Dimensions of Community Change: How the Community of Sudbury Responded to Industrial Exposures and Cleaned up its Environment

Desre M. Kramer, Emily Haynes, Keith McMillan,
Nancy Lightfoot, and D. Linn Holness

Abstract

A city in northern Ontario, which has suffered more than a century of pollution from mining, went from being internationally notorious for its pollution to winning awards for its environmental restoration. The inquiry was into the levers of change that led from an awareness of environmental destruction to taking action. Semi-structured interviews were conducted with 60 people from the community, politicians, industry, miners, and academics. The theory-based analysis led to a community-change model that has helped identify the multiple layers of change required for the re-greening of the environment. With reference to the collective impact literature, this city-level case study found that the city has embraced change based upon agreement on an emerging vision, taking advantage of a confluence of timing and events, adopting evidence-based knowledge, building a sense of pride and place, and having a diffuse yet linked leadership. The Sudbury story is helpful for other industrial communities looking to achieve change.

Introduction

The City of Sudbury has a present population of 160,000 and is located 400km (249 miles) due north of Toronto, Ontario. Since the beginning of the 20th Century, Sudbury has been a highly industrialized mining town. For nearly a century, it was also known as one of the most damaged and devastated landscapes in the world. This is the story of how the community in Sudbury came together to fulfill their vision of a remediated, recovered, reclaimed, and restored environment. How the community of Sudbury achieved this transformation can be a model for other highly industrially devastated communities who want to rebuild, and re-green.

Sudbury's rocks and the source of its immense mining wealth are the result of a meteor that fell 1.87 billion years ago, creating the second largest impact structure on the planet, and one of the world's largest deposits of nickel, copper, and precious metals. Sudbury has historic production and future reserves and resources of nickel exceeding 18 million tons of metal valued in today's prices at over $180 billion (Lightfoot, 2016).

However, this wealth has come with a significant environmental price tag. By 1960, the region was the largest point source of industrial pollution on earth, equivalent to nearly the total emissions from the United Kingdom (Potvin & Negusanti, 1995). Some scientists coined an international unit of pollution, called "The Sudbury,"

to emphasize how large the Sudbury source was compared to that of many whole countries. (Gunn, 2014). The pollution was a result of the processes used in the mining and smelting of the mineral ore that has released more than 100 million tons of sulfur dioxide (SO2) and several tens of thousands of kilotons (one kiloton = 1,000 tons) of nickel, copper, and iron into the atmosphere (Gunn, 2014). There were no trees, the area's pink-grey granite rocks were coated in a thick layer of black soot, 7,000 fresh-water lakes were sterile from the falling acid rain, and the air was thick and yellow with the smell of sulfur. It was a dangerous place to live and work.

As the environmental movement grew, so did the community's awareness of the occupational, economic, societal, and health impacts of their city's industrial pollution. In the early 1970s, environmental legislation was passed in the USA and then in Canada, which targeted SO2 emissions from large polluters such as the Sudbury smelters. Ironically, regardless of this increasing awareness of environmental pollution, in 1972, following the principle that the solution to pollution is diffusion, Inco Limited, Sudbury's largest mining company and for most of the 20th Century the world's leading producer of nickel, built a 1,250 ft. smokestack at their smelting plant. The smokestack dispersed the industrial pollutants, including SO2, arsenic, copper, and nickel, out even further to a radius of 240 km. (149 miles) affecting 100,000

hectares (386 square miles). At the time this was the tallest smokestack in the world.

With this exception, the Sudbury mining industry began to respond to the regulations. In the 1970s, and again in the 1980s, the industry started introducing new ore sorting and processing procedure technology and introduced better gas capture methods with the side benefits of reclaiming metals and gases with a recycle value. In the past 40 years, the total emissions of both sulfur dioxide and metal particulates have been reduced by almost 95% (Sudbury Community Foundation, 2012).

Moreover, building upon the growing awareness of the impact of pollution on people's health and the environment, workers and their unions, politicians, university academics, industry, and community representatives came together with the goal of restoring Sudbury's environment. Aligned with a vision of a clean, re-greened environment, leaders mobilized their different groups, organizations joined the cause, advocacy groups formed, and groups acquired the skills and resources needed to lobby the government and harness the media to their cause.

For the next 35 years, applying the knowledge that the academics at Laurentian University in Sudbury had acquired about land and water restoration, many of Sudbury's black rocks and large areas of barren soil were revegetated, and its lakes, benefiting from the cleaner rain and runoff water from remediated land, began to recover (City of Greater Sudbury, 2015). Driven by a vision of green forests, living lakes, and clean air, with the help of 367,530 volunteers, including unemployed miners, high school and university summer students, local businesses, the mining companies, volunteer groups, First Nation and Metis groups, and community groups like the YMCA, the land began to recover. The community acquired a sense of pride and place.

This was not an overnight initiative; it took a lot of perseverance. By 2015, the city celebrated the planting of 9.5 million trees and 282,000 shrubs—others say 13 to 15 million trees have been planted since 1978 (Tollinsky, 2015)—and the full reclamation (liming, seeding, grassing, and tree planting) of over 3,460 hectares (8,550 acres) of land. Over $30 million has been spent on the re-greening program, the money mostly coming from solicited federal and provincial government funds, the mining companies, and private sources, with only 15% spent directly by the city (City of Greater Sudbury, 2015).

Crossing the Divide from Awareness to Action: What Do We Know?

How the community in Sudbury acted upon their awareness of the social, political, environmental, and health impact of their industrial pollution is the focus on this study. The question of how, and why, any community, organization, or individual decides to take action based on awareness is one that has been posed by many. We know that awareness of a problem is an essential and necessary first step to achieve change, yet it is not sufficient for change (Watzlawick, Weakland, & Fisch, 2011). Moreover, the change itself, whether at the individual, organizational, or community level is often so complex that it can become an elusive goal embedded in conflicting social forces (Berger & Luckmann, 1966). However, once engaged, change initiatives can develop social resilience, which Dr. Judith Kulig, from Alberta's Lethbridge University, has found to be very good for one's health (Kulig, Edge, Townshend, Lightfoot, & Reimer, 2013).

How the awareness-to-action gap can be closed has been of consistent interest to multiple fields including: the field of organizational change (Mintzberg & Westley, 1992; Senge, 1990); public health (Green & Kreuter, 2005); occupational health and safety (Bjorkdahl, Wester-Herber, & Hansson, 2008; Stokols, McMahan, Clitheroe, & Wells, 2001; Tompa, Kalcevich, Foley, McLeod, Hogg-Johnson, Cullen, MacEachen, & Mahood 2016); environmental action (Klein, 2014); education (Huberman & Miles, 1984); community-based participatory research (Minkler, Vásquez, Tajik, & Petersen, 2008); knowledge transfer and exchange/ implementation science (Graham, Logan, Harrison, Straus, Tetroe, Caswell, & Robinson, 2006; Lau, Stephenson, Ong, Dziedzic, Treweek, Eldridge, Everitt, Kennedy, Qureshi, Rogers, Peacock, & Murray, 2016; Lomas, 1997; Rogers, 2003) and very relevant for this study, the newly emerging collective impact literature embedded in community engagement (Barnes & Schmitz, 2016; Cabaj & Weaver, 2016; Kania & Kramer, 2011).

In general, the different fields examining the awareness-to-action gap have determined that for change to take place there needs to be a need or a sense of urgency for change; a vision of the change that aligns all those involved; preparation and planning for change; a strategy on how to implement the change; and ongoing communication to sustain the change. To different degrees they add that the change needs to be clearly communicated; packaged so it is attractive; regularly evaluated against metrics that track the change; and have an

obvious advantage over what already exists. Moreover, those engaged in the process need to want the final change; there need to be champions with credibility to advocate for the change; and linkages and networks need to be built between people and organizations to support the change. Some also advocate for a charismatic (vs. a transactional) leader to lead the change. Many of these variables emerged in the Sudbury case study as will be shown in the **Results** section.

Of the fields mentioned, the conditions for community change highlighted by the collective impact literature are deemed the most relevant to the Sudbury case study (see Table 1 for a comparison between the collective impact literature and Sudbury). Kania and Kramer (2011) wrote the seminal paper on collective impact referenced by all subsequent papers over the subsequent six years. They identified five conditions that communities need to fulfill in order to achieve collective impact: a common agenda; a shared measurement system; mutually reinforcing activities; continuous communication; and having a separate organization and staff with a very specific set of skills to serve as the backbone for the entire initiative. Their particular contribution, and what makes collective impact different from the much larger community change literature, is their emphasis on shared metrics to track the change (although the organizational change management literature has advocated scorecards since the 1980s), and having a "backbone structure" to mobilize and support the collective effort.

In 2016, Cabaj and Weaver wrote that they have deepened, broadened, adapted and upgraded the Kania and Kramer model. Their model asks for a transformation in thinking from the players involved in the process. They say there needs to be a paradigm shift from managing the change process to building a movement for change. They advocate a shift in focus to community aspiration; strategic learning; high leverage activities; reinforcing community engagement; and developing containers for change. They say the change process needs to be authentic and participatory, and directed by a true, shared vision. They advocate for strategic learning that includes shared measurement, but is more than just metrics; a focus on high-leverage and loose/tight working relationships; and having a "container for change" that assists the participants with personal change and growth. Additionally, they write that for community impact to be effective, individuals need to open up their hearts and minds to new possibilities, and shift boundaries

from what is socially acceptable and politically accepted. The Cabaj & Weaver model is worth noting since Sudbury was an extensive community change process, but the variables they identify as needed did not emerge strongly in this study.

Two Communities Cross the Divide from Awareness to Action

The previous section summarizes some of the overarching themes that have emerged when the social sciences have attempted to determine what is needed for organizational and community change. However, the particular question of what are the levers of change that a city needs in order to change itself in response to the awareness of industrial exposure and environmental pollution is explored in this case study.

To try and answer this particular question, the research team initially undertook an investigation in the City of Sarnia (a city in western Ontario with a population of about 70,000 that is dominated by over 60 petrochemical companies). In that case, the city acted upon an increasing awareness of a large number of workers in their "chemical valley" who were dying from lung cancer and mesothelioma caused by their exposure to asbestos. The awareness campaign was led by the unions and one charismatic leader. The unions formed a widows group, the Victims of Chemical Valley, which raised community awareness and lobbied government. As a result of this advocacy, in the late 1990s, at least 30 major articles in the Sarnia and national newspapers were written about asbestos and cancer in Sarnia. As a result of this pressure, an occupational health clinic was established to help process the more than 100 workers compensation claims. A hospice was built. The Ontario government lowered some of the occupational exposure limits. A policy was put in place that expedited the claims of the workers in Sarnia so they could take advantage of a presumption of work-relatedness for a diagnosis of mesothelioma. This made it much easier for the widows of these workers to receive compensation. This study has been written up in more detail (Kramer, McMillan, Gross, Pefoyo, Bradley, & Holness, 2015).

A second investigation was initiated, this time in the City of Sudbury, to examine if similar levers of change would emerge. The focus for the study was on occupational exposures in Sudbury. It examined how the mining sector and the miners and their unions took action in response to their awareness of injuries, fatalities, and occupational exposures in the mines. This study has been written

Table 1. A Comparison Between the Community Change Literature and Findings from the Case Study of Community Action to Remediate Industrial Pollution in Sudbury, Ontario

Summary of Conditions for Selective Impact

1. Common agenda. "Collective impact requires all participants to have a shared vision for change, one that includes a common understanding of the problem and a joint approach to solving it through agreed upon actions" (Kania & Kramer, 2011, p. 39).
- Creating a shared vision for change is the defining feature (supported by Cabaj & Weaver, 2016).
- Look at data surrounding problem, get all stakeholders on same page, identify actions to address problem (Cabaj & Weaver, 2016; Gardner, 2011).
- Take "theory of change" approach (Gardner, 2011).
- Focus on innovative approaches that reform or transform systems (Cabaj & Weaver, 2016; Gardner, 2011).
- A crisis, new funding opportunity, or innovation can create urgency for change (Hanleybrown, Kania, & Kramer, 2012).

2. Shared measurement system. Need "agreement on the ways success will be measured and reported. Collecting data and measuring results consistently on a short list of indicators at the community level and across all participating organizations not only ensures that all efforts remain aligned, it also enables the participants to hold each other accountable and learn from each other's successes and failures" (Kania & Kramer, 2011, p. 40).
- The literature places emphasis on continuous feedback, evaluation, learning, and adaptation (Barnes & Schmitz, 2016; Cabaj & Weaver, 2016; Gardner, 2011).

3. Mutually reinforcing activities. "Collective impact initiatives depend on a diverse group of stakeholders working together, not by requiring that all participants do the same thing, but by encouraging each participant to undertake the specific set of activities at which they excel in a way that supports and is coordinated with the actions of others" (Kania & Kramer, 2011, p. 40).
- Success will come from the combination of many interventions (Kania et al., 2014; Gardner, 2011) by many working groups (Hanleybrown et al., 2012).
- Consider decisions in context of others (Kania et al., 2014).
- Activities might necessarily compete (Cabaj & Weaver, 2016).
- Quick wins secure future funding and support (Barnes & Schmitz, 2016).
- Focus on activities that create biggest impact, not on those that simply make collaboration easier (Cabaj & Weaver, 2016).

4. Continuous communication. "Developing trust…is a monumental challenge. Participants need several years of regular meetings to build up enough experience with each other to recognize and appreciate the common motivation behind their different efforts" (Kania & Kramer, 2011, p. 40).
- Community must be included, if not at the center of the change (Barnes & Schmitz, 2016; Cabaj & Weaver, 2016; Gardner, 2011).
- Empowerment and capacity building must also be a priority (Gardner, 2011; Barnes & Schmitz, 2016).
- Collective impact and building trust among stakeholders takes time (Gardner, 2011; Kania et al., 2014).
- Patient urgency is a productive tension that's part of the process (Barnes & Schmitz, 2016).
- The best cross-sectoral partners must be included in the change (Gardner, 2011; Kania et al., 2014).
- Applying an equity lens. Having the right people at the table in the right positions, and doing this at the outset, not as an afterthought. Members of the community should hold leadership positions, create a culture where diverse leaders can collaborate effectively by building trust, commit to "hearing all voices, valuing all perspectives, and taking swift action to correct disparities of representation" (Barnes & Schmitz, 2016, p. 37).

5. Backbone support organizations. "Creating and managing collective impact requires a separate organization and staff with a very specific set of skills to serve as the backbone for the entire initiative" (Kania & Kramer, 2011, p. 40). Functions include: supporting inner setting for change among stakeholders (Concoran, 2010, cited in Cabaj & Weaver, 2016); balancing conflicts, managing communications, building relationships (Gardner, 2011); backbone staff "guide the vision and strategy of an initiative, support aligned activities, establish shared measurement practices, build public will, advance policy, and mobilize resources" (Kania, Turner, Justilien & Philips, 2016).
- Managing stakeholders through the change process (Barnes & Schmitz, 2016).
- Providing financial resources and an influential champion (Hanleybrown et al., 2012).

Matched with Findings From the Sudbury Study

The crisis of the big labor strike in 1978–1979 created an urgency for change. Changes in the social, economic, and political environments such as the environmental movement, mechanization and automation in the mining industry, labor strikes, mining layoffs, foreign buy-outs of the mining companies, and the political will to develop Canada's north also contributed to this urgency for change. Leaders came together, knowing that change was needed. They needed to reform or transform the systems in which they lived. Together, they agreed upon a common agenda by conceptualizing "Sudbury 2001."

The community leaders did not come together to formally decide upon a shared measurement system. The scientists provided a scientific measurement system to track the re-greening progress. The Sudbury Soils Study involved community members as panel members, and findings were reported during community meetings. The community member panelists gave feedback on methodology and results, and were thus involved in continuous feedback, learning, and adaptation. The community harnessed empirical data to advocate for the reduction in emissions that affected the community. The City of Greater Sudbury monitors certain progress indicators related to the environment.

One of the strongest themes that emerged from the Sudbury interviews was that there was diffuse, yet linked leadership. Different groups worked on different, yet mutually reinforcing, projects. An unintended outcome of these mutually reinforcing activities was that a sense of pride and place was built among the community members.

The Sudbury community was at the center of this change and the right cross-sectoral stakeholders were at the table. These groups (the unions, companies, academics, politicians, and community members) developed trusting relationships. Notably, Inco and the Steelworkers were in the middle of a rough labor strike, but understood the importance of putting those issues to the side when at the community change table.

The community change process has taken almost four decades (an indicator of "patient urgency," and there is still work to be done on pollution reclamation and social changes. The First Nations and Métis that reside in the Sudbury Basin have not been noticeably engaged in the economic diversification or restoration process. This was a notable theme at the 2016 Sudbury Protocol conference, and the urgent need to ensure they are included as partners going forward was noted.

This is the only Collective Impact condition that did not align with the findings from the Sudbury case study. Leadership was diffuse and linked (which allowed for mutually reinforcing activities); however, there was no single organization or entity leading the change process.

The Sudbury community regreening efforts have resulted in the creation of EarthCare Sudbury, a partnership between the City of Greater Sudbury and over 150 community groups and individuals. However, they act more as a secretariat than providing significant leadership.

up in more detail (Kramer, Holness, Haynes, McMillan, Berriault, Kalenge, & Lightfoot, 2017). What emerged from that focused study was that in 1974, a long and acrimonious strike was initiated by a single miner who raised awareness of the rising death rate of miners in the uranium and nickel mines in northern Ontario (Sudbury and its environs). The strike led to a provincial inquiry, the Ham Royal Commission, which provided the foundation for the province's occupational health and safety legislation. This strike was the first of a number of significant labor disputes, which industry took advantage of by mechanizing and automating. This led to a considerable improvement for the lives of those who worked underground. However, it also led to a precipitous reduction in the number of miners (from about 20,000 to less than 3,000 workers). This resulted in a decline of the power of the unions and a rise in the number of non-unionized contract workers who are more vulnerable to occupational exposures.

The investigation into the Sudbury mining sector opened up a third investigation that looked beyond the exposures in the mines to examine community change. The pollution that was released by the Inco smokestack affected the whole population, and hence a wider analysis was thought necessary to understand Sudbury's community-level change and the levers for change that were important for this community-wide engagement. A new research question emerged that examined what was needed for this community to come together to take action in response to their rising awareness of the health and environmental impact of industrial pollution. This is the investigation that is reported here.

Methods
Conceptual Frameworks

For the initial study based in Sarnia that looked at the impact of asbestos on petrochemical workers, we adapted a conceptual framework that comes from the community based participatory research (CBPR) literature (Minkler, Vásquez, Tajik, & Petersen, 2008). This framework was created to examine how communities come together on environmental-justice issues. Using the framework for this study highlighted the importance of internal dimensions of community change such as awareness and understanding of the community's history; leadership; social and organizational networks; skills and resources; individual and community power; shared values, beliefs and opinions; and perseverance. The

external climate, such as political, economic, and social forces, did not emerge as strongly in this change process, although the mechanization and automation of the petrochemical industry had a significant impact on the number of workers required in the plants. The positive of having fewer workers exposed to toxins was totally undermined by the social problems of having a precipitous rise in unemployment.

For the second study based in Sudbury that looked at the impact of occupational exposure on miners, we built on the conceptual framework, adapting it to capture the major variables that emerged from that analysis. In that study, we noted that the external climate had a very strong influence on the change in the mining sector, including changes in occupational and environmental law; the price of nickel that created boom and bust cycles; the buyout of the mines by multinationals; and the mechanization and automation that cleaned up the mines but led to unemployment. The benefits to the remaining underground miners were more of a collateral benefit from these levers of change than the awareness of the health impact of occupational exposures on the miners.

For this third community-change study that examines the impact of the industrial exposures on the community and environment in Sudbury, we find that the dimensions of community change model is still appropriate for this study's new research question: "What are the necessary criteria for communities to act upon awareness of environmental and occupational exposures?" The model aligns with our view that levers of change are complex and influenced by multiple layers of pressures and opportunities. Both of the previous two models were used to frame our semi-structured interviews and our analysis. We have adapted the model to reflect our findings from the analysis.

The results from this study have demonstrated that the levers of community change in Sudbury sometimes aligned with the literature and sometimes did not (see Table 1 for a comparison). The conceptual model for this study include as levers of community change: (1) awareness of the impact of the pollution that led to a shared vision; (2) taking advantage of events and timing; (3) creating a shared measurement system to monitor the change; (4) having a diffuse yet linked leadership; (5) building a sense of pride and place; and (6) perseverance (see Figure 1). The model and the findings also highlight the importance of the external climate as a lever of change. Important external climate levers included globalization,

Figure 1. Re-Greening Conceptual Framework. Impact Literature, Sudbury Comparison

What leads from *awareness* to *action*?

The Sudbury Community
Embarrassment
Awareness of Problem
Labour Unrest

The "Collective Impact"
Emerging Vision
Confluence of Timing & Events
Adopt Evidence-based Knowledge
Sense of Pride and Place
Diffuse, Linked Leadership

External Climate
Environmental Legislation
Mechanization/Automation
Price of Nickel
Foreign Ownership of Mines
Government Funding
Rise of Mining Supply Sector

automation, the social climate, the economic climate, the political climate, and environmental, legislative, and regulatory changes, (see Figure 1).

Participants

In order to try to understand the complex confluence of events that led to the changes in Sudbury, multiple sources of data were collected. There were one-on-one interviews with 60 people. The interviewees fell into five groups: community (18), policy/government (7), academics and public health officials (10), industry (9), and workers and their union representatives (16). Interviews lasted from 30 minutes to an hour. There were also four focus groups during 2014–2016.

The community group was a broad range of activists who sit on committees and groups that have focused on Sudbury's re-greening efforts or mining reform, leaders of associations involved in occupational health and safety with companies in Sudbury, and two First Nations community members involved in healthcare in Sudbury. The seven politicians were both present and retired representatives at the municipal, provincial, and federal levels. The academics and public health officials were experts in the field of health, occupational health and the environment, and the economy, and came from Laurentian University in Sudbury and the Sudbury District Health Unit. The industry representatives included mining company researchers and occupational health and safety experts from the two major mining companies based in Sudbury (Vale, previously known as Inco, and Xstrata, previously known as Falconbridge). The workers included Sudbury miners, retired miners, and representatives from the two mining unions: United Steelworkers of America and Unifor (previously known as the Mine Mill and Smelter Workers).

The study received ethics approval from the Waterloo-based Community Research Ethics Board. Interviewees were approached with a letter of information and a brochure describing the study. Each interviewee signed a letter of informed consent approving being recorded, and acknowledging confidentiality.

A one-day conference organized by Laurentian University on Sudbury's re-greening efforts, called the Sudbury Protocol, explored how the lessons learned in Sudbury could be of help to other communities (Sudbury Protocol, 2016). Presentations from the conference and a workshop on community engagement were included in this study. Document analysis included: local newspaper clippings from the 1970s and 1980s about labor and occupational disease issues in Sudbury; the gray literature on the Ontario mining sector; an analysis of data on productivity and employment in the region; histories of Sudbury; and local historical health data obtained from the regional health authority. Data collection ceased when no new names were mentioned as part of the snowball recruitment, and the concepts were deemed adequately explored since no new ideas were emerging.

Interview Schedule

For consistency, one researcher (the lead author) conducted all the interviews and groups with one exception. These were conducted wherever convenient for the interviewees: in homes, workplaces, union halls, or restaurants. The questions asked during the semi-structured interviews were based upon the conceptual framework. The interview schedule's questions evolved during the study as our understanding of the Sudbury context deepened, but focused on the increase in awareness of occupational exposures and environmental emissions and chronic disease.

There were questions on the pivots of change at the community level: the awareness of the impact on health and the environment from the pollution; leadership from individuals and community groups; how momentum was built through a common agenda and collaboration, but also through shaming and embarrassment; how the needed resources were obtained to advocate and pay for the re-greening and the limitations in resources; and how the community linked and communicated with each other. Questions were also asked about the external environmental forces that could have had an impact. These included changes in the occupational and environmental legislation; the rise and fall of the price of nickel, strikes and layoffs in the sector; and globalization and mechanization of the mining industry.

Analysis

All the interviews were listened to multiple times by the research team members. The interviews and focus groups were transcribed and entered into NVivo software. The analysis of the data was conducted from a social constructionist theoretical perspective (Berger & Luckmann, 1966), with the idea that individuals and groups approach a problem from multiple perspectives and assumptions, and the final story of what occurred is created from a shared understanding of these many viewpoints. The analysis occurred in two phases. The interviews were divided into the five target groups (industry, worker, politicians, academics, and community) and were analyzed within groups, and then across groups. The initial coding, axial coding, and grounded coding was conducted by one person in the research team (Haynes) as advocated by best practices in qualitative research (Kendall, 1999; Strauss & Corbin, 1990). Through constant comparisons, a meta-matrix of themes and sub-themes was created from the deconstructed data from the participants' accounts, focusing first on the individual groups, and then across the five groups. These often fell into the variables that were identified by the initial conceptual framework. Through this inductive process, there also was a change in importance or priority of variables— some variables were dropped and new themes emerged. The second layer of analysis was conducted by two research team members (Holness & Kramer), who had been involved in conceptualizing and creating the study. The emergent conceptual framework was discussed at multiple research team meetings, the transcripts of the interviews were re-read, and representative quotes were selected. Through this process, we identified important factors in the "causal net" of what led to the re-greening of Sudbury (Sparks & Farsides, 2012).

Results

The major themes that were highlighted by the analysis of how Sudbury's community engaged to achieve its re-greening included that the city: (1) embraced change based upon an emerging awareness and common vision; (2) took advantage of a confluence of timing and events; (3) adopted evidence-based applied research; (4) built a sense of pride and place; (5) created a diffuse yet linked leadership; and (6) perseverance. The levers of change identified by this study resonate with the conditions identified by Kania and Kramer (2011), however less so with those more recently identified by Cabaj and Weaver (2016).

1. Embrace change based on an emerging awareness and vision

Over the decades that it took to achieve the re-greening of Sudbury, the community of Sudbury's vision of their city has fundamentally changed three times. It took a while for the city to achieve what Kania and Kramer (2011) call a "shared vision for change." At the beginning, Sudbury was a company town, with the associated mentality and unquestioning dependency on the mining companies. People still talk of the past when "Mother Inco" built the town, gave them jobs, housed its miners, and gave their children schooling.

The first transformation occurred during Sudbury's worst strike in 1978–1979 because of a planned, strategic initiative that led to the eventual diversification of the Sudbury economy. Members from business, government, academia, media, miners, and other interest groups came together to diversify the economy and move away from the total dependence on the mining sector. They strategized how to move Sudbury from a one-industry town, to a more diverse, knowledge-rich economy. The group included some leaders of the unions who were not supported by their unions who saw this initiative as a push to reduce the importance of mining to the city's economy. However, the miners that joined this initiative, and who later suffered for this decision, did so since they felt it was the right thing to do (Sparks & Farsides, 2012). This highlights the importance of a shared vision. The group created a vision statement, called "Sudbury 2001" that saw Sudbury

as no longer a mining town, but instead would be a sustaining metropolitan center of health, education, and industry:

> There was a group of like-minded, smart individuals that bridged the gap between labour and capital. …There was a sense of urgency. We were able to get this interesting multi-partite group to sit around the table and do something that was very unique and everyone left their politics at the door (from the community group).

Over the decades, this vision has been realized. Sudbury is now the economic hub of Ontario's north with a large education and medical sector and a significant federal tax center. People began talking about the end of mining. They even thought of closing the school of mining at Laurentian University, convinced it had outstayed its need or welcome.

However, by the 1990s, and entering the new millennium, the second transformation of Sudbury from barren moonscape to a lush green environment, attracted the highly qualified personnel needed to also develop a high-tech mining sector. Laurentian University's engineering department now looks forward to meeting a 2020-predicted employment need of between 60,000 and 130,000 new workers in this new mining sector. A summary from their report follows:

> People were almost all saying that mining can't possibly be the focus of the economy here. We don't want it to be. We've got to diversify away from mining. This is not a mining town! Mining is dead! It's a sunset industry! People were not aware that building around the mining core was a bunch of other businesses that were only there because the mining sector was there. So you got a re-understanding of what the city was, that followed the economic transformation (Laurentian University engineering department).

And with this development, an understanding grew of the legacy, and an appreciation for the past, as shown in the following:

> The roots of this community will always be associated with mining. You can't get away from it. Yes, they diversified and they've had to diversify, but [mining has

a] very strong, strong hold. It's here. It's always going to be part of our roots (from the community group).

The community felt that this transformation of the economy could not have been achieved or sustained if it were not for a simultaneous decision the community made to also reclaim, restore, and re-green Sudbury. That decision was made organically. Unfortunately, there was no similar, high-level summit meeting where that decision or common vision was recorded, but it was made nonetheless. The community interviewees stated repeatedly that Sudbury could not have attracted or kept the highly qualified personnel it needed to diversify the economy or develop the mining support, supply, and high-tech mining sectors if the vision of a re-greened Sudbury had not been made or acted upon.

2. Take advantage of a confluence of timing and events

The 1970s and 1980s were a time of change. There was a combination of events, circumstances and political will that offered opportunities for those who could see them. There was a sense of urgency that now, in retrospect can be seen as a "perfect storm" that the community of Sudbury took advantage of. That is what made Sudbury special; the ability to take advantage of the confluence of circumstances. "Carpe Diem" could easily be the city's motto. This category emerged very strongly out of the interviews. It has not been identified by either Kania and Kramer (2011) or Cabaj and Weaver (2016) although the emerging collective impact movement could be seen as an indicator, in and of itself, to people taking advantage of beneficial political, economic, and social climate during the years of the Obama presidency.

In the 1970s and 1980s there were significant changes in the social, economic, and political climates, as well as changes in globalization, automation, and legislation. The environmental movement was raising everyone's awareness that local disasters like Sudbury's pollution had global effects. Acid rain from a point-source could kill lakes miles away. Environmental legislation started to be passed in the United States in 1970, and Ontario's Ministry of Environment was created in 1972. Dr. John Gunn at Laurentian University gives one of the first ministers of this portfolio, Jim Bradley of the Ontario Ministry of Environment, significant credit for initiating the clean-air

legislation and how it was communicated to the Sudbury mining sector (in small enough steps and with shared responsibility among competing companies).

The mining sector was going through epic changes that have continued. The mechanization and automation of the sector has led to improvements in the industrial processes that have facilitated less environmental contamination. Simultaneously, the price of nickel has risen and dropped precipitously, which has instigated further productivity efficiencies, layoffs, and cuts in salaries and pensions to miners. That was the reason for the 1978–1979 strike. In the 1970s, 25,000 miners were employed in Sudbury. There are now about 3,000 to 5,300 miners. More recently, the two major mining companies in Sudbury, Inco and Falconbridge, have been bought out by foreign multi-nationals that have much less social or economic investment in the city or its miners. This has led to further social and labor disruptions.

There was a federal political initiative to develop Canada's north instigated to ensure Canada's national security. The "Sudbury 2001" group took advantage of this to lobby the different levels of government to develop Sudbury as the hub of Ontario's north. The federal and provincial government responded to this unified voice and gave Sudbury the resources it needed to become northern Ontario's center of healthcare, education, and research. It also became the site of one of Canada's seven federal taxation centers and the site for the provincial Ministry of Northern Development and Mines. As one official put it:

> Regulatory change never comes by itself. It comes because people affected are motivated to see change and they lobby, they campaign, they build a body of evidence to motivate the legislature and people like me to take action. When the parade is ready to cross the finish line, [legislators] get at the front once all the work has been done and then we make changes to the laws.

3. Adopt evidence-based knowledge

The community has had strong leadership from the academics at Laurentian University, who have supplied the city with a shared measurement system of their success. This is one of the five conditions of change identified by Kania and Kramer (2011). A quick search on Sudbury's environment in Google Scholar offers over 51,000 citations, most of which cover details on Sudbury's

soil, air, and water. Amazon.com lists about a dozen professional and technical books covering the geography and environment of Sudbury. The academic environmentalists have determined the re-greening formula—the quantities of limestone, fertilizer, and grass-seed that must be planted the year before planting the trees, bushes, and undergrowth. Using empirical data, the unions, the occupational health and safety academics, and public health officials have advocated for the reduction in emissions that affect the community. Thirdly, the City of Greater Sudbury, on an ongoing basis, monitors progress indicators of air quality, energy, green buildings, land use planning, the variety of aquatic species, and the natural environment. The latter includes indicators of the number and variety of trees and vegetation planted, the area limed, schoolyards re-greened, and trends in soil quality, as indicated by the following:

> I think what really helped in Sudbury was the university. When we [moved here], Laurentian was full of young professors. They came from all over the world. All young, energetic, [with] ideas, the biologists and the geologists…. I think they just brought a breath of fresh air and ideas from all over the world (community member).

The general health impact of the pollution on the community has received some attention. The Sudbury District Health (2016) area, in comparison to the rest of Ontario, had consistently over the years reported high rates of asthma, silicosis, cancer (lung, nasal, and gastrointestinal), chronic obstructive lung disease, and other chronic diseases. The environmental epidemiologists and air pollution experts at Laurentian University agree that it is probably the metal-rich particulates (especially the very fine-range particles such as oxides and sulphides) in the emissions that can be causally linked to the health issues.

In 2002, using industry and public money, the Sudbury Soil Study was initiated to experimentally study the health impact of the environmental pollution. It was significant in terms of its scope (based on 8,500 soil samples), the money spent on it (over $10 million for external consultants), and the time dedicated to it (seven years). It examined the potential human health risks related to exposure to arsenic and metals from the soil, water, food, and air. Contradictorily, the soil study did not find any issues of significance to the community's

health (see http://www.sudburysoilsstudy.com/EN/indexE.htm). These results were not universally well accepted by the community, the major criticism being the lack of epidemiological studies looking at long-term health effects. Some even said the soil samples had not gone deep enough. Some members responded strongly:

> [The Sudbury Soils Study] was a joke. They claimed there's nothing in the soil. I was born and raised here. I recall being at home and all of a sudden when they would start pouring the slag you couldn't breathe because of the sulfur in the air. Tell me that that didn't go into the soil. Please tell me that!

On the other hand, the health impact of the mining chemicals on the miners themselves—given their higher, and more intensive exposures — has received more interest and attention (Lightfoot, Berriault, & Semenciw, 2010; Lightfoot, Berriault, Seilkop, & Conard, 2017), and investigations into miners' health has found significant elevations in lung cancer incidence and mortality, colorectal cancer incidence, cardiovascular mortality, and silicosis.

4. Building a sense of pride and place

In the 1970s and 1980s, the City of Sudbury had a reputation, worldwide, as a devastated moonscape, as the unemployment capital of Canada, and as a place everyone wanted to leave and no one wanted to come back to. It was notable that at the workshop on community engagement at the 2016 Sudbury Protocol conference, most of the people over the age of 35, were either natives who had left Sudbury and then come back, or were from elsewhere and had moved to Sudbury only in the past couple of decades. There was also a group of 20-somethings who had never left Sudbury and had no wish to do so. The older generation spoke of how embarrassed they had been in the past to say they came from Sudbury, but that they now say it with pride. For example:

> What happened with the re-greening process gave us hope. It gave us a sense of an attitude that we can take on huge challenges and develop them and overcome them, and it has led to other [positive] outcomes (community member).

Since then, there is much to be proud of. The miners who were laid off started an important and substantial mining-service, education, and research sector, now worth almost $4 billion of Sudbury's $5.5 billion GDP (Keown, 2015). The research hub now includes Science North, the Centre for Excellence in Mining Innovation (CEMI), the Living with Lakes Centre, and the Sudbury Neutrino Observatory (SNOLAB), a 2 km-deep (1.24 miles) neutrino observatory. In 2016, a SNOLAB scientist (Arthur B. McDonald, director of the Sudbury Neutrino Observatory) was co-winner of the Nobel Prize. The city has attracted highly qualified people with national and international reputations to contribute their expertise and leadership to SNOLAB, Laurentian University, Health Sciences North, the Mining Innovation Rehabilitation and Applied Research Corporation, Mineral Exploration Research Ontario, and many more. In 2015, the city was declared by Statistics Canada to have the happiest people in Canada. The city has won numerous international, national, and provincial awards because of its reclamation achievements, and has hosted visitors from around the world who are curious to learn about the program.

Although the goal set out by the re-greening initiative and the economic diversification was not necessarily community pride, it has been the result. As the people of Sudbury saw their city become green, they re-engaged. The hundreds who have been involved in the tree planting now have an invested interest in the City's restoration, and have taken on more projects such as cleaning up their schools, planting trees in empty parking lots, and established walking trails. These changes can be seen as one of the five Kania and Kramer (2011) conditions for social change, mutually reinforcing activities. As one community member said:

> From the hard work that this community has done and from how we have engaged, we have not only recovered from the damaged physical environment, we have also recovered from the damage to our psychological identity.

5. Create a diffuse yet linked leadership

In the previous study in Sarnia, there was a charismatic leader in the community and another among the unionized workers that led the change that recognized the health effects of asbestos on workers' health. Leadership has not been identified by either Kania and Kramer (2011) or Cabaj and Weaver (2016) as a pre-condition for change, although their case studies identify problems with

leadership, the need for community leadership, and the need to change the leadership paradigm from managerial to transformative (builders of movements).

In Sudbury, certain names emerged out of the interviews as leaders. The miners all spoke about the work of Homer Seguin and more recently Leo Gerard. The industry representatives still remembered the improvements made when Mark Cutifani was chief operating officer of Inco Limited. The academics mention the foundational ecology of Dr. David Pearson and Dr. Peter Beckett. The community leadership included Bill Lautenbach, Narasim Katary, and Michael Atkins, and leading politicians included Elie Martel and his daughter, Shelley Martel. This list could easily be three times as long. However, although the leadership across the five groups was linked, no one person or group dominates in the re-greening of Sudbury. Here are representative examples regarding Sudbury's leadership:

> It's really difficult to isolate "buckets" of influencers—the union bucket, the community bucket. I have a feeling that this community, Sudbury, is all intertwined. We're all one big group kind of moving together (industry member).

> Everybody's aware of the history but they don't seem to realize how oddly cohesive the community's become over that time. Many of the divisions have disappeared, partly because over time people worked together on a whole bunch of projects (academic member).

> Not only did we have people talking together for the first time and listening for the first time that never did before, but as we got used to that and we got doing other things, you could actually talk to people who had met one another and therefore felt there was credibility one side to the other. Then you could have a longer conversation. [You] could pick up the phone and say, "I want your help" (community member).

Achieving the interlocking and interdependent goals of diversifying the economy and reclaiming the industrial landscape took different leaders at different times to achieve different aspects of the enterprise. There was not one group that acted as the "backbone support organization" as identified by Kania and Kramer (2011). However, recently, the City of Sudbury has taken on the role of listing and linking all the environmental groups and their initiatives under their Re-greening Program.

Taking on the mutually reinforcing activities (Kania & Kramer, 2011) that were required to achieve these two significant goals did take time, or as Mark Kramer said in 2012, it required "an attitude of burning patience" (retrieved https://www.gcn.org/articles/the-promise-of-collective-impact). As early as 1973, the newly formed Regional Municipality of Sudbury created a Technical Tree Planting Committee. In 1978, it proposed a land reclamation program, and changed its name to the "Vegetation Enhancement Technical Advisory Committee" to reflect a broader mandate than just planting trees. This small beginning grew into EarthCare Sudbury, which is a unique partnership between the City of Sudbury and over 150 community agencies, organizations, and businesses, and hundreds of individuals who are creating a greener, more sustainable community. This collaboration ensures another of the Kania and Kramer (2011) criteria for change: continuous communication. One industry member put it like this:

> Sometimes leadership comes from the unions. Sometimes leadership comes from a mother that just lost her son and says that's not good enough and we need to look at ways of improving. It just depends.

Discussion

This analysis has tried to distill the essence of what one community did to remediate their environment from severe industrial pollution. The re-greening of Sudbury's environment unfolded organically over the decades. There was not one leader or community group who led the movement; many individuals and organizations responded to the need. They took on different initiatives: The unions raised awareness of occupational disease; the public health practitioners collected and published information on the population's health; the academics studied and published papers on the state of the land, water, and air, and advanced research on restoration; diverse community members came together to create the "Sudbury 2001" vision; industry embraced new technology to help clean emissions from the smokestacks; the media took up the banner of first shaming the city for its pollution, and then later, giving kudos for achievements; and the politicians worked on passing environmental and occupational

regulations and found ways to obtain funds that helped diversify Sudbury's economy. Of course, the schools, universities, laid-off workers, and environmentalists who planted the trees, limed the soil, set up bike paths, and led walks through the newly emerging forests made it all happen.

The restoration of the environment was a mutually reinforcing process: The greening of the city gave pride to its residents and attracted back those who had left and enticed newcomers to make Sudbury their home. In turn, this initiated even more community engagement activities, perpetuating a positive cycle. However, this process was not easy. As one scientist said at the Sudbury Protocol conference in 2016, coming up with the recipe for how to restore the land (the quantity of lime, trees, bushes, grasses and understory growth) was relatively easy in comparison to understanding the needs at the political, economic, and most importantly, at the social level.

The groups that have noticeably not been engaged in the economic diversity or restoration process are the members of the First Nations and Métis that reside in the Sudbury Basin (about 10,000 people). Sudbury is located on the ancestral, traditional territory of Atikameksheng Anishnawbek (Whitefish Lake First Nation). The absence of their voice is an indictment of the inclusivity and equity of the process, and is a notable limitation of this study. Even taking into consideration the inherent legacy of colonialism and racial exclusion, there are structural barriers in Canada that have limited Aboriginal peoples from engaging at the community level. Aboriginal peoples fall under the federal government's constitutional jurisdiction, whereas the community initiatives have mostly been municipal and provincial initiatives. However, this is an evolving situation. A notable theme at the 2016 Sudbury Protocol conference was the absence of the voice of First Nations and Métis and the need to ensure they are included as partners moving forward.

Although Sudbury is without doubt a good-news story and a model for other communities facing devastating industrial pollution, a number of the interviewees emphasized that the Sudbury project is not complete. Perseverance was a commonly mentioned need. The region still ranks second of 158 Canadian cities in emissions of nickel, cadmium, and arsenic, and remains one of the province's largest contributors to SO2 air concentrations (Potvin, 2007). Although nearly 4,000 hectares (9,884 acres) of land have been restored, over 100,000 hectares (386 square miles) were damaged by the many decades of pollution.

Moreover, the buyout of the two largest nickel mines by multi-nationals also puts in doubt the ongoing financial support from industry for future environmental improvements.

The social indicators also tell a story of unfinished work. As of the beginning of 2016, Sudbury's population had seen a slight decline; it had the highest unemployment rate of any city in Ontario (8.7 percent); and in 2015, there were estimated to be 1,419 people who were homeless or at risk for homelessness (Kauppi, Pallard, & Faries, 2015). However, although there is still much work to be done, with their own past to use as a model for the future, the Sudbury citizens surely have a head-start over other communities.

We believe the changes Sudbury has initiated and implemented to transform its environment from black, bare rock, and acid lakes back to a green environment through reclamation, revitalization, and re-greening is worth exploring and assessing as a model of community engagement and collective impact. Its model could be used by other communities that are experiencing the impact of industrial pollution to help rebuild and revitalize their communities by offering an example of the interactions between the personal, social, political, and environmental contexts.

References

Barnes, M., & Schmitz, P. (2016, Spring). Community engagement matters (now more than ever). *Stanford Social Innovation Review*. Retrieved from https://ssir.org/articles/entry/community_engagement_matters_now_more_than_ever.

Berger, P.L., & Luckmann, T. (1966). *The social construction of reality: A treatise in the sociology of knowledg*e. London: Penguin Books.

Björkdahl, C., Wester-Herber, M., & Hansson, S.O. (2008). Effects of workplace inspections: The Swedish noise campaign. *Policy and Practice in Health and Safety, 6*(1), 55–63. Retrieved from http://dx.doi.org/10.1080/14774003.2008.11667715.

Cabaj, M., & Weaver, L. (2016). Collective impact 3.0: An evolving framework for community change. Retrieved from Tamarack Institute website, http://cdn2.hubspot.net/hubfs/316071/Events/CCI/2016_CCI_Toronto/CCI_Publications/Collective_Impact_3.0_FINAL_PDF.pdf?t=1473775736492.

City of Greater Sudbury. (2015). *Regreening program annual report 2015*. Retrieved from https://www.greatersudbury.ca/living/environmental-initiatives/regreening-program/pdf-documents/2015-regreening-program-annual-report/.

Gardner, H. (2011). Frames of mind: The theory of multiple intelligences, New York, NY: Basic Books

Graham, I.D., Logan, J., Harrison, M.B., Straus, S.E., Tetroe, J., Caswell, W., & Robinson, N.J. (2006). Lost in knowledge translation: Time for a map? *Journal of Continuing Education in the Health Professions, 26*(1), 13–24. doi: 10.1002/chp.47.

Green, L., & Kreuter, M. (2005). Health program planning: An educational and ecological approach (4th ed.). New York, NY: McGraw-Hill.

Gunn, J. (2014, February 28). Global lessons from a hard-rock mining town. TED[x]. Retrieved from https://www.youtube.com/watch?v=ANmAWMRy-u0.

Hanleybrown, F., Kania, J., Kramer, M. (2012). Channeling change: Making collective impact work. *Stanford Social Innovation Review*. Retrieved from https://ssir.org/articles/entry/channeling_change_making_collective_impact_work.

Huberman, M.A., & Miles, M.B. (1984). *Innovation up close: How school improvement works*. New York: Springer.

Kania, J., & Kramer, M. (2011, Winter). Collective impact. *Stanford Social Innovation Review*. Retrieved from https://ssir.org/articles/entry/collective_impact.

Kania J., Turner, S., Justilien R., & Phillips, D. (2016). Evaluating community change. *Stanford Social Innovation Review*. Retrieved from https://ssir.org/articles/entry/evaluating_community_change.

Kauppi, C., Pallard, H., & Faries, E. (2015). Homelessness in Greater Sudbury: 2015 period prevalence count. Retrieved from http://www3.laurentian.ca/homelessness/wp-content/uploads/2012/06/PPC-2015-Sudbury-REPORT-CGS-July-2015.pdf.

Kendall, J. (1999). Axial coding and the grounded theory controversy. *Western Journal of Nursing Research, 21*(6), 743–57. Retrieved from http://wjn.sagepub.com/.

Keown, M.K. (2015, June 19). Sudbury mayor stresses the positive. The Sudbury Star. Retrieved from http://www.thesudburystar.com/2015/06/19/sudbury-mayor-stresses-the-positive.

Klein, N. (2014). *This changes everything: Capitalism vs. the climate*. Toronto, ON: Knopf Canada.

Kramer, D.M., McMillan, K., Gross, E., Pefoyo, A.J.K., Bradley, M., & Holness, D.L. (2015). From awareness to action: The community of Sarnia mobilizes to protect its workers from occupational disease. *New Solutions: A Journal of Environmental and Occupational Health Policy, 25*(3), 377–410. doi: 10.1177/1048291115604427.

Kramer, D.M., Holness, D.L. Haynes, E., McMillan, K., Berriault, C., Kalenge, S., & Lightfoot, N. (2017). From awareness to action: Sudbury, mining and occupational disease in a time of change. *WORK 58*(2),149–162.

Kulig, J.C., Edge, D.S., Townshend, I., Lightfoot, N., & Reimer, W. (2013). Community resiliency: Emerging theoretical insights. *Journal of Community Psychology, 41*(6), 758–775. doi: 10.1002/jcop.21569.

Lau, R., Stevenson, F., Ong, B.N., Dziedzic, K., Treweek, S., Eldridge, S., Everitt, H., Kennedy, A., Qureshi, N., Rogers, A., Peacock, R. & Murray, E. (2016). Achieving change in primary care—causes of the evidence to practice gap: Systematic reviews of reviews. *Implementation Science, 11*, 40. doi: 10.1186/s13012-016-0396-4.

Lightfoot, N., Berriault, C., & Semenciw, R. (2010). Mortality and cancer incidence in nickel cohort. *Occupational Medicine, 60*(3), 211–218. doi:1093/occmed/kqp197.

Lightfoot, N.E., Berriault, C.J., Seilkop, S.K., & Conard, B.R. (2017). Nonrespiratory mortality and cancer incidence in a cohort of Canadian nickel workers. *Archives of Environmental & Occupational Health, 72*(4) 187-203. Retrieved from http://www.tandfonline.com/i/.1080/19338244.2016.1197879?journalCode=vaeh20.

Lightfoot, P.C. (2016). Nickel sulfide ores and impact melts: Origin of the Sudbury igneous complex. Amsterdam, The Netherlands: Elsevier.

Lomas, J. (1997). Improving research dissemination and uptake in the health sector: Beyond the sound of one hand clapping (Policy Commentary C97–1). Retrieved from McMaster University Centre for Health Economics and Policy Analysis website (http://www.cfhi-fcass.ca/migrated/pdf/mythbusters/handclapping_e.pdf).

Minkler, M., Vásquez, V.B., Tajik, M., & Petersen, D. (2008). Promoting environmental justice through community-based participatory research: The role of community and partnership capacity. Health Education & Behavior, *35*(1), 119–37. doi:10.1177/1090198106287692.

Mintzberg, H., & Westley, F. (1992). Cycles of organizational change. *Strategic Management Journal, 13*(S2), 39–59.

Potvin, R.R., & Negusanti, J.J. (1995). Declining industrial emissions, improving air quality, and reduced damage to vegetation. In J.M. Gunn (Ed.), *Restoration and recovery of an industrial region* (section B). Retrieved from http://rd.springer.com/chapter/10.1007/978-1-4612-2520-1_4.

Potvin, R. (2007). *Air quality trends in the Sudbury area: 1953–2002.* Sudbury, ON: Laurentian University.

Rogers, E. (2003). *Diffusion of innovations,* 5th edition. New York: Simon and Schuster.

Senge, P.M. (1990). *The fifth discipline: The art & practice of the learning organization.* New York: Doubleday Currency.

Sparks, P., & Farsides, T. (2012). The pub, the people, the place, the passions and the principles: The social and personal context of engagement in a collective action. *Journal of Community Engagement and Scholarship, 1*(2), 40–49.

Stokols, D., McMahan, S., Clitheroe Jr., H.C., & Wells, M. (2001). Enhancing corporate compliance with worksite safety and health legislation. *Journal of Safety Research, 32*(4), 441–463.

Strauss, J.M., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques.* Thousand Oaks, CA: Sage Publications, Inc.

Sudbury Community Foundation. (2012). Greater Sudbury's vital signs: City of Lakes edition. Retrieved from https://www.scribd.com/document/108755647/Vital-Signs-Expanded-Report.

Sudbury Protocol (2016). Retrieved from https://www3.laurentian.ca/sudbury-protocol/#about.

Tollinsky, N. (2015, August 18). From barren rock to lush forests: Restoring the Sudbury Basin to its original state. *Sudbury Mining Solutions Journal.* Retrieved from http://www.sudburyminingsolutions.com/from-barren-rock-to-lush-forests.html.

Tompa, E., Kalcevich, C., Foley, M., McLeod, C., Hogg-Johnson, S., Cullen, K., MacEachen, E., Mahood, Q., & Irvin, E. (2016). A systematic literature review of the effectiveness of occupational health and safety regulatory enforcement. *American Journal of Industrial Medicine, 59*(11), 919–933. doi: 10.1002/ajim.22605.

Watzlawick, P., Weakland, J.H., & Fisch, R. (2011). *Change: Principles of problem formation and problem resolution.* New York: WW Norton & Company.

About the Authors

Desre Kramer is the associate director of the Occupational Cancer Research Centre at Cancer Care Ontario and adjunct professor at the School of Occupational and Environmental Health at Ryerson University in Toronto. Emily Haynes was a research associate at the Occupational Cancer Research Centre. She is now a medical student at Dalhousie University. Keith McMillan is a research associate at the Occupational Cancer Research Centre. Nancy Lightfoot is an associate professor at Laurentian University in Sudbury. D. Linn Holness is an occupational medicine physician and professor at the Dalla Lana School of Public Health and Department of Medicine at the University of Toronto.