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Reconstructing the Spatial and Temporal Patterns of Daily Life in the 19th Century City: A Historical GIS Approach

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A thesis submitted in partial fulfillment of the requirements for the degree in Doctor of Philosophy

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by

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ABSTRACT

In recent years, historians and historical geographers have become interested in the use of GIS to study historical patterns, populations, and phenomena. The result has been the emergence of a new discipline, historical GIS. Despite the growing use of GIS across geography and history, the use of GIS in historical research has been limited largely to visualization of historical records, database management, and simple pattern analysis. This is, in part, due to a lack of accessible research on methodologies and spatial frameworks that outline the integration of both quantitative and qualitative historical sources for use in a GIS environment. The first objective of this dissertation is to develop a comprehensive geospatial research framework for the study of past populations and their environments.

The second objective of this dissertation is to apply this framework to the study of daily life in the nineteenth-century city, an important area of scholarship for historical geographers and social historians. Other daily life studies have focused on various experiences of daily life, from domestic duties and child rearing to social norms and the experience of work in early factories. An area that has received little attention in recent years is the daily mobility of individuals as they moved about the 'walking city'. This dissertation advances our understanding of the diurnal patterns of daily life by recreating the journey to work for thousands of individuals in the city of London, Ontario, and its suburbs in the late nineteenth century. Methodologies are created to capture past populations, their workplaces, and their relationship to the environments they called home. Empirical results outline the relationship between social class, gender, and the journey to work, as well as how social mobility was reflected through the quality of

individuals' residential and neighbourhood environments. The results provide a new perspective on daily mobility, social mobility, and environment in the late nineteenth-century city. Results suggest that individuals who were able to be upwardly socially mobile did so at the expense of substantial increases in their journey to work.

Keywords: Historical GIS, Journey to Work, Time-Space, Daily Life, Qualitative GIS, Social Mobility

CO-AUTHORSHIP STATEMENT

The following dissertation contains a manuscript which has been published in a peer-reviewed journal. Donald Lafreniere was the principal and corresponding author for the manuscripts. Dr. Jason Gilliland was the co-author providing important guidance, supervision, and review of the manuscripts. The following citations are provided to indicate the destinations of the manuscripts:

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Chapter Five: Lafreniere, D. and Gilliland, J. (in preparation) Following the butcher, the baker, and the candlestick-maker: Urban Environments, Social Mobility, and the Journey to Work in the Nineteenth-Century City.

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CHAPTER ONE

Introduction

1.1 RESEARCH BACKGROUND

What was the experience of living in the nineteenth-century industrial city? To what extent did people segregate themselves along ethnic lines, religious affiliation, and social status? What was the daily life like outside of the home domain—in the workplace, schools, churches, and social clubs? A diverse literature exists on the residential patterning in the rapidly industrializing cities of nineteenth-century North America. Sam Bass Warner Jr.'s classic work on Philadelphia (1968) and Peter Goheen's sophisticated empirical study of the spatial organization of population in Toronto (1970) are among the early influential works. Olivier Zunz's (1982) work on heavily-segregated industrial Detroit extended population studies beyond residential patterns to divisions within employment, religion, education, and access to services. Studies like these have mainly been constructed using aggregated samples of census records and tax rolls to examine the nature and patterns of ethnic and socioeconomic concentration, as well as other social indicators such as rate of homeownership, family organization, and demographic behaviour. Their results are often summarized in indices, tables, and graphs which highlight concentrations and fluctuations of various populations over time and space. But what was life like outside of the home? While these early empirical studies highlight the nocturnal spatial patterns and allow inferences of the social processes behind segregation and home ownership in selected cities, they do not tend to reveal very much about how these patterns and processes influenced the diurnal

experiences of ordinary people. The practices of daily life outside of the home are typically absent in historical geographic studies.

Ever since the emergence of *La Nouvelle Histoire* (Le Goff, Chartier and Revel 1978), nineteenth-century daily life studies have become an important area of scholarship for many social historians (Alexander 2007, Bradbury 1996, Lacelle 1987, Mitchell 2009, Picard 2005). Daily life in this scholarship has been framed in the narrative tradition of history: rich textual explorations of the most intimate details of life, from the practicalities of refuse collection to proper dress for an outing to the music hall. In most cases, this scholarship is derived from an examination of the literary accounts of city life, including daily newspapers, letters, and personal diaries (McCulloch 2004). This scholarship is an important layer in our understanding of the day-to-day experiences of ordinary people; however, it is not the only approach found within the historiography of nineteenth-century urban life.

