download the materials from the intranet; we measured which staff were exposed to this information by tracking clicks on emails and web site traffic and document downloads. In contrast, only some staff were actively involved in drafting or reviewing the technical guidance, among other targeted activities.

Professional Development. These opportunities included an in-person conference with a session on CbD 2.0 (September 2015), an online training related to considering human well-being as part of CbD 2.0 (January 2016), online informational presentations (WebEx) about CbD 2.0 (March 2015 and March 2016, two months prior to the time 1 survey and time 2 survey, respectively), or participation in a "beta-pilot" of CbD 2.0 (July-September 2015).

Out of these multiple measures of direct exposure and professional development, we selected two to include in the full models. Selecting a subset of the measures avoided over-fitting the final model. The selection criterion was the measure with the highest significant partial correlation with practices in time 2, controlling for practices in time 1. The measure that fit this criterion was participation in the WebEx in March 2016 ($r=0.15$, $p<0.005$). We also included participation in the WebEx in March 2015 because it was the first of this two-part WebEx series. The WebEx in March 2015, however, did not have a significant partial correlation with time 2 practices. These WebEx's followed the release of the CbD 2.0 overview document and the technical guidance.

Non-CbD 2.0 Professional Development Training Data

As a control, we also developed a measure of employees' propensity for learning. This measure used data on the number of non-CbD 2.0 professional development training courses offered by TNC that individuals completed, whether online or in-person (counted separately), from April 2013 through October 2015.

Variable Description

Dependent variable

Our dependent variable is SEBPs in time 2 measured by eight binary survey items (α=.72 based on the full sample at time 2: N=691; Table 1). A value of 1 for a survey item indicates an individual engaged in this activity in the past 12 months and a value of 0 indicates that they did not. Thus, we defined an individual's SEBPs by taking the average of the items: an average value of 1 indicates the individual was engaged in all eight practices and 0 indicates no engagement in any of the eight SEBPs. Individuals on average engaged in 44% of the possible SEBPs at time 2 (*M*=0.44, *SD*=0.28, Table 2).

Independent variables

Prior SEBP. We used the same set of items that we used for the dependent variable to generate a composite score for SEBPs at time 1. Individuals on average engaged in 42% of SEBPs at time 1 (*M*=0.42, *SD*=0.29, Table 2).

Network exposure to colleagues' SEBPs. We quantified individual *i*'s exposure to colleagues' practices through shared projects. Individuals on average connected with nine colleagues in their network (*M*=8.92, *SD*=5.36), with a minimum of one colleague and a maximum of 26 colleagues (Table 2). Among the 2,868 network ties between staff and their colleagues, individuals on average shared two projects with a colleague (*M*=1.74, *SD*=1.38), with a minimum of one and maximum of 12 projects shared (Table 2). We weighted colleague *j*'s prior practices by the log of the number of projects shared by individual *i* and colleague *j*. The weighting represents our assumption that each additional project contributes less to the tie than the previous shared projects.

To calculate exposure to all colleagues, we then took the average of weighted prior practices across all colleagues with whom individual *i* shared projects:

$$Network\ exposure\ to\ colleagues'practice\ through\ project\ interaction_i = \frac{\sum_{i=1, j \neq i}^{n-1} (\log(1 + number\ of\ projects\ shared_{ij})) \times (colleague's\ prior\ practice_j)}{n-1}$$

where $number\ of\ projects\ shared_{ij}$ is the number of projects individual *i* shared with person *j*. Consider Employee A who worked on four projects with Employee B and on three projects with Employee C, and Employee B had implemented 30% and Employee C 50%, then the total network exposure for Employee A is $\frac{\log(1+4)\times 0.3 + \log(1+3)\times 0.5}{2} = 0.59$ (Fig 2). In this way the exposure term collapses information about exposure to multiple others into a single measure representing the combined forces to which a person is exposed. By further categorizing colleagues into two types, we used the same approach to construct two separate network exposure terms to colleagues from the same operating unit (bonding) and to colleagues from different operating units (bridging). For any observation, these two measures sum to the overall network exposure term. Continuing the example above, Employee A and B were in the same operating unit and employee C was in a different operating unit, then A's exposure within the operating unit would be $\frac{\log(1+4)\times 0.3}{1} = 0.48$ and A's exposure to employees in different operating units would be $\frac{\log(1+3)\times 0.5}{1} = 0.69$ (Fig 2). The total network exposure is highly correlated with network exposure to colleagues from the same operating unit ($r(317)=0.88$, $p<.001$), and moderately correlated with network exposure to colleagues from different operating units ($r(305)=0.32$, $p<.001$; Table 3). Individuals on average collaborate with 5.69 colleagues within the same operating unit, and with 4.59 colleagues from different operating units across projects (Table 2).

Job family. An individual's job family is either conservation, science, or executive. A Tukey test showed that at time 2 science staff used SEBPs 16.23% more than conservation staff (p<.01), executive staff used these practices 10.23% more than conservation staff (p<.01), and science staff's practices were not significantly different from executive's practices. Based on this analysis, we set conservation staff as the reference group in the model and created indicator variables for the science and executive job families.

Location in formal organizational structure

Job grade is determined based on the requirements of each job as enumerated in formal job descriptions (e.g. required education and years of experience, expectations about managing staff or budgets, etc.). Within NAR, the average job grade is 7 (M=6.90, SD=1.90), with the lowest grade of 2 (e.g. a member of a land stewardship crew) and the highest grade of 12 (e.g. a regional executive vice-president) (Table 2). We assume that job grade has a non-linear relationship with SEBPs. Thus, we created a quadratic term based on the centered job grade variable along with the linear specification.

Organizational hierarchy. We used supervisor data to generate an organizational hierarchy of the NAR (N=2,264). Individuals that are not a supervisor of any staff were assigned a hierarchy level of 1. To move up a level in the hierarchy, an individual must be a supervisor of someone that is one step lower than themselves in the hierarchy (for example, a manager who supervises staff with no direct reports would be a level 2 and the supervisor of that manager would be level 3). In the case of our study population, all staff eventually reported up to a single executive vice-president. Individuals on average are located at level 2, with 8 being the maximum level (M=2.09, SD=1.38, Table 2).

Direct Exposure

WebEx 2015. Initial WebEx informational presentations about CbD 2.0 took place on March 12-26, 2015, following the release of the CbD 2.0 overview document. Of those TNC staff sampled, 44% attended one of these online presentations.

WebEx 2016. Further information was disseminated via WebEx on March 29, 2016 and April 1, 2016, following the release of the technical guidance for CbD 2.0. Of those TNC staff sampled, 49% of people attended this CbD 2.0 online informational presentation.

Propensity for learning

Total number of optional learning events completed. All "required" trainings/learning were excluded and the number of remaining trainings each recipient completed was calculated, irrespective of the learning type. On average, individuals attended 12 optional learning events (*M*=11.71, *SD*=6.30), with a minimum of no learning events and a maximum of 58 learning events (Table 2).

Insert Table 3 here

Validity of SEBP and Network Exposure Measures

SEBP Measure

Content Validity. We believe that the SEBPs have content validity because of how these measures were developed. Following Salkind (2010), subject matter experts on our team developed survey items that directly corresponded to the three new features in CbD 2.0 described in the case study subsection above. These were then tested with TNC staff not included in the study but were involved in the development of CbD 2.0 (the Steering Committee members), and refined based on their feedback. One threat to content validity may be that there is heterogeneity in the types of projects and domains between organizational units, which may in turn threaten content validity if staff in different organizational units interpret or understand some of the SEBPs practices in the survey differently. However, there is little evidence or reason to believe this is a threat, as the survey items are generalizable to various projects and contexts. For instance, the survey item, which asked participants if they "promote conservation work to incorporate cross- or multi-disciplinary knowledge when communicating science and activities," is applicable to any type of biome, context, partnership, or strategy. Further, when developing survey items the CbD 2.0 subject matter experts were themselves situated in different units, thus providing perspectives on whether and how various staff may interpret the survey items. The issue itself did not come up.

Construct Validity. The items were then mapped onto Lang et al.'s (2012) principles of transdisciplinary sustainability research. Starting from a theory of an ideal process, Lang et al. (2012) defined principles based on a synthesis of literature from multiple fields and empirical evidence from projects in Europe, North America, Africa, and Asia. The purpose of these projects were to produce "evidence-based strategies" to solve sustainability problems and to advance science. The result of the analysis was a set of 12 principles corresponding to each of three phases of research, as well as cross-cutting design principles. Our eight survey items for measuring SEBPs mapped onto principles in each of the three phases and onto one of the three cross-cutting design principles. Consistent with our argument for construct validity, Masuda et al. 2018 found that a measure of attitudes about CbD 2.0, which we would expect to be correlated with SEBPs, was higher in organizational units where bridgers diffused more information about CbD 2.0. Specifically, staff in these units believed that applying the approaches from CbD 2.0 (i.e., SEBPs) increased the number of contexts in which we can work.

Network Exposure Measure

We avoided the reliability issues caused by human error in self-reported network measures by using administrative (i.e., timesheet) data to estimate network ties. Studies show that respondents are less likely to report infrequent interactions (Marsden, 2011), especially if the respondent is a novice (Pitts & Spillane, 2009). In contrast, timesheet data objectively records all interactions created through project team assignments, no matter how infrequent.

Of course, one potential concern with administrative data is that it might not be a good measure of the network ties that are most important for learning, such as informal ties. We were able to provide evidence of the validity of our network measure based on timesheet data by comparing it to a network measure based on self-reported ties.

Modeling Strategy

Our modeling strategy aimed to identify individual-level changes in practices resulting from one-to-one diffusion of practices within the social network. To do so, we estimated how network exposure to colleagues' prior SEBPs (as measured by the time 1 survey) impacted a given individual's SEBPs (as measured by the time 2 survey), holding constant other learning opportunities and job condition as well as the individual's prior SEBPs (as measured by the time 1 survey). As described above, we defined network exposure as the average of the weighted prior practices of colleagues who shared projects with an individual. We controlled for the tendency for people to interact with others of the same orientation by including prior practices as an independent variable, rather than using the difference between current and prior practices as the dependent variable (Allison, 1990). Frank & Xu (2018a) show through proof and simulation that this approach eliminates bias due to selection of network members based on one's prior behaviors. We estimated three separate models. Model 1 includes an overall network exposure term to estimate effects on individual's SEBPs at time 2. It does not differentiate types of network ties (bridging vs. bonding). Model 2 used the same modeling approach but does differentiate between types of network ties. It does so by including separate variables for network exposure to colleagues from the same operating unit (bonding) and network exposure to colleagues from different operating units (bridging). Building on model 2, model 3 further included an indicator for low implementers of SEBPs in time 1, and the interaction terms between the low implementers and each of the network exposure terms, i.e. to colleagues from the same operating unit (bonding) and to colleagues from different operating units (bridging). Recognizing potential concerns for omitted variables, we quantify the bias in our estimates necessary to invalidate our inferences following Frank et al. (2013) in the result section.

Model 1

$\text{SEBP}_{i,\text{t}} = \text{Intercept} +$

$\text{SEBP}_{i,\text{t-1}} +$

$\text{Exposure to all colleagues' SEBP}_{i,t\text{-}1\text{->}t} +$

$\text{Science}_{i,t} +$

$\text{Executive}_{i,t} +$

$\text{Job Grade}_{i,\text{t}} +$

$(\text{Job Grade}_{i,\text{t}})^2 +$

$\text{Organizational Hierarchy}_{i,t}$

$+e_{i,t}$

Model 2

$SEBP_{i,t}$ = Intercept +

$SEBP_{i,t-1}$ +

Exposure to SEBPs of colleagues from same operating unit $(OU)_{i,t-1->t}$ +

Missing indicator for exposure to same OU $colleagues_{i,t-1->t}$ +

Exposure to SEBPs of colleagues from different operating units $(OU)_{i,t-1->t}$ +

Missing indicator for exposure to different OU $colleagues_{i,t-1->t}$ +

$Science_{i,t}$ +

$Executive_{i,t}$

Job $Grade_{i,t}$ +

(Job $Grade_{i,t})^2$ +

Organizational $Hierarchy_{i,t}$

$+e_{i,t}$

Model 3

$SEBP_{i,t}$ = Intercept +

$SEBP_{i,t-1}$ +

Exposure to SEBPs of colleagues from same operating unit $(OU)_{i,t-1->t}$ +

Missing indicator for exposure to same OU $colleagues_{i,t-1->t}$ +

Exposure to SEBPs of colleagues from different operating units $(OU)_{i,t-1->t}$ +

Missing indicator for exposure to different OU $colleagues_{i,t-1->t}$ +

Low $implementer_{i,t-1}$ +

Low $implementer_{i,t-1}$ * Exposure to SEBPs of colleagues from same operating unit $(OU)_{i,t-1->t}$ +

Low $implementer_{i,t-1}$ * Exposure to SEBPs of colleagues from different operating units $(OU)_{i,t-1->t}$

+

$\text{Science}_{i,t}$ +

$\text{Executive}_{i,t}$

$\text{Job Grade}_{i,\text{t}}$ +

$(\text{Job Grade}_{i,\text{t}})^2$ +

$\text{Organizational Hierarchy}_{i,\text{t}}$

$+e_{i,t}$

$\text{SEBP}_{i,t}$ are individual i's practices at time t=2 (2016). This individual's prior practices (i.e., baseline measure of SEBPs) are captured as a covariate at time t-1=1 (2015). As described above, we estimate the general network exposure effect (model 1), the effect of specific network ties (model 2), and the interaction between level of implementation and exposure through specific network ties (model 3). In model 2, we include indicator variables for missing data (see next section). For model 3, we assumed a non-linear relationship between the moderating effect of the starting practice level on the network exposures and the practice level at time 2. Thus, we dichotomized the prior practices measure to be people who were below the 25^{th} percentile (time 1 low implementers) compared to those who were above this threshold. In each model, we also estimated effects of job family (science and executive), job grade, job grade squared, and level in the organizational hierarchy.

In addition to these parsimonious model specifications, we estimated specifications of model 1 to 3 that include measures of direct exposure to CbD 2.0 (WebEx 2015 and WebEx 2016) and propensity for learning (optional learnings completed).

To compare the size of the effect of independent variables measured in different units, we standardized all variables to have variance of 1. Standardized coefficients (β) therefore indicate the change in practices measured in standard deviations resulting from a change in one standard deviation of the independent variable.

Missing data

We collected surveys from 691 individuals in time 2; however, 355 individuals lacked information on their prior SEBPs (time 1). In addition, 33 respondents had missing information on their colleagues' prior SEBPs. Finally, 4 respondents were missing data on their position in the organizational hierarchy and 2 respondents were missing information on optional learning activities. We used listwise deletion to handle missing data for estimating the overall network effect in model 1 (see Appendix A for a more detailed description of missing data). Therefore, the final analytical sample for model 1 estimating the overall network effect was 317.

In model 2, we separated the network exposure term into exposure to one's colleagues from the same operating unit and exposure to colleagues from different operating units. Of the 317 individuals included in the final analytical sample, 119 had missing data on their network exposure to colleagues from different operating units. These cases represented individuals who either did not collaborate on projects outside their operating unit or we lacked survey data on their outside operating unit collaborators' prior SEBPs. Similarly, we observed 12 individuals missing network exposure to colleagues in the same operating unit under the same mechanism. (Appendix A, Table A1).

We used a dummy variable adjustment method to address missing data in model 2 by flagging and accounting for the missing information in the model, and we did the same for model 3 (Cohen, Cohen, West, & Aiken, 2013). We flagged missing data by creating indicator variables for missing network exposure data, one for colleagues in the same operating unit and another for colleagues from different operating units. If the missing data indicator is 1, we assign a 0 to replace the missing data in the corresponding network exposure variable. We then include these indicator variables in the model to account for variation in the outcome variable that is due to missing data in two separate network exposure terms. The final analytical sample for model 2 was 317 respondents.

Insert Table 4 here

RESULTS

Supporting hypothesis 1, we found a significant and positive impact of exposure to colleagues' time 1 SEBPs on an individual's time 2 SEBPs ($\beta = 0.109$), controlling for an individual's prior practices (Table 4, model 1). As expected, an individual's prior practices had the greatest positive impact on SEBPs in time 2 ($\beta = 0.453$) (Table 4, model 1). Put another way, individuals were likely to continue SEBPs if they had already adopted them in time 1. Exposure to colleagues' SEBPs through the social network was 24% as influential as one's own prior practices.

Both job grade ($\beta = 0.160$) and being a member of the science staff ($\beta = 0.128$) had positive effects on practices in time 2. These effects were larger than the effect of network exposure (Table 4, model 1). Job grade squared, being an executive staff, and position in the organizational hierarchy had no significant effect (Table 4, model 1).

When we separated network exposure by type of network tie (i.e., bridging vs. bonding ties), we found that exposure to colleagues' time 1 SEBPs from different operating units (bridging) had a significant, positive effect on an individual's practices in time 2 ($\beta = 0.174$); however, exposure to colleagues' time 1 SEBPs from the same operating unit (bonding) was not statistically different from zero (Table 4, model 2). The two are borderline different from each other (p < .14, using a Wald test). These findings support hypothesis 2a and 2b. Exposure to colleagues' practices from different operating units is 38% as influential as one's own prior practices. This relative effect is 60 % greater than what was estimated for general network exposure in model 1. This, of course, is consistent with the model 1 results because the general network exposure metric in model 1 combines exposure to colleagues from the same OU ($\beta = 0.059$) and colleagues from different OUs' SEBPs ($\beta = 0.174$). Note that the average change in practices across the sample was close to zero, with nearly half of all individuals increasing practices by less than 0.10.

Following Frank, Maroulis, Duon, & Kelcey (2013), we calculate that 18% of the estimated effect of exposure to all colleagues, and 21% of the network effect to colleagues from different OUs would have to be due to bias to invalidate the inference of an effect of network exposure. For example, 21% (about 67) of the cases would have to be replaced with null hypothesis cases to invalidate the inference. This level of robustness is similar to the median level of robustness across observational studies reported on in Frank et al., (2013).

Like model 1 estimates, model 2 estimates show that job grade ($\beta = 0.161$) and being a member of science staff ($\beta = 0.127$) had positive impacts on practices (Table 4, model 2). No other variables had a significant effect, including the missing indicators for the network exposures to colleagues from the same OU and to colleagues from different OUs.

When we estimated the moderating effect of starting level of practices in model 3, consistent with hypothesis 3a, we found that staff with a lower starting level of SEBPs practices are more effected by network exposures of colleagues from different operating units (bridging, $\beta = 0.203$). Also consistent with hypothesis 3b, we found no effect of the starting level of practices on the effect of network exposures to colleagues from the same operating unit (bonding) (Table 4, model 3). A comparison of these results to results from model 2 shows that low implementers particularly benefit from exposure to colleagues from different operating units (bridging): the standardized network effect of bridging ties for low implementers is 0.328 (model 3), which is larger than the standardized network effect of 0.174 from bridging ties for all staff regardless of initial SEBPs levels (model 2).

The main results of the network effects reported here were robust to the inclusion of additional variables (Appendix B, Table B1). We used the Wald test to examine the significance on the difference between the same estimates on the network effects across two different model specifications, and none of the differences were significant at an alpha level of 0.05. Job grade was borderline significant in the alternative models. The additional variables measuring direct exposure to CbD 2.0 (i.e., WebEx 2015, 2016) and propensity to learn (i.e., optional learnings completed) did not have a significant impact on SEBPs.

DISCUSSION

This study applied social capital theory to advance our understanding of how and which network ties within an organization promote the adoption of complex sustainability practices. Our findings that internal bridging promoted adoption while bonding did not supports the argument that the cross-unit project team ties (i.e., internal bridging ties) have social learning advantages for complex practices. As we propose in Figure 1, these cross-unit project team ties can be thought of as being on a spectrum with external bridging ties and internal bonding ties: they have value in terms of both exposure to new practices and conditions that promote integration and local adaptation of practices.

The finding that bridging ties had a stronger effect on individuals with low levels of practices who still need to access new information provided additional support to our theory (Fig 1). While internal bridging ties have moderate levels of value both in terms of exposure to new practices and conditions for integration, they are superior to bonding ties for exposure to new practices. Consistent with this finding, we observed that the variance in practices was higher across units than within units, meaning that individuals with low levels of practices were unlikely to get exposed to new practices without bridging. This suggests that at this early time in the diffusion process when practices were relatively low, maximizing social cohesion through bonding ties, which is thought to help transfer tacit knowledge (Hansen, 1999), was relatively unimportant. Instead, it suggests that minimizing redundancy in networks by bridging structural holes was an important mechanism for diffusion of sustainability practices (Burt, 1992; Granovetter, 1973; Nahapiet & Ghoshal, 1998). An experiment conducted in the same context lends further support to this mechanism by showing that bridgers helped diffuse information about these sustainability practices at higher rates than non-bridgers (Masuda, Liu, Reddy, Frank, Burford, et al., 2018).

Although we found evidence for the effect of bridging ties, the average effect size was small. A small average effect size is expected when there is heterogeneity in learning. Social learning through network exposure is localized and, hence, heterogenous by definition. Social groups exposed to innovators will increase the use of new practices, while social groups not exposed to innovators may not change practices at all in the short term. Network effects therefore can lead to polarization (Frank & Xu, 2018b). To understand the current polarization situation in the studied organization, we partitioned the variance in the SEBP practice and found that 95% of the variance is between operating units, with only 5% of the variance within operating unit. This indicates that the SEBP practice within operating unit is homogenous to a great extent, while SEBP practice between operating units is heterogeneous. This pattern is consistent with polarization of practices across the entire organization. To counteract polarization and promote adoption of SEBPs, managers should strategically form cross-operating unit project teams.

A small effect size would also be expected for complex practices at the start of a change process, but could grow rapidly because network groups' practices build on themselves (part of the polarization effect). Our study only observed changes in practices over one year at the start of the organizational initiative. The size of the impact from network exposure relative to an individual's prior practices (24%) is consistent with findings from other network studies of complex innovations with similar attributes (Frank, Zhao, & Borman, 2004). Examining the moderating effect of starting levels of sustainability practices provided insights into the potential non-linear effects of social learning. The sign of the moderating effect was consistent with non-linear learning.

More generally, our results support the theory that social capital that enables individuals to get exposed to innovators is important for learning complex practices (Frank, Zhao, & Borman, 2004; Valente & Pumpuang, 2007; Valente, 1995). These are important findings because there have been few studies examining the effects of organizational social networks on sustainability practices or EBPs (except see Palinkas, Holloway, Rice, Fuentes, Wu, Chamberlain, 2011 for study of EBPs). Individuals who were implementing SEBPs in time 1 were innovators because they engaged in these practices prior to CbD 2.0. Exposure to these individuals through project work provided effective social learning opportunities (Bandura, 1986). Project work suggests that individuals had repeated exposure to innovators and may even have engaged with them in joint problem solving. These conditions that enabled social learning are potentially more profound than previously studied conditions, such access to and level of expertise of the innovator (Keating, Ayanian, Cleary, Marsden, 2007). Yet, our results also showed that projects weren't sufficient for diffusion of innovation, projects needed to create social ties across organizational units. The project as a mechanism for learning in organizations warrants further investigation, especially given that more organizations are "reinventing themselves to operate as networks of teams to keep pace with the challenges of a fluid, unpredictable world" (McDowell, Agarwal, Miller, Okamoto, Page, 2016).

Of course, organizational leaders could promote sustainability practices through approaches that do not take advantage of social capital and networks [e.g., professional development training (Sarkis, Gonzalez-Torre, & Adenso-Diaz, 2010; Vidal-Salazar, Cordón-Pozo & Ferrón-Vilchez, 2013)]. Yet, we found no evidence that these alternative mechanisms were effective. Our findings are not surprising for a complex practice, such as SEBPs, or experienced employees (Frank, Zhao, Penuel, Ellefson, & Porter, 2011; Sun, Frank, Penuel, Kim, 2013). However, there may be two alternative explanations for why we saw no effect of non-network mechanisms. First, conventional learning opportunities were limited in scope. A comprehensive professional development program has not yet been implemented for CbD 2.0. Second, individual trial and error may take longer than one year. Interviews we conducted lend some support to the second explanation. We found that some individuals were aware of CbD 2.0 but were unsure of how it affected their day-to-day job and had not experimented with the new practices yet. These results are consistent with other studies suggesting that social learning is faster than learning through trial and error (Thompson, 1967; Woodward, 1965). Social learning and other forms of learning are not mutually exclusive and may even positively influence each other. Future research could, for instance, investigate whether individuals who learned through professional development and trial and error in turn enhanced the learning of others through social interactions.

In addition to network exposure, being in a science job and having a higher job grade were associated with an increase in SEBPs. In this context, job family and grade are indicators of an individual's job requirements. Uptake of SEBPs may be higher amongst staff in science jobs and those in higher job grades simply because they may be more relevant to these individual's objectives (Rogers, 1995; Wolfe, 1994). For instance, interviews that we conducted provided evidence that a director of conservation and director of science within a state program may work together to develop and lead "efforts to build an evidence base to inform strategies and priorities" (Table 1).

It is unsurprising that an individual's prior practices had the largest impact on SEBPs in time 2 because of the now well-established evidence for status quo bias (Kahneman, Knetsch, & Thaler, 1991) (see examples from farming, healthcare, and governance, respectively: Fu & Li, 2014; Hermann, Musshoff, & Agethen, 2015; Hsieh, 2015). Despite the potential benefits of SEBPs, current practices are "sticky" or hard to change (Rousseau, 2006). This raises the question: what caused innovators to initially use SEBPs? Although our results cannot address this question, related qualitative research provides some hypotheses (Galey, 2015). For example, the parts of TNC that found it necessary to work on sustainability challenges first, may have also adopted SEBPs first (Galey, 2015). Specifically, interviews suggest that staff in regions with critical freshwater issues may have been some of the first staff to work on broader sustainability challenges and adopt SEBPs. In contrast, in regions where the ecological, political, and funding context continued to support traditional land conservation, interviews suggest that staff were not early to adopt SEBPs.

This study is distinct from many other network studies in its use of administrative data (Masuda, Liu, Reddy, Frank, Burford, et al., 2018). Administrative data has three advantages for measuring network exposure. It is readily available to individuals within an organization. It represents formal, but dynamic, networks defined by projects and project teams. It is more reliable than self-reported ties [i.e., timesheet data objectively records all ties, even infrequent ones that are less likely to be self-reported (Marsden, 2011)]. A disadvantage of using administrative data, however, is that it could be a poor measure of the informal networks that individuals use to seek advice or information. To investigate this concern, we used survey data on self-reported closest colleagues from two subgroups. We compared the probability of nominating a project teammate and someone who is not a project teammate as a closest colleague. People who shared at least one project were 53.04 times (subgroup 1) and 64.41 times (subgroup 2) more likely to nominate their teammate as a close colleague as compared to people who did not share projects. This result gives us greater confidence that project teammates are close colleagues who may be relied on for advice or information.

While we believe that this study provides robust evidence for the role of social capital (i.e., bridging ties) in diffusing sustainability practices, it is not without its limitations. Neither the direct exposure to CbD 2.0 nor the exposure through the social network were randomized. Randomization was not feasible because of the commonplace challenges of conducting randomized controlled trials within organizations, e.g., all staff must have equal access to new policies and trainings. The fact that staff self-selected to attend the online informational presentations may actually further strengthen our results because staff who self-selected to attend may be more likely to change practices due to the presentation and, yet, we found no effect. By the same logic, it is possible staff who were more likely to adopt SEBPs through social learning sought out projects with colleagues already using SEBPs. However, we eliminated this concern by including prior practices as an independent variable. In addition, survey coverage was neither random nor complete; it was voluntary, creating potential biases in our measurement of responses. For instance, employees who were already engaging in these practices may have been more likely to respond to both the baseline and the follow-up survey. However, in order for this to bias our estimates of changes in practices upward, people who changed practices would have to be more likely to respond to the survey even before they were practicing. Probably one of the largest limitations to this study is the relatively short time over which we could examine changes in practices. Some of the SEBPs that we examined may only be needed at certain stages in a project life-cycle. This would bias the effect of network exposure on practices downward. In addition, as noted above, no widespread, in-depth professional development training has occurred to date.

CONCLUSIONS AND RECOMMENDATIONS

This study makes theoretical and empirical advances for the role of social capital in diffusion of sustainability practices and the influence of organizations on the natural environment. We show that learning sustainability practices can be accelerated through working on project teams that create cross-organizational unit ties (bridging ties), while we found no evidence for accelerated learning from within organizational unit ties (bonding ties). Specifically, staff learn new sustainability practices from project teammates who are in other organizational units and who are already using sustainability practices (i.e., colleagues who are innovators). Although social learning has been proposed as important in the context of organizations and sustainability (Ryan, Mitchell, & Daskou, 2012; Mostert, Pahl-Wostl, Rees, Searle, Tàbara, Tippet, 2007), this study represents some of the first robust evidence for this mechanism and does so in a way that distinguishes between different types of social capital (Adler & Kwon, 2002).

A practical recommendation from this study is that project team assignments that enable staff to learn from innovators may be a simple and cost-effective way to promote organizational learning for sustainability. Leveraging existing networks does not require conducting expensive network analyses. Supervisors should be able to observe who is doing SEBPs and assign staff to work on projects with innovators or early adopters to promote learning. Human resource managers could facilitate learning by helping multiple supervisors coordinate the assignment of project teams. On-the-job learning is not novel, but it is novel to take a social network perspective to improve organization learning for sustainability.

When using a network approach to organizational learning, supervisors and human resource managers will need to consider new ways to expose staff to innovators and early adopters that work in other organizational units. Internal fellowship programs and short-term assignments are some ways to do this. Supervisors who seek to expose staff to innovators or early adopters should consider how it might negatively affect internal social networks by elevating the status of these staff or taking time away from their normally assigned duties. While there is a strong tradition of intern- and mentor-ship in natural resource management, these are often perceived as hierarchical, whereas the relationships we were observing were often peer-to-peer or collaborative in nature. There are a multitude of structures for integrating social and natural environmental objectives into organizations (Lankoski & Smith 2018). Ensuring that managers throughout the organization understand how fostering these relationships may enhance the ultimate organizational objectives may increase the support for and sensitivity to the nuances of mainstreaming sustainability practices.

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FIGURES & TABLES

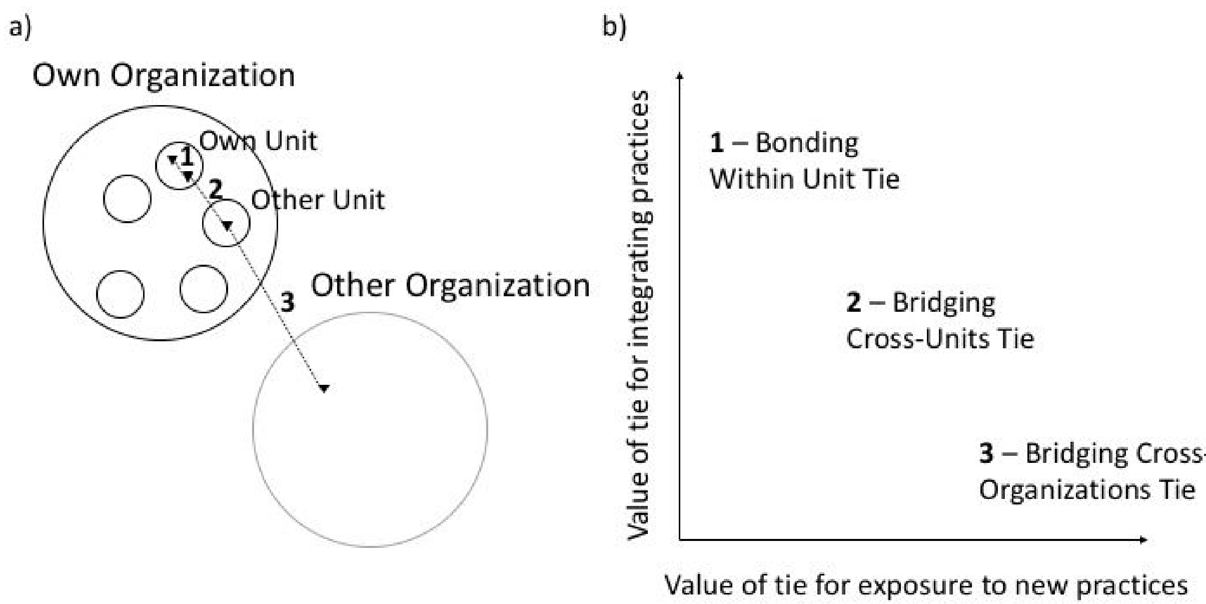

Figure 1. Social capital theory of organizations has focused on internal ties (1. within units, 2. across units) and on external ties (3. across organizations). These ties have different values in terms of exposure to new practices and conditions that promote integration and local adaptation

of practices. We propose that these ties should be thought of as being on a spectrum, where cross-unit ties may have advantages by providing moderate levels of both of these values that are important for adopting new complex practices, such as sustainability practices.

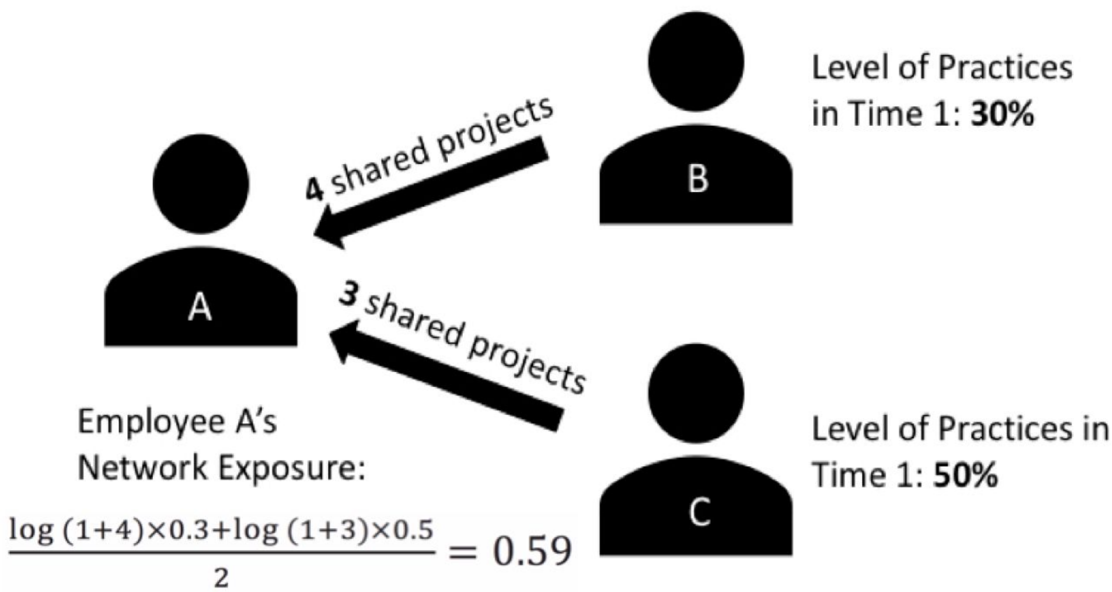

Figure 2. The network exposure of the colleagues B's and C's SEBPs to employee A.

1 Table 1. Survey items (n=8) on Sustainability Evidence-Based Practices (α=0.72) promoted by Conservation by Design 2.0

Principles (Lang et al. 2012)	Practice Survey Items	Item-Total Correlation (r)
Transdisciplinary team-building	Promote conservation work to establish new partnerships with outside organizations to address new disciplinary perspectives and expertise when communicating science and activities	0.42
Develop joint understanding	Identify conservation opportunities by conducting or participating in developing theory of change linked and informed by data	0.44
Facilitate continuous formative evaluation	Analyze and identify new opportunities by conducting some type of systematic review or synthesis of the peer reviewed, grey, and white literature when leading, developing, or adaptively managing conservation efforts	0.45
Apply methods for integration of sustainability science and practice	Evaluate alternative strategies for taking advantage of conservation opportunities by reading the conservation literature (e.g., government or policy reports, peer reviewed literature) when analyzing and building evidence for conservation	0.40
Realize integration into practice and scientific knowledge for transfer or scaling	Developed and led efforts to build an evidence base to inform strategies and priorities in conservation management	0.45
Generate targeted products	Promote conservation work to incorporate cross- or multi-disciplinary knowledge when communicating science and activities	0.44
Evaluate scientific and societal impact	Evaluate the effect or impact of conservation outcomes by qualitative assessment (e.g., key informant interviews, focus groups, administrative documents or photographs) when analyzing and building evidence for conservation	0.36
Cross-cutting		
Enhance capabilities and interest in sustainability science and practice	Cultivated fundraising support to build an evidence base in conservation management	0.33

2 Note: The survey asked, “please indicate if in the past 12 months you have engaged in the following activities.”

Table 2. Descriptive statistics for variables in the network influence model

	N	Mean or Percent	SD	Min	Max
Sustainability evidence-based practice$_t$	317	0.44	0.28	0.00	1.00
Sustainability evidence-based practice$_{t-1}$	317	0.42	0.29	0.00	1.00
Network Exposure					
Exposure to all colleagues' sustainability evidence-based practices	317	0.40	0.17	0.00	0.98
Exposure to colleague's sustainability evidence-based practices from same operating unit (OU)	311	0.43	0.22	0.00	1.21
Exposure to colleague's sustainability evidence-based practices from different operating units (OU)	202	0.32	0.17	0.00	0.82
Job Family					
Conservation	233	73.50%			
Science	59	18.61%			
Executive	25	7.89%			
Location in formal organizational structure					
Job grade	317	6.90	1.90	2.00	12.00
Organizational hierarchy	317	2.09	1.38	1.00	8.00
Professional Trainings					
WebEx 2015	317	0.44	0.50	0.00	1.00
WebEx 2016	317	0.49	0.50	0.00	1.00
Other optional learning completed	317	11.71	6.30	0.00	58.00
Number of colleagues per individual	317	8.92	5.36	1.00	26.00
Number of projects shared with colleagues	2868	1.74	1.38	1.00	12.00
Number of colleagues within same OU	324	5.69	3.76	1.00	19.00
Number of colleagues from different OUs	223	4.59	3.83	1.00	18.00

Table 3. Correlations between SEBP, network exposures, job family, location in organizational structure, direct exposure, and propensity for learning

	1	2	3	4	5	6	7	8	9	10	11	12
1. Sustainability evidence-based practice$_t$	–											
2. Sustainability evidence-based practice$_{t-1}$	0.55***	–										
3. Exposure to all colleagues' sustainability evidence-based practices	0.15**	0.04	–									
4. Exposure to colleague's sustainability evidence-based practices from same operating unit (OU)	0.09	0.05	0.88***	–								
5. Exposure to colleague's sustainability evidence-based practices from different operating units (OU)	0.16*	-0.01	0.32***	-0.10	–							
6. Conservation	-0.24***	-0.17**	-0.09+	-0.06	-0.02	–						
7. Science	0.24***	0.15**	0.10+	0.06	-0.01	-0.80***	–					
8. Executive	0.04	0.06	0.01	0.02	0.04	-0.49***	-0.14*	–				
9. Job grade	0.32***	0.29***	0.03	0.03	0.11	-0.39***	0.12*	0.47***	–			
10. Organizational hierarchy	0.16**	0.14*	-0.06	-0.05	0.05	-0.18***	-0.18***	0.57***	0.63***	–		
11. WebEx 2015	0.05	0.06	0.01	0.01	0.04	-0.12*	0.16**	-0.03	0.04	-0.05	–	
12. WebEx 2016	0.21***	0.19***	0.19***	0.18**	0.15*	-0.05	0.07	-0.03	0.30***	0.12*	0.10+	–
13. Other optional learning completed	-0.04	-0.01	0.06	0.05	-0.10	0.05	-0.04	-0.03	-0.10+	-0.04	0.01	-0.03

*p < .05. **p < .01. ***p < .00

Table 4. Regression analysis for sustainability evidence-based practices in time 2 (N = 317)

Independent variable	Model 1		Model 2		Model 3	
	B (SE B)	β	B (SE B)	β	B (SE B)	β
Sustainability evidence-based practice$_{t-1}$	0.440*** (0.047)	0.453	0.441*** (0.047)	0.454	0.545*** (0.056)	0.561
Exposure to all colleagues' sustainability evidence-based practices$_{t-1}$	0.179* (0.075)	0.109				
Exposure to colleague's sustainability evidence-based practices from same operating unit (OU)$_{t-1}$			0.071 (0.060)	0.059	0.101 (0.063)	0.084
Missing indicator for exposure to same OU colleagues$_{t-1}$			-0.065 (0.074)	-0.045	-0.016 (0.072)	-0.011
Exposure to colleague's sustainability evidence-based practices from different operating units (OU)$_{t-1}$			0.237* (0.095)	0.174	0.169+ (0.094)	0.125
Missing indicator for exposure to different OU colleagues $_{t-1}$			0.066 (0.041)	0.114	0.083* (0.040)	0.143
Low implementer$_{t-1}$					0.082 (0.091)	0.104
Interaction between low implementer$_{t-1}$ and exposure to SEBPs of colleagues from same operating unit (OU)$_{t-1->t}$					-0.155 (0.159)	-0.103
Interaction between low implementer$_{t-1}$ and exposure to SEBPs of colleagues from different operating units (OU)$_{t-1->t}$					0.549** (0.174)	0.203
Science	0.091** (0.035)	0.128	0.091* (0.036)	0.127	0.091** (0.035)	0.128
Executive	-0.081 (0.062)	-0.078	-0.084 (0.062)	-0.081	-0.076 (0.061)	-0.074
Job grade	0.024* (0.010)	0.160	0.024* (0.010)	0.161	0.023* (0.010)	0.160
Job grade squared	-0.003 (0.003)	-0.053	-0.003 (0.003)	-0.055	-0.003 (0.003)	-0.048
Organizational hierarchy	0.018 (0.014)	0.086	0.016 (0.014)	0.078	0.015 (0.013)	0.075
Intercept	-0.009 (0.065)		-0.033 (0.073)		-0.102 (0.073)	
R^2	0.360		0.366		0.413	

*$p < .05$. **$p < .01$. ***$p < .001$ B: regression coefficient; SE B: standard error of B; β: standardized coefficient for comparing estimates among predictors.

Appendix A

Description of missing data

Table A1. Description of missing data at variable level and sample size after deleting missing observations sequentially

Variable	Number of non-missing observations	Number of missing observations	Sample size (after missing observations deleted sequentially in the order below)
Sustainability evidence-based practice$_t$	691	0	691
Sustainability evidence-based practice$_{t-1}$	356	355	356
Exposure to all colleagues' sustainability evidence-based	323	368	323
Job grade	680	11	323
Organizational hierarchy	670	21	319
WebEx 2015	691	0	319
WebEx 2016	691	0	319
Classroom optional learning completed	687	4	317
Other optional learning completed	687	4	317
Exposure term further separated in model 2 based on 317 observations in model 1			
Exposure to same OU colleagues' sustainability evidence-based practices	305	12	
Exposure to outside OU colleagues' sustainability evidence-based practices	198	119	

Appendix B

Alternative models for regression analysis

Table B1. Summary of regression analysis for practice of sustainability evidence-based practices at t=2 (2016), including additional professional learning predictors (N = 317)

Independent variable	Model 1		Model 2		Model 3	
	B (SE B)	β	B (SE B)	β	B (SE B)	β
Sustainability evidence-based practice$_{t-1}$	0.448*** (0.047)	0.462	0.451*** (0.047)	0.464	0.542*** (0.057)	0.559
Exposure to all colleagues' sustainability evidence-based practices$_{t-1}$	0.186* (0.077)	0.113				
Exposure to colleague's sustainability evidence-based practices from same operating unit (OU)$_{t-1}$			0.080 (0.061)	0.066	0.098 (0.065)	0.082
Missing indicator for exposure to same OU colleagues$_{t-1}$			-0.055 (0.073)	-0.037	-0.015 (0.073)	-0.011
Exposure to colleague's sustainability evidence-based practices from different operating units (OU)$_{t-1}$			0.247* (0.096)	0.182	0.161+ (0.096)	0.119
Missing indicator for exposure to different OU colleagues $_{t-1}$			0.074+ (0.041)	0.128	0.082* (0.040)	0.142
Low implementer$_{t-1}$					0.080 (0.092)	0.102
Interaction between low implementer$_{t-1}$ and exposure to SEBPs of colleagues from same operating unit (OU)$_{t-1->t}$					-0.158 (0.159)	-0.104

Interaction between low implementer$_{t-1}$ and exposure to SEBPs of colleagues from different operating units (OU)$_{t-1->t}$					0.554** (0.175)	0.205
Science	0.099** (0.036)	0.138	0.100** (0.036)	0.139	0.093** (0.035)	0.129
Executive	-0.068 (0.063)	-0.066	-0.072 (0.063)	-0.070	-0.070 (0.062)	-0.068
Job grade	0.019 (0.010)	0.133	0.020+ (0.010)	0.136	0.022* (0.010)	0.149
Job grade squared	-0.003 (0.003)	-0.052	-0.003 (0.003)	-0.053	-0.003 (0.003)	-0.050
Organizational hierarchy	0.018 (0.014)	0.091	0.017 (0.014)	0.083	0.015 (0.013)	0.076
WebEx 2015	-0.006 (0.026)	-0.011	-0.008 (0.026)	-0.014	-0.008 (0.026)	-0.015
WebEx 2016	0.017 (0.028)	0.031	0.016 (0.029)	0.028	0.014 (0.027)	0.024
Other optional learning completed	-0.001 (0.002)	-0.027	-0.001 (0.002)	-0.015	-0.001 (0.002)	-0.020
Intercept	0.016 (0.073)		-0.023 (0.081)		-0.079 (0.081)	
R^2	0.373		0.380		0.414	

+p<.10. *p < .05. **p < .01. ***p < .001. B: regression coefficient; SE B: standard error of B; β: standardized coefficient for comparing estimates among predictors.