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Disaster incubation, cumulative impacts and the urban/ex-urban/rural dynamic

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Abstract

This article explores environmental impacts and risks that can accumulate in rural and ex-urban areas and regions and their relation to urban and global development forces. Two Southern Ontario cases are examined: an area level water disaster and cumulative change at the regional level. The role of disaster incubation analysis and advanced environmental assessment tools are discussed in terms of their potential to contribute to more enlightened and effective assessment and planning processes. It is concluded that conventional approaches to EA and planning are characteristically deficient in addressing the full range of impacts and risks, and particularly those originating from pathogens, dispersed and insidious sources. Rigorous application of disaster incubation analysis and more advanced forms of EA has considerable potential to influence a different pattern of planning and decision making.

Keywords: Disaster incubation; Disaster incubation analysis; Cumulative impacts; Ex-urban regions; Environmental assessment

1. Introduction

In this article we explore the general utility of recent work from disaster research for the enhancement of contemporary methods and approaches to Environmental Assessment (EA). In particular we discuss the potential disaster research has for assessing slowly evolving and under-appraised environmental problems, including environmentally related health impacts and those problems involving the cumulative impacts of the ever changing relations between the urban, ex-urban and rural regions. To illustrate and discuss this potential of disaster research we give context

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and substance to our analysis by focusing on two case studies, the first involving water contamination/pollution problems in rural Ontario and the other focusing on the changing ecological and social landscapes of areas which surround the Greater Toronto Area (GTA). These particular cases were selected because frequently EA may neglect or at least minimize the potentially significant impacts of the urban/ex-urban/rural dynamic. This may be perhaps because of the complexities inherently involved in this dynamic, often involving longer time scales and expansive distances, thus making the incorporation and consideration of the factors related to this dynamic difficult. Nonetheless, the adoption of certain principles and the general orientation of disaster research, especially if coupled with cumulative impact assessment, may better enable environmental assessors to broaden the conventional lens of EA. In turn, this may facilitate the identification of not only the physical and biological antecedents to many environmental problems, but their social and political economic undercurrents as well, thereby providing a means through which some of the difficulties of incorporating the urban/ex-urban/rural dynamic can be addressed. Notably, the analysis of both the physical and social dimensions in a disaster research inspired EA process will enable assessors to more effectively grapple with the vexing issues related to the complex cumulative and latent effects of many understudied and conventionally neglected environmental problems. We begin with an overview of recent approaches in disaster research that are of relevance to EA.

2. Disaster research

Generally speaking, disaster research has tended to evolve as an interdisciplinary and applied field, although notable pioneering contributions have been made primarily by geographers and sociologists. Traditionally, the field has investigated a large array of issues often related to practical issues such as the role of organizations during emergencies, evacuation behaviours, emergency medical service delivery, the protection of property, the spatial aspects of disasters and so on. Recently, there has been increased attention focused on issues related to what Turner (1976) has termed “disaster incubation” – the period before disaster onset when the causal factors that contribute to, or precipitate, a disaster accumulate and interact in an *unnoticed* manner. For our discussion in this article, the key feature of the research on disasters is this idea of disaster incubation. The notion of disaster incubation has particular relevance to EA because of the analytical emphasis on the latent character of the causal factors and processes that underlie a given disaster, or more specifically in the case of EA, those latent factors/processes that underlie environmental impacts and problems. Over the last several years, there have arisen a number of case studies that illustrate the incubation of various disasters. For example, Ali (2002) discusses how the political economy of an industrial city in Southern Ontario had contributed to a large toxic conflagration at a private recycling firm, while Beamish (2001, 2002) relates how one of the largest oil spills in American history occurred on a stretch of land on the Guadalupe Dunes in California over four decades by chronic leaks that were the result of numerous instances of institutional neglect and corporate malfeasance that accumulated over time. Perhaps one of the most notable studies of a the incubation period of a technological disaster was conducted by Diane Vaughan (1996) who reveals how the Space Shuttle Challenger disaster (28 January 1986) was the outcome of social phenomena involving, for example, among other social factors, the transformation of deviant practices into acceptable behaviours at NASA. Specifically, this transformation process is referred to as the “normalization of deviance” wherein danger signals occurring during the pre-disaster period gradually become accepted as normal by those in the organization. As Vaughan shows through her institutional ethnography, it was just such a process that ultimately and tragically led to the decision that the space shuttle could be safely launched despite certain technical concerns on launch day. In addition to technological disasters, the analysis of disaster incubation has also been applied to natural disasters, as for example in the case of Hurricane Katrina in 2005 (Bakker, 2005; Rydin, 2006; Seager, 2006) and the 1995 Chicago heatwave (Klinenberg, 1999), in which analysts have noted that particular social groupings, such as poor African–Americans and women, were particularly vulnerable to the impacts of the "natural" agents because of land use and political decisions which put the particular groups in harms way. The latter two cases point to the important issue of disaster vulnerability in the urban context, but, as will be discussed, disaster vulnerability is also a particularly relevant consideration for EA in the rural context.

At this point in time, research progress in the area of disaster incubation has proceeded on a somewhat incremental and ad hoc basis with particular insights gained through case study analyses. As such, the work on disaster incubation has not yet crystallized into a set of propositions in such a way as to define a formal theory. Although it is perhaps true that the study of disaster incubation has not yet achieved paradigmatic status, we contend that there now exists sufficient theoretical and empirical development in this area to define a coherent approach which for the purposes of this article we will refer to as Disaster Incubation Analysis (DIA). Largely informed through research in organizational sociology, DIA has tended to focus on the organizational foundation of disasters. In this vein, Turner's pioneering work in the area has been based on the analysis of the inquiry proceedings that followed three high-profile disasters in the United Kingdom. Notably, his analyses examined how regulatory agencies and firms were implicated in the disaster incubation process. In this connection, Turner identified several important underlying organizational factors, including: rigidities in institutional beliefs; the presence of distracting decoy phenomena; the neglect of outside complaints; multiple information-handling difficulties; the exacerbation of the hazards by strangers; the failure to comply with regulations; and the psychological tendency to minimize emergent danger. More recent efforts have built on the work of Turner, both by expanding his focus on the organizational foundation of disasters (see for example: Clarke, 1998, 1993; Couch and Kroll-Smith, 1985, 1991; Dynes, 1993; Erikson, 1991; Freudenburg, 2001, 1997; Freudenburg and Gramling, 1994) as well as through expansion of the analytical scope of DIA to now consider the role of biophysical and environmental factors alongside the social factors emphasized by Turner (Ali, 2003; Klinenberg, 1999; Murphy, 2001). It is perhaps this focus on both the biophysical *and* the socio-organizational factors that holds the most promise for the formal impact assessment and management of natural resource use, such as in the case of ground and surface water impacts we will discuss shortly. In this light, a critical feature of adopting DIA for environmental assessment is to address the latency dimension of the problem incubation; in particular, the question as to why the conditions that fostered a particular disaster went unnoticed. As much of the research in DIA has been based on post-hoc analyses, the challenge for the environmental assessor is to bring together the relevant insights from these retrospective case studies in order to apply them in a prospective manner to future scenarios in the planning process. This leads to a second point. As foresight is an essential foundation for effective planning, the need to identify the reasons for the failure of foresight is critical and DIA facilitates this identification by focusing explicit attention on these very reasons. Third, DIA is especially well-designed to address those situations in which largely overlooked cumulative impacts are critical. This is the case for example in relation to such processes as: those related to development pressures (such as incrementally increasing urban sprawl), globalized economic activities (such as intensification of livestock operations (i.e. "factory farms)", as well as creeping "natural" disasters such as desertification, global climate change, and the pathogenic contamination of groundwater, all of which may develop gradually over time in an unnoticed manner until the catastrophic impacts can no longer be ignored. Let us now consider empirically how such latent biophysical and social processes have environmental impacts and how they can be analyzed using DIA by considering the following two cases involving rural ground water and water use within the context of Toronto and its ex-urban and rural regions.

2.1. Case #1: rural groundwater contamination

While public concern about Southern Ontario's water future is substantial, it is usually focused on more immediate and higher profile issues, at the expense of some of the more insidious and cumulative risks. The broader surroundings – three of the Great Lakes are in close proximity – have long ensured public consciousness of water pollution, but also a complacent if misplaced sense of infinite supply and regeneration. Surface water issues have commanded most of the attention, while the magnitude of groundwater problems and risks remains largely unknown and neglected. This changed to a significant extent in 2000 with the Walkerton drinking water contamination disaster.

2.1.1. The Walkerton crisis

Situated within the agricultural heartland of Ontario, the town of Walkerton is located on the Saugeen River about 150 km northwest of Toronto and 30 km east of the shores of Lake Huron. Although relatively close to the Great Lakes, the town is entirely dependent upon groundwater that is drawn from wells. During the third week of May 2000, Walkerton (population: 4800) became the site of the largest outbreak of a waterborne infectious disease in Canadian history. After a public outcry, an independent inquiry was commissioned a month later to determine the causes of the outbreak as well as to fulfill the extended mandate of making recommendations about how best to manage the water supplies in the province. The Inquiry concluded that the contamination of the municipal water supply occurred after a period of very intense rainfall whereupon cattle manure containing the pathogen *E. coli* O157:H7 spread on the fields of a nearby farm was washed into a particular well (Walkerton Inquiry, 2002). As this pathogen can only survive in groundwater for very short periods of time, it was suspected that rapid flow of water contaminated with the pathogen was able to reach the municipal water supply because of the presence of fractures in the carbonate substrata structure of the region. Aside from identifying the source of contamination, the Inquiry Commission also identified a list of other factors that contributed to the outbreak, including malfeasance on the part of the local water operator and serious deficiencies in the provincial regulatory framework that governs water management.

The case of Walkerton immediately raised the question of the magnitude of the groundwater contamination problem within the national and regional context. One of the difficulties faced in identifying the particular pathogen involved in the Walkerton case was that *E. coli* O157:H7 was normally associated with food-borne, and not waterborne, outbreaks. Sometimes referred to as "hamburger disease", illness due to *E. coli* O157:H7 first began to be recognized as a newly emerging public health problem in the 1980s with the onset of several sporadic outbreaks throughout North America (Nadakavukaren, 2000). From a DIA perspective, the association of the disease with food served as distracting decoy phenomenon.

2.1.2. The broader picture

As DIA casts a wider net in its analysis, it often considers the wider biophysical and social context of a disaster. Such an orientation has practical implications for EA, which may benefit from such an expanded perspective by employing a wider scan that would be alert to broader social and ecological trends (for example, see Krieg, 1998, 1995 for trends regarding the distribution of hazardous waste in North America). In this spirit, let us consider some of the relevant trends in terms of the Walkerton disaster, starting with that related to increased incidence of water contamination in the North American context. By being knowledgeable about such trends, EA processes may be redirected to focus on the more likely scenarios in environmental and land use planning.

One relevant trend that EA professionals may want to consider is the increase in new and emerging diseases more generally, as it is likely that the protection of groundwater from such threats will become an issue of growing importance in the future. In recent times, Western societies have witnessed the rise of a new class of emerging (and re-emerging) pathogens that are extremely insidious and virulent, including, to name just a few: the Severe Acute Respiratory Syndrome (SARS) coronavirus, HIV/AIDS, West Nile, Huntavirus, Ebola, the Lyme disease virus, the avian flu virus, the monkey pox virus, and the hoof-and-mouth pathogen (Drexler, 2003; Levy and Fischetti, 2003; Garrett, 1994, Institute of Medicine, 1992). The bacteria *E. coli* O157:H7 involved in the contamination of the Walkerton groundwater is another example from this new group of pathogenic threats. The emergence of these new pathogens has several important implications for planning in general and rural planning in particular. First, it needs to be recognized that a wide range of social and environmental factors are involved in the evolution of these pathogens as well as in the onset of the respective disease epidemics themselves. Such factors include: ecological, human demographic and behavioural changes; travel and commerce; technology and industry; microbial adaptation and change; and the breakdown of public health measures. For this reason, whether contamination occurs within the groundwater source, through the food distribution system, or through the air and soils, the wider contextual factors that could amplify or mitigate the spread of the pathogen need to be considered as part of the assessment and planning process. In particular, the possible interactions of such factors need to be studied. For example, as is argued below, the need to monitor groundwater for pathogens may not be possible under the tight fiscal circumstances that many resource-based communities face.

The rural geographic dimension of the new and emerging pathogenic threats is often neglected in groundwater management. Part of the latency of the disaster incubation involved in disease outbreaks is a function of the fact that most of the relevant incubating processes and factors are occurring in remote locations — they are "under the radar" of most observers. Such tendencies are especially worth noting in light of such disaster incubation elements as rigidities in institutional beliefs (as for example with respect to rural versus urban, as well as municipal versus provincial versus federal government agencies) and neglect of outside complaints (as for example, the neglect of the input and concerns of farmers by government agencies). Furthermore, most of the new and emerging pathogens are based on animals raised or otherwise inhabiting relatively remote areas. For example, it is thought that the Human Immunodeficiency Virus (HIV) originates from the simian reservoir in the rural jungles of East Africa (Institute of Medicine, 1992); the SARS coronavirus in the palm civet cat reservoir of rural Southern China (Guan et al., 2003; Martina et al., 2003) and the avian flu virus in the wild duck and fowl reservoir of the same region (Institute of Medicine, 1992). The crossover of the pathogen from the animal to the human reservoir is influenced by distinctly social processes; thus, for example, it has been noted that the paving of the Kinshasa Highway through the forests of the Rift Valley led to increased traffic thereby facilitating the spread of disease from remote posts to urban areas as prostitutes working the stretch of road plied their trade. Local doctors estimate that as many as 30% of those living in this area are infected with HIV (Preston, 1994:382), while strong evidence indicates that the SARS coronavirus crossover occurred in live animal markets in urban centers where animals were brought in from rural areas to be sold. The significance of the interrelationship between humans, animals and the environment highlights the importance of the interface of urban–rural areas and particularly the encroachment of humans into formerly untouched environs, as seen by the rise in cases of Hantavirus Pulmonary Syndrome (HPS) (Buck and Aron, 2001:32) and Lyme disease. Incidence rates increased as exposure to the vectors transmitting the viral agent increased as development into forested areas brought humans into closer contact with deer mice carrying the sin nombre virus in the case of HPS and wilderness ticks hosting the bacterium *Borrelia burgdorferi* and carried in songbirds and mice in the case of Lyme disease (Bourette, 2005).

A second general trend refers to increased incidence of contamination within rural areas themselves. Although drinking water contamination problems tend to be associated with developing nations – the World Health Organization notes that the leading cause of illness and deaths in most developing countries is attributable to gastrointestinal infections from the ingestion of water containing pathogens (Nadakavukaren, 2000) – the Walkerton outbreak dramatically illustrates that the waterborne route of the disease may pose an equal, if not greater, threat to public health in the North American, and particularly, Canadian context. The potential for groundwater contamination is particularly noteworthy in light of the finding that approximately 90% of Canada's drinking water is stored as groundwater (Howard, 2000). At the same time, almost 70% of those reliant on groundwater as a source of drinking water live in rural areas (Howard, 2000). The Center for Disease Control and Prevention data indicates that between 1971–1992 there were on average 31 outbreaks of waterborne diseases per year in the United States (Nadakavukaren, 2000) while there were 39 published reports of waterborne outbreaks/incidents associated with drinking water in Ontario alone from 1974 to 1996 (Edge et al., 2003). In many cases, waterborne disease afflictions run their course in 5–10 days and the victim recovers completely without treatment (Nadakavukaren, 2000:337). As a result, it should be noted that the U.S. Environmental Protection Agency (Nadakavukaren, 2000) estimates that for every case of waterborne disease identified, 25 more never appear in the statistics because of haphazard reporting. Edge et al. (2003) estimate that only one-tenth of waterborne outbreaks are reported. Thus the problem of pathogenic contamination of drinking water may be much more pervasive than what is currently realized. In this way, the neglect of the issue of pathogenic contamination of groundwater may in fact illustrate Turner's observation that in disaster incubation, there is a psychological tendency to minimize an emergent threat. Again, EA would clearly benefit by being cognizant and vigilant of such tendencies.

Rural areas tend to face especially challenging water quality problems due to high levels of dissolved organic material and predominantly agricultural drainage basins (Peterson, 2001). In this connection, the EPA has found that the leading source of pollution of contaminated rivers in North America is agricultural runoff (Mallory, 2000; Nadakavukaren, 2000). In the case of Ontario, agricultural runoff in the form of manure (i.e. nutrients), as opposed to herbicides or pesticides, is particularly problematic because of the nature and type of farming practiced in this region. Reflecting a more general trend throughout North America, from the Second World War onward, agriculture in the province has become more industrialized, with fewer farms that are larger in size and growing many more animals per farm. Thus, for example, although today agriculture and food is Ontario's second largest industry, employing some 640,000 people (OMAFRA, 2000b), the number of farmers has dropped dramatically over time – between 1951 and 1998 the number of dairy farmers in Ontario went from approximately 40,000 to 7200; while the number of pork producers dropped from 93,000 to 5500 (OMAFRA, 2000b). Notably, Walkerton itself is situated within one of the rural Ontario counties with the highest number of cattle per unit area grown in what are referred to as “factory farms” (Nikiforuk, 2000).

Typically, factory farms (also known as feedlots) may contain as many as 25,000 cattle feeding in crowded areas the size of a city block (other regions of such intensified farming include specialized regions in Alberta, South Carolina and Iowa). The animal waste generated by these intensive livestock operations is enormous. For example, a 25,000 head feedlot will produce 50,000 tonnes of waste annually — more fecal matter than that produced by a city of 250,000 humans in the same period (Nikiforuk, 2000). The animal waste is stored in manure lagoons before being applied to farm fields. Contamination problems often arise because these lagoons tend to leak into groundwater and streams, while sometimes the lagoon walls may even collapse, resulting in massive manure spills. Further problems can also arise because the manure is frequently applied at rates far above what the crop and soil base can absorb — the resultant excess finding its way into surface and groundwater. The entry of manure into ground and surface water pathways becomes a public health threat if the manure contains pathogens.

Elevated levels of bacteria in Ontario’s rural drinking water sources have been detected for at least a decade. For example, a survey of groundwater quality in farm wells across Ontario found that 30% of the wells had bacteria levels above the safety guidelines (Michael Goss cited by Rankine and Boyd, 1998). Second, a Health Canada study published in 1999 found that those counties with the highest cattle density (including Walkerton) routinely registered the highest rates of *E. coli* O157:H7 infection in the province between 1990 and 1995 (Nikiforuk, 2000). Further still, for several years prior to the outbreak, Ontario Ministry of Environment inspectors were aware that the well contaminated in Walkerton was vulnerable to contamination by surface water (referred to as GUDI — groundwater under the direct influence of surface water) and that the Ontario Drinking Water Objectives of 1994 required that such sources be monitored continuously for chlorine residuals and turbidity, which they were not in the case of Walkerton (Walkerton Inquiry, 2002). If such knowledge existed, the pertinent question that arises is why were preventative planning measures not taken and how could such information be incorporated into effective drinking water management and planning practice? In other words, to use the lexicon of DIA, why were danger signals missed? As we shall see, by addressing such questions through a DIA-inspired EA process, the knowledge attained from the past experiences of a disaster can be used to more effectively identify and better plan for the impacts of the situation or undertaking currently under consideration.

2.1.3. Walkerton's implications

The Walkerton case suggests a number of significant implications for water management and planning. First, it suggests that other similar disasters may be incubating, since water-related incidents tend to be underreported and since monitoring has been shown to be frequently inadequate. Ex-urban areas appear to be at particular risk as the hazards associated with factory farming accumulate and converge. The relatively brief history of farming on such a scale makes it difficult to understand its implications fully and in historical context. Second, the case points to the risks of incomplete or partial approaches to monitoring in which some of the risk factors may be watched, but less so in relation to other factors. Over time, key risk interrelationships may thus unfold but be missed until disaster strikes. Third, the case casts doubt on the reliability or effectiveness of environmental assessment processes to identify the probable cumulative effects of an activity like factory farming — or, more precisely, the recurring reality that many significant development activities are not subject to rigorous or formal assessment at all. Fourth, the case confirms the paradox of groundwater resources: they are relied on heavily but taken for granted, literally out of sight and mind most of the time.

Rural–urban interfaces therefore provide excellent opportunities for such crossovers to occur and need to be incorporated into assessment and planning considerations. The outbreak in Walkerton is another case in point; it involves the relationship between the bacteria *E. coli* O157:H7, the surface and groundwater environment, livestock and humans. It was clear that the human-made water distribution system, the geophysical characteristics of the land in the region, and agricultural practices in the area were instrumental in the spread of the disease.

In light of the above, it is also apparent that rural and ex-urban areas may be highly vulnerable to waterborne disease outbreaks — a situation which could be described in terms of a "rural health penalty" (Ali, 2003) in which such areas are prone to confluence of circumstances that make residents vulnerable to certain health problems. This includes health-threatening conditions due to the rise of factory farming and the use of agricultural pesticides and herbicides that may contaminate drinking water. This increased vulnerability to health threats may also be due to broader social and political circumstances, as an analysis based on an expanded scope of DIA reveals.

2.1.4. Rural vulnerabilities: a neglected dimension

Under Ontario's climate of cost-cutting that began in earnest in the 1990's, activities related to the prevention of health threats, such as the protection of drinking water, became particularly difficult for smaller rural communities. Not only did such communities have to deal with reductions in the transfer payment funds available to them, but, at the same time, they were forced to absorb the costs of new responsibilities and practices that were formerly conducted by higher levels of government (i.e. the downloading of costs and services from federal and provincial levels to the municipal level). The smaller tax base of rural communities meant that these municipalities did not have an abundance of public money available to them to invest in infrastructure and public projects. Consequently, they lacked the sophisticated equipment and facilities as well as the highly trained personnel generally found in larger cities. Under such circumstances, it is not surprising that most of the recent outbreaks of *E. coli* O157:H7 have occurred in municipalities with small water systems. (Nadakavukaren, 2000:602).

Walkerton was further prone to *E. coli* O157:H7 contamination because of the costs it had to assume in relation to privatized laboratory testing of water (previously done by the provincial Ministry of the Environment). The need to pay for private water testing was especially difficult for the town of Walkerton. To compete with other small towns in luring new residents, business and industry, inexpensive water is a major selling point, and Walkerton offered the cheapest water rates in the area even though its utility company was losing money (Perkel, 2002:30). Therefore, any additional financial costs associated with the water monitoring functions (such as privatized water testing) could not be easily assumed by the Walkerton Public Utilities Company (PUC). Furthermore, as part of Ontario's neo-liberal initiative to cut public spending, the number of inspections conducted by the Ministry of the Environment, the number of site visits and other contacts between MOE officials and municipal water officials, all decreased dramatically (Walkerton Inquiry, 2002). For example, from 1994 to 2000, annual planned inspections for the Walkerton region decreased from 25 to 10, the number of actual annual site inspections decreased from 16 to 10, while the amount of employee resources expended on municipal water requirements decreased from 10.17% to 5.12% (on a province-wide scale, the number of inspections fell by 50%)(Walkerton Inquiry, 2002).

2.2. Case #2: cumulative regional change in Headwaters Country

A dynamic and diverse place, Southern Ontario defies simple description, but a number of aspects are worth noting. In socioeconomic terms, it is an industrial center, dominated by automobile and related industries. It is home to more than a quarter of Canada's population, clustered in cities like Hamilton, London, Windsor, Kitchener and, to a rapidly increasing extent, the Greater Toronto Area (GTA). The sprawling GTA exerts a shadow effect over much of Southern Ontario, driving development patterns and real estate speculation hundreds of kilometers away. In turn, its economy is shaped by close proximity to some of the most populous regions of the United States. The wide ranging environmental impacts of Southern Ontario's development have been well documented; loss of high quality farmland in the Niagara peninsula, contamination of the Great Lakes and other waterways, increasing incidence of smog, habitat fragmentation and loss of biodiversity are a few of the many problems. (U.S. EPA and Environment Canada, 2003).

In recent years, some of Southern Ontario's most bitterly contested development battles have centered around land uses on urban–rural fringes, pitting forces of sprawl against conservation values. Diminishing physical and psychological boundaries remain between the highly urbanized areas and the prized rural landscapes and cottage country. In between, the ex-urban areas are in transition, in some instances clinging to rural character and in others imminently suburban. On a typical journey across this increasingly ex-urban landscape, one would see aggregate pits, horse farms, touristy villages, densely developed subdivisions, factories, brownfields, "estate" properties, woodlots, wetlands, moraines, watercourses and lakes. The geologically and ecologically significant Niagara Escarpment, some 450 million years old and more than 700 km long, crosses the length of Southern Ontario, defining and highlighting much of the landscape. (Niagara Escarpment Commission, 2003).

Although development-driven politics have tended to dominate land use planning processes in Southern Ontario, a mix of environmental laws, policies and practices have ensured a measure of protection. A system of conservation authorities, historically created to address flooding risks, manage many of the river areas. The Niagara Escarpment Commission is responsible for planning and development control along the areas close to the escarpment. A variety of local, national and binational initiatives seek to protect and remediate Great Lakes waters. Growing realization about moraine destruction has led to new greenbelts and other policies limiting development in areas of prime concern. The strategic location of the moraines, just north of Toronto's city limits, and their hydrological importance as the "rain barrel" for millions of people helped make one initiative – protection of the Oak Ridges Moraine – a galvanizing and consciousness raising ecological issue. While not unequivocal environmental victories, the Oak Ridges battles have helped foster a broader and more regional view of water resources (Oak Ridges Moraine, 2006; Oak Ridges Moraine Foundation, 2006).

The ongoing environmental challenges in Southern Ontario continue to exceed the capability of current management and planning practices. Even when the more conventional planning practices such as official community planning processes, land use planning regimes and environmental assessment are augmented by additional protection regimes (such as greenbelts, the Niagara Escarpment Commission, moraine protection measures, conservation areas or trusts) the southern Ontario landscape continues to be transformed and urbanized at a rapid and largely uninterrupted pace. The change is particularly evident when considered from a cumulative perspective and the landscape is compared to even the fairly recent past. Valuable natural features, resources and systems remain at risk as the transformation unfolds.

2.2.1. Headwaters Country and the Greater Toronto Area

Canada's largest city extends over a vast area, but for most of Toronto's history it was known primarily for its setting on Lake Ontario. Many of its current ecological issues continue to concern, directly or indirectly, the lake and its associated waterways. Toronto's immediate waters are now synonymous with pollution; its beach waters are hazardous and its surviving rivers and creeks are long-term restoration projects. Toronto's drinking water comes from Lake Ontario via elaborate water treatment systems. Water supplies for its suburban and ex-urban areas, however, are more likely to come from groundwater, unless costly and ecologically risky "big pipes" draw the water from the Great Lakes and transport it to considerable distances. With Lake Ontario deeply embedded in Toronto's identity, it is not surprising that its headwaters tend to be less well known.

Toronto's waterfront has been the subject of numerous campaigns and planning exercises, most notably a Royal Commission chaired by former Mayor David Crombie, which culminated in the early 1990's (Government of Canada, 1991). The Crombie Commission received national attention and reflected at the time some leading edge thinking about ecologically enlightened planning for water. It advocated a watershed-based approach and went beyond a Toronto-centric perspective. As an educational initiative, it made an important contribution in encouraging a more regional-based dialogue on development and restoration, situating the challenges facing Toronto's waterfront in a wider perspective.

The still largely rural region known as Headwaters Country lies directly north of the Greater Toronto Area (Fig. 1). The contrast in landscape between the two regions is striking, although it is diminishing through sprawl and the expansion of transitional ex-urban areas. The relationship

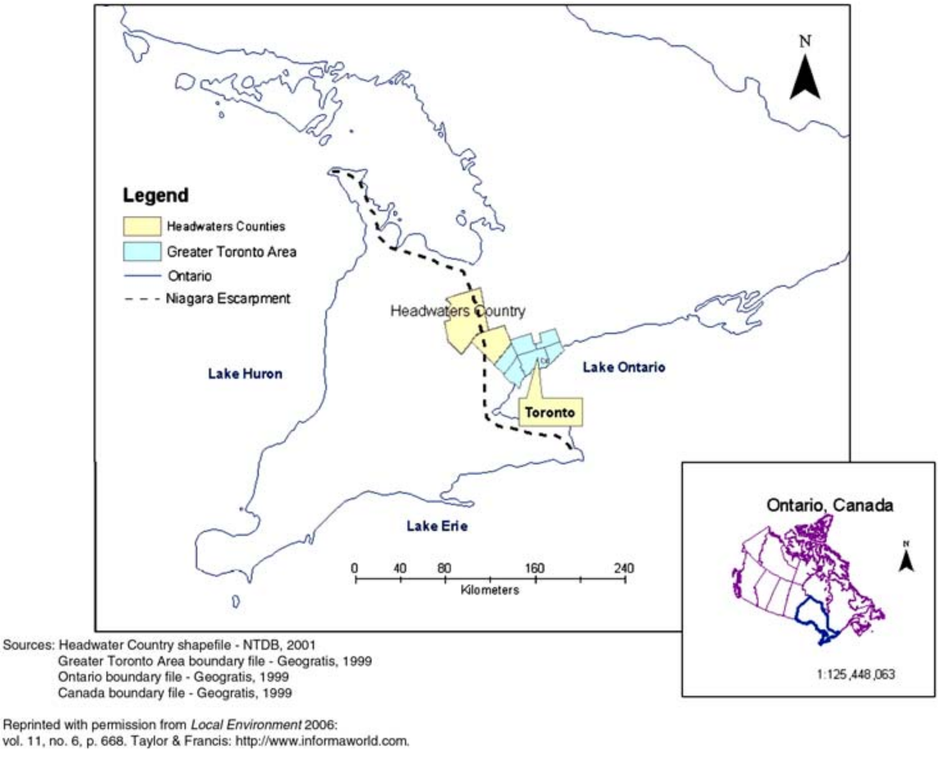

Fig. 1. Southern Ontario, Headwaters Country and the Niagara Escarpment.

between the two regions raises many questions about urban/rural relationships and sustainability at local, regional and trans-regional scales. Headwaters Country, comprised of two counties – Dufferin and Caledon – features the origins of four substantial waterways – the Grand, Humber, Nottawasaga and Credit rivers (Fig. 2). It lies just north of the GTA, but its ecological significance for Canada's most populated region is generally under-appreciated. Despite its ecological aptness, the name "Headwaters Country" is unofficial and used mainly for tourism purposes. In physical

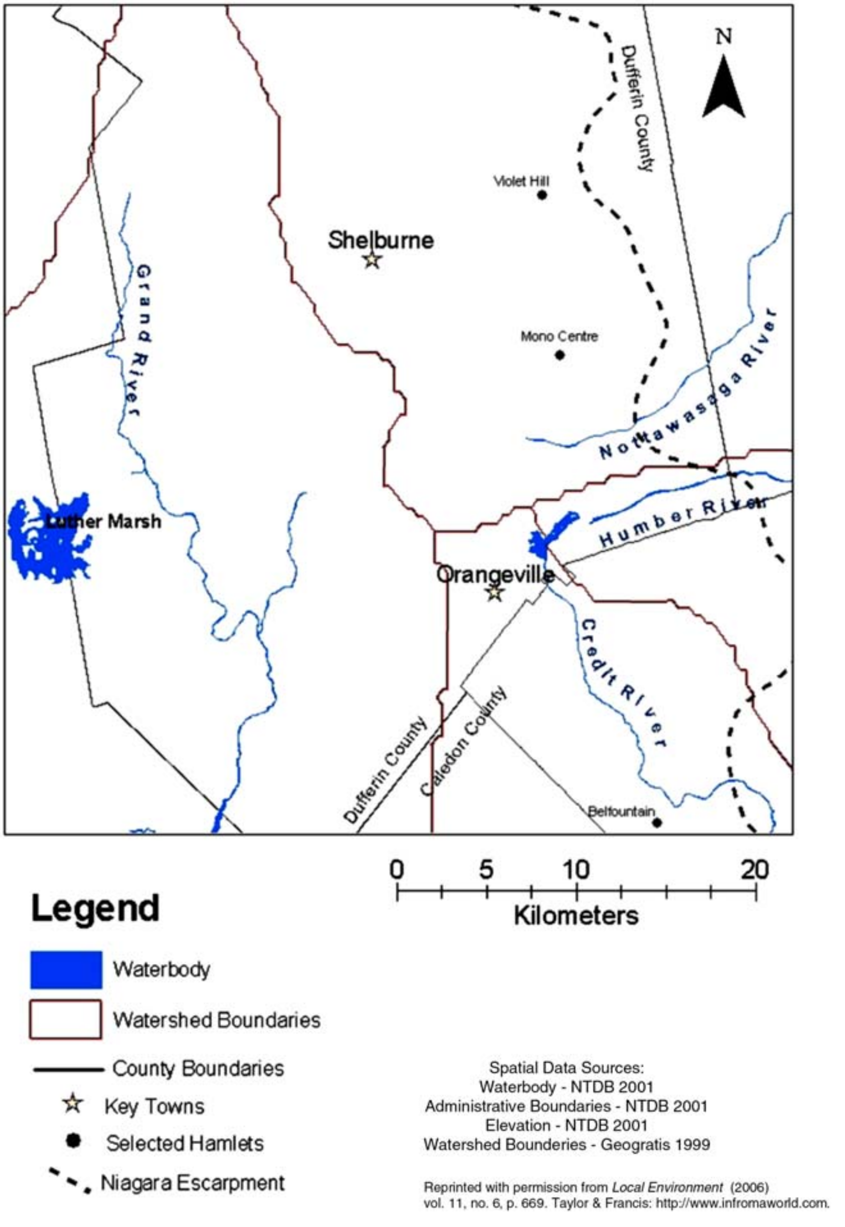

Fig. 2. Rivers of Headwaters Country.

terms, the region still presents a striking contrast to the highly developed GTA, with extensive rural areas, small towns and villages. Its inhabitants include many prosperous retirees and urban commuters, but the economy of the region is still based largely on agriculture and related industries. Important secondary industries in Headwaters Country include tourism, recreation and crafts.

2.2.2. Shifts to intensive agriculture

Agriculture remains the largest industry and employer in Dufferin County and is equally important in the rest of Headwaters Country. Some of the most contentious environmental issues revolve around the tension between the traditional agricultural economy and newer development trends and impacts. Global market forces are pressuring the region's farmers to find new efficiencies, economies of scale, technologies and vertically integrated operations (OMAFRA, 2000a). The trend to larger, factory farms is strong, conflicting with ideals about traditional farming. Factory farms typically demand a large and continuous supply of water to maintain their operations — much of it drawn from aquifers. Meanwhile, large agribusiness can reduce local autonomy and bring increased vulnerability to globally determined commodity prices.

In Ontario the percentage of rural non-farm inhabitants continues to grow; one estimate claims that it grew by nearly 300% in the 1931 to 1991 period (OMAFRA, 2000a). Rural newcomers often have limited understanding of modern agriculture, and their lifestyles and expectations may clash with those of neighboring farmers. Many parts of Southern Ontario that were rural until recently now feature an uneasy mix of livelihoods, lifestyles and expectations. Municipalities are taking planning measures to address impacts of farming that were more acceptable in a rural context but less so in an ex-urban one. These include, for example, nutrient management plans (including adequate manure storage facilities), moratoria or limits on the construction of new livestock barns, and minimum distances between land uses (OMAFRA, 2003). Meanwhile, farm lot severances are one of the most contentious issues, since they can bring much-needed income to farmers but also tend to fragment landscapes and facilitate sprawl.

As agriculture intensifies in scale and is combined with other activities and hazards, groundwater risks can increase. Contamination can result from point sources such as landfills, distributed sources such as fertilizers, or line sources such as road salt. Hazards may be surface (e.g. direct runoff into watercourses or spills infiltrating into the ground) or sub-surface (e.g. septic tanks, underground storage tanks, improperly sealed abandoned wells or buried waste producing leachate) (Howard, 2000). Sinton et al. (1997) showed that viruses are much more readily transported through sub-surface substrata than are bacteria. In the United States, the EPA estimates that agricultural runoff from animal factories and traditional farms are the leading source of water pollution in that country.

2.2.3. Sludging

The practice of "sludging" is increasingly prevalent in Headwaters Country. It involves the spreading of partly treated human waste on farmers' fields as a form of fertilizer. Most of the sludge is trucked in from the GTA and applied to fields at little or no direct cost to local farmers. Sludging may be a quick fix both from the perspective of urban waste managers and farmers, but it can entail significant ecological and human health risks. The longer-term effects of the pharmaceutical content of the sludge are worrisome and may pose another hazard to groundwater systems, but the full effects may not be apparent for many years.

Finally, although the region is largely defined by water, the full hydrological picture is not well known, either in terms of quantity or quality. The groundwater resources are typically surveyed only when required and paid for as a direct cost of development processes. With water extraction and export on the increase, and not tightly regulated, groundwater levels may be lower than believed, making assumptions about regeneration speculative at best.

2.2.4. Cumulative change and stealth transformation

Compared to the GTA, Headwaters Country is popularly perceived as a quiet, rural hinterland. The reality is quite different and the speed of cumulative change is dramatic, with impacts that may or may not be perceived, assessed or managed. Sprawl continues despite greenbelts and moraine protection, leapfrogging over urban/rural boundaries as new subdivisions appear. Farmland is lost through severances or conversion, in some cases replaced by large residential estates and in many instances further fragmenting habitats and ecological corridors. Moraines are depleted or damaged by development. Groundwater resources are depleted or neglected. Big pipes traverse regions, distorting regional hydrological systems. Rivers and sub-watersheds are stressed. Factory farming intensifies contamination risks. Overall, cumulative impacts at the regional level are insidious, obscured by the urban/ex-urban/rural dynamic. Urban/rural boundaries have significance at administrative, geographic and psychological levels, but in an ecological sense these boundaries exist to a diminishing extent. What is assumed to be an urban shadow, with incremental influence over the hinterland, is in practice a more rapid, synergistic process of regional transformation. In this regard, the rural image that is cultivated in places like Headwaters Country can backfire, reinforcing visions of an undisturbed and salubrious setting even as irreversible change occurs.

With the GTA as the main driver of change in Headwaters Country, and with global economic forces also exerting a strong influence, a number of unsustainable patterns are unfolding upstream and downstream, and the ability of EA and planning processes to intervene and influence is limited. This is due partly to the legal planning arrangements in Headwaters Country (Dufferin County, for example, has official community planning at the municipal level, but no official planning at the regional or county level). It is also due partly to the general under-use of regional level tools such as cumulative effect assessment or strategic environmental assessment.

The recent history of Southern Ontario demonstrates that virtually no region, area or water resource is fully protected from sprawl. History also reveals misplaced confidence in conventional approaches to planning, with the cumulative picture consistently ignored or underestimated. There are strong trends but also key uncertainties driving Southern Ontario's future; continued strong population growth and sprawl appear to be inevitable for the foreseeable future. The full impacts of sprawl can be unpredictable, cumulative and insidious. Vulnerability to pathogens adds further complexity and unpredictability. The ex-urban/rural/urban relationship, along with global forces, thus creates a dynamic that enables a variety of impact scenarios to unfold quietly and cumulatively.

Greener futures are also possible for Headwaters country, but would require a shift to more explicitly ecological forms of planning and development. In support of such a shift, the use of advanced forms of EA would need to be normalized. This might include rigorous approaches to cumulative assessment, use of scenarios and regional visioning exercises, disaster incubation analysis and strategic, regional level EA. More routine approaches to EA, combined with controversial exemptions of undertakings from rigorous EA, tend to merely reinforce the current path of development.

3. Conclusion

The experience of environmental assessment (EA) has provided abundant evidence that impacts frequently originate from sources and pathways that are difficult to detect, assess and manage. Even as the art and science of EA continue to be refined, impacts are to a great extent becoming more difficult to detect and study — originating, accumulating and playing out in ways that undermine common assumptions. At the regional scale, the urban/ex-urban/rural dynamic exemplifies the complicated challenge of perceiving impacts early enough to influence their timely management. In this dynamic, when rapidly growing urban centers exert inordinate development pressure, sprawl transforms rural places to ex-urban, and less visible but insidious impacts unfold in remaining rural areas. In a context of increasingly globalized economic activity, this unfolding dynamic increases the challenges of cumulative impact assessment and management at the regional scale. The sustainability challenges facing rural and ex-urban places have been well documented in a variety of literature (for example, Audirac, 1997; Daniels, 1999; Duany et al., 2000; Nelson, 1992; Storper, 1997). In this article we have examined two types of change – an area level disaster and the specter of transformative regional change – in rural and ex-urban settings in Southern Ontario. In both cases, water systems, one underground and the other watershed-level, figure prominently. Both cases underline the need for more enlightened and sophisticated approaches to assessment and planning. At present, there is relatively little use of longer-term, wider scale and preventive approaches to planning for water in Southern Ontario, but accumulating experience with water crises of various scales should stimulate increased experimentation. We have argued here that the foundations of improved practice include: 1) use of disaster incubation analysis to consider a fuller range of present and historical risk factors; 2) increased use of advanced EA tools such as cumulative effects assessment (CEA) and strategic environmental assessment (SEA), and use of scenario planning to detect weak signals of problematic development trends, cumulative effects and future risk factors.

In sum, both the Walkerton and Headwaters Country cases reflect the shift from the standard perspective that impacts arise primarily from primarily local human activities and development processes to more of a pathogen-driven view of impacts in which they originate from dispersed and insidious sources, not only accumulating but also incubating in ways that are difficult to perceive and monitor. They reflect the increasing vulnerability of rural and ex-urban places to an intensifying urban shadow along with global forces. The resulting challenges are complex, trans-jurisdictional and multi-scalar. The lurking risks and cumulative changes are compounded by incomplete approaches to assessment, underreporting, latency of risk phenomena and decoy issues. In the particular case of Southern Ontario, persistent urban sprawl ensures continued challenges. EA, in its advanced forms, when applied in a consistent and rigorous fashion and supplemented with innovative approaches such as those informed by disaster incubation analysis, could make a substantial difference and nudge the urban/ex-urban/rural dynamic toward a different pattern of planning, decisions and outcomes.

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