Inspired by the techniques and writings that emerged during the quantitative revolution of geography in the 1960s, urban historical geographers began to revisit the numerical evidence available in census records, tax rolls, and city directories to construct their interpretations of the patterns of daily life (Dennis 1977, Greenberg 1981, Lees 1969, C. Pooley 1984). Coupling this quantitative approach with the qualitative, narrative approach familiar to social historians provides a well-diversified historiography on the daily life of Victorian citizens. However, Richard Dennis (2000), in a critical review of the state of urban historical geography, argues that modern urban historical geographers should be “eclectic in the sources they use and the approaches they adopt”

(p. 242). Dennis calls for a 'triangulation' of different kinds of sources that inform one another. Literary accounts of city life should be cross-examined by the statistical record, while quantitative sources require the contextualization of the narratives (Dennis 2000).

The empirical aim of this dissertation is to advance our understanding of the social spaces and interactions in the industrial city by 'triangulating' a host of sources to reconstruct the daily movements of people within the nineteenth-century city. I take a theoretical lead from Robert Park's (1925) assertion that social relations are inevitably correlated with spatial relations, that physical distances are the indexes of social distances. Richard Dennis (1977), in his examination of marriage patterns in Victorian Huddersfield, England, tested Park's theory and found that physical distance operated independently of social distance. Dennis concluded, however, by saying that this relationship needs to be reassessed at multiple scales of analysis, with information on forms of interaction other than marriage, and with more precise measurements of distance than were afforded by the district-to-district calculations he computed. This study tests Park's concept empirically by taking Dennis' (1977, 2000) suggestions and reconstructing the daily movements of individuals using a 'triangulation' of archival sources rich with spatial and temporal data, such as censuses, city directories, personal diaries, school attendance registers, and cartographic sources. I examine daily social spaces at multiple scales of analysis, using Chombart de Lauwe's (1965) hierarchy of social spaces as a guide (Table 1.1), by reconstructing what has become one of the unifying experiences of daily life: the journey to work.

Space Type	Types of Use	Frequency of Use
Familial Space	Household	Daily
Neighbourhood Space	Household, Social Activities	Daily
Economic Space	Work, School, Low Order Retailing	Daily, Weekly
Urban Regional Space	Financial, High Order	Monthly, Yearly
The World	Varies	Occasional Forays

Table 1.1 – Chombart de Lauwe's Hierarchy of Social Spaces

This dissertation also has a broader aim: to set forth a comprehensive geospatial research framework for the study of past populations and their environments. To do so, this work will utilize a tool that in recent years has been applied by scholars for historical geographic research, a Historical GIS (HGIS). The use of GIS for historical research was championed by a small cohort of historical geographers in the early 2000s. Arguably, the first substantial collection of work utilizing HGIS was featured in a special issue of *Social Science History*, edited by American historical geographer and vocal cheerleader of HGIS Anne Kelly Knowles (2000). It was followed quickly by a special edition of *History and Computing*, edited by British historical geographers Paul Ell and Ian Gregory, that outlined the rapid progress and future directions of the emerging discipline (Ell & Gregory, 2001; Gregory, Kemp, & Mostern, 2001). In Canada, Jason Gilliland and Sherry Olson established a uniquely Canadian approach applying GIS capabilities to the study of 19th century Montreal (Gilliland & Olson, 2003). Several books quickly followed (Gregory, 2003; Knowles A. , 2002; 2008) which have captured the attention of non-geographers, specifically historians, and prompted them to explore using GIS for

historical inquiries. In Canada, HGIS has particularly caught attention of historians with interests in past environments (Bonnell & Fortin, 2014). Very recently HGIS scholarship has inspired humanists to also embrace a geospatial approach to their craft, resulting in three edited collections (Bodenhamer, Corrigan, & Harris, 2010; Dear, Ketchum, Luria, & Richardson, 2011; Gregory & Geddes, 2014). HGIS (or, as it is increasingly being coined, spatial history) as a discipline is now in its adolescence. Increasing numbers of researchers and students are utilizing the database management and visualization capabilities that are readily accessible to novice GIS users. With very few exceptions, scholars have not taken advantage of the spatial analytical capability that GIS has been developed for.

Researchers have been limited from harnessing the full capabilities of GIS in historical research for many reasons. These include a limited access to dedicated HGIS training, few detailed methodologies that are broadly accessible and relevant for novice users, and very few historical datasets ready for use in GIS. Only a handful of institutions worldwide are offering graduate courses in HGIS and only the History Department of Idaho State University is offering a degree program in HGIS (MA in Historical Resources Management with a GIS track). Instead, formal HGIS training has been offered in the form of short workshops, which may provide a solid introduction but generally do not allow new users to fully develop skill-sets needed to move beyond visualization or database management. Despite the rich library of guidebooks, manuals, methodological academic articles, and websites on GIS and other geospatial technologies, there is a dearth of resources available for researchers who are new to using GIS in historical research. The only notable exception is a book by Gregory and Ell (2007) that

treats the issue with some authority. However, the historical data needed is rarely digitalized, most often sitting in archival collections dispersed across research institutions, government depositories, and in local community libraries or museums. Historical data is never complete and requires the historian's craft of juxtaposing sources against each other to check for representativeness and accuracy. Additionally, rarely does historical data include spatial references, and those that do are referencing archaic locations for which there are no geolocators and reference tables available. Some of these hurdles have been overcome by other HGIS scholars; however, rarely are the details of these critical decisions made known to the rest of the research community. Significant research and methodological expertise is needed before many historical sources can be used for spatial or statistical analysis in a GIS. This dissertation researches these issues and outlines a methodological framework that can be applied to a wide range of HGIS projects.

1.2 GEOGRAPHIC CONTEXT

This research is broadly applicable to any geographic area for which there exists a good repository of data on individuals and their habitations. The applicability is more fully discussed within each individual manuscript. Generally, this work will be found as most relevant to scholars of North American and European cities from the late 18th to early 20th centuries, though the research framework has also been applied to study a rural setting as well (Van Allen & Lafreniere, in review).

The study site is the mid-sized city of London, Ontario, Canada in the late nineteenth century. London is located halfway between Toronto and Detroit on the plains

of the lower Great Lakes basin (Figure 1.1). During this period, London was evolving from a regional commercial centre to a bipolar city with commercial functions in the downtown core and an expanding industrial district on the eastern edge of the city and in the Village of London East. This period of rapid industrialization marks a shift in production from home-based artisans to factory-based wage labour (Pred, 1966; Vance, 1967). Additionally, this is a period of early suburbanization, with residential neighbourhoods being established at the fringe of the city. Nineteenth-century London was a quintessential British town on Canadian soil. Both the established citizenry and the waves of recent immigrants were predominantly from the British Isles, and Protestant faiths dominated the religious composition of the growing city (Table 1.2). More than just the town's namesake, London, England contributed the inspiration for many features in the urban landscape. The Thames River meandered through the city, Victoria Park dominated the urban core, and British toponyms were found throughout the city's streets, with Piccadilly, Wellington, and Oxford among them. With a population of 19,746 at the time of the 1881 Census of Canada, London ranked 8th among Canadian cities and 86th in North America, making it comparable to cities such as St. John, NB, Lancaster, PA, and Des Moines, IA. For this study, I also included the three major suburbs of London: Petersville (aka London West), the Village of London East, and the urban section of Westminster Township (aka London South). Together these suburbs totaled 3,890 residents. It was critical to include these suburbs as they contributed significantly to the available employers and the diverse workforce found about the city. Additionally, suburban populations and industries are often overlooked in other studies, mostly because the census separates them from the urban core when disseminating their enumerations.

Figure 1.1 – Location of Study Site: London, Ontario, Canada

Ethnic Origin	Population Count	% of Population
English	11014	46.6%
Irish	6216	26.3%
Scottish	4514	19.1%
Others	853	3.7%
German	591	2.5%
French	225	0.95%
African	222	0.94%
Total	23636	100%

Table 1.2 – Distribution of Population by Ethnic Origin: London City and Suburbs, 1881 Census of Canada

London makes an ideal case study because mid-sized North American cities are under-represented in social historical geographic studies. The bulk of research on the 19th century city focuses on the large urban areas that were the centre of political, economic, and arguably, social influence of their respective nations. In the United States, New York City, Philadelphia, Boston, and Chicago receive the bulk of attention. In Canada, it is Montreal and Toronto. This curious void of interest in and scholarship on the small and mid-sized cities may be because many scholarly projects are completed in the environment surrounding the university by which the scholar is employed and universities are predominantly located in large urban centres. It might also be due to the lack of early scholarship to guide later inquiries or the perception that primary historical sources would be lacking. In our day, London, Ontario has been described as quintessentially average (Perdo, 2011), a position the city also held in the late nineteenth century. Many other mid-sized cities, such as Windsor, Winnipeg, Lansing, and Milwaukee, share a similar distinction, yet little historical geographic research has been done in these areas. Small and mid-sized cities are worthy of academic investigation, as insights garnered from them are applicable to a much wider range of cities than the exceptions which are often the focus of the nation's largest cities. As well, perhaps we could begin to understand what it truly meant to be average.

Studying small centres comes with a particular advantage—the ability to study the 'whole community' (Debats, 2009). A small city research strategy permits us to view patterns and discover processes by studying populations at the scale of the individual. Gilliland and Olson (2010), using a sample of individuals mapped to their exact residential addresses, discovered that certain social processes, such as segregation, were

only visible at the smallest of spatial scales, such as the street level or block face. Their impressive HGIS of Montreal captured a sample of 17,000 individuals, representing only 10% of the city's population. The sheer size of Montreal, at 175,000 people, coupled with few sources that captured the entire metro area, restricted their ability to capture the entire population. By embracing the study of smaller urban centres, we are better able to capture the entire city, allowing for analysis at a limitless range of spatial scales and for the re-aggregation of data at the most appropriate interval for a given statistical method. This dissertation outlines a full-count population-based approach to the creation of a historical spatial infrastructure that is flexible and adaptive to future research questions, new sources, and analytical tools. This tool can be applied to a large range of topics from social mobility, segregation, educational opportunities, religious patterns, rural-urban migration, diffusion of technology, and retail and industrial development, as well as issues that relate to present city life such as historical preservation, archeology, cultural heritage, land use and transportation planning, urban green space preservation, and brownfield redevelopment. In this dissertation, I will examine the daily journey to work and its relationship to social mobility.

1.3 STRUCTURE OF THE DISSERTATION

This dissertation is in an integrated article format. Following this introductory chapter is a short chapter that outlines a broad review of the literature and themes that guide and support the subsequent research. Chapters 3-5 are written in a manuscript format for publication in academic journals. Chapter 6 concludes the dissertation with a discussion and suggestions for future research.

The first manuscript (Chapter 3), published in *Transactions in GIS*, investigates and presents a methodological model for incorporating both qualitative and quantitative historical sources in a GIS. The manuscript outlines the initial spatial data infrastructure needed to complete the studies in chapters 4 and 5.

Chapter 4 outlines a new methodological framework for recreating the journey to work in the nineteenth century city. Case studies are analyzed and the results compared to previous studies.

Chapter 5 outlines a methodological framework for studying the same population longitudinally through time. Two environmental indices are created to examine the relationship between social mobility and the changing journey to work from 1881-1891.

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CHAPTER TWO

Broad Literature Themes

A comprehensive literature review covering the scholarship relevant is included within each separate study in this dissertation. This chapter reviews literature that does not belong to any one of the studies herein but must be addressed to help contextualize some of the larger approaches and themes found throughout the dissertation.

2.1 DISCIPLINARY CONTEXT

This dissertation contains three studies that contribute broadly to the sub-discipline of historical geography. Though if you were to read through the pages of the disciplines two premier journals, *Historical Geography* or *Journal of Historical Geography* you would be hard-pressed to find studies that take an approach to past geographical patterns in the same way as I do here. While identified as historical geography by geographers, these studies borrow techniques and approaches familiar to many social historians, demographers, and computer scientists. This interdisciplinary perspective, known at Historical GIS, owes its inspiration to, and benefits from, over half a decade of epistemological change within the broader discipline of historical geography. This next section reviews the literature, illustrating the morphology of historical geography and outlines the debates that have driven the progress and emergence of the new discipline of Historical GIS.

2.1.1 Historical Trends

The sub-discipline of historical geography has served as a foundation for the larger discipline of geography since the eighteenth century. The earliest academic studies in geography, c. 1700-1850, were historical in nature, focusing on scriptural and biblical geographies and on geographies of changing boundaries and territories (Butlin, 1993). Using these three centuries of philosophical thought as a guide, Modern North American historical geography has been through three phases of epistemological and methodological exploration from the 1950s to the present. The earliest phase treated regional settlement history as the major concern of study and was anchored by geographers such as Don Meinig, Alan Baker, John Clarke and Cole Harris (Holdsworth, 2002). They were influenced by Carl Sauer's Berkeley School where the study of human-environment relationships (cultural landscapes), the reconstruction of past geographies, and their change over time were central ways of knowing (Clayton, 2000; Sauer, 1925). The re-creation of place, culture and identity were central to their work in regional studies (Holdsworth, 2002). Prince (1971), writing on the methodological approaches prevalent in this phase, suggests that historical geographers studied "real worlds", past geographies and their processes of change, through a narrative-based empirical approach. Modernisation theory, which posits an evolutionary change from a 'traditional' to a 'modern' society, grounded this first phase of historical geography (Baker, 2003).

The catalyst for the second phase of epistemological and methodological exploration was the quantitative revolution in geography in the 1960s. It pushed historical geography to the margins of the discipline, as narrative-based, empirical

scholarship was not as valued as the new epistemology of spatial science (Clayton, 2000). The epistemological shift away from description and towards interpretation was central to this phase. Some historical geographers (Goheen, 1970); (Haggett, 1965); (Peach, 1975); (Pitts, 1965) embraced the new spatial analytic methodologies in spatial science, such as network models, gravity models, segregation indices and simulation models. While others such as (Clark, 1968); (Meinig, 1968); (Smith, 1966) continued writing as they had for years with a strong commitment to the historical study of landscapes and occasional ventures into the reconstructions of regional geographies of the past. Historical geography was 'saved' from the margins of the discipline by the development of humanistic geography in the 1970s and 80s. The period saw a sub-disciplinary shift away from source-bound empiricism, which had dominated historical geographical study to that time, to explorations of different methods of explanation. These humanistic historical geographers sought to integrate social theory into their studies and thus embraced the philosophies of Marxism, humanism, idealism, and structuralism (Butlin, 1993).

The third epistemological and methodological phase (1980s to present) is described by Clayton (2000) as 'eclectic'; he suggests that no single orthodoxy is likely to emerge from it. As Holdsworth (2002, p. 676) observes, a trend in this phase is that "modern historical geographies are more likely to simultaneously embrace the local and the global, rather than dwell at the regional scale." Williams (1994) highlights how historical geographers have returned to their 'stock-in-trade' interest in human-environment relationships in response to recent public concern over environmental issues. Informed by the perspectives of postmodernism, some recent work in historical

geography starts from the premise that “geographers create and communicate meaning from partial vantage points” rather than simply recreating a prior and separate geographical reality (Clayton, 2000, p. 338). For example, Cosgrove (1984) argues that landscape becomes a ‘way of seeing’ the spatiality and temporality of social life and human identity. As Graham and Nash (2000) suggest, the cultural turn in geography has influenced historical geographical approaches by extending the concern with class to other axes of domination and identity such as race and gender. Mitchell (2002) says that this has caused historical geography to become deeply theoretical without sacrificing, but instead relying on, its traditional empirical richness.

Despite many historical geographers finding a comfortable place within this marriage of theory and empiricism, it is the eclecticism of the sub-discipline which has once again pushed historical geography to the margins of the discipline. An “anything goes” attitude has emerged, resulting in no unifying theory or epistemology for the sub-discipline. Historical geographers are becoming increasingly interdisciplinary in their collaborations, often looking first to the closest cognate discipline than within geography itself (Holdsworth D. , 2002). Williams (2002) worries this may lead to the sub-discipline being swallowed by cultural geography and environmental history. Writing in self-reflection, a historical geographer (Kay, 1990) describes his sub-discipline as “antiquarian in its purpose”. Such an identity crisis, coupled with the pressures to compete for resources with other geographies that appear to be more contemporarily relevant, has resulted in fewer students being trained in the sub-discipline and even fewer hired upon the retirement of their mentors (Meinig, 1989). However, despite this apparent impending mortality, it is the same eclecticism of the 1980s and 90s that has

allowed some aspiring historical geographers to forge a new epistemology, one that is moving to completely reshape the discipline.

2.1.2 An Emerging Discipline: Historical GIS

Aided by the computational advancements in geographic information systems (GIS) and the "spatial turn" in history (Withers, 2009), the next generation of historical geographers has developed a new methodology and epistemology: historical GIS. Historical GIS, or HGIS, is the creation and use of a relational database of historical geographical data in a GIS. Anne Knowles, one of the earliest supporters and most prolific writers on the methodology, suggests that "almost every historical document contains some kind of geographical information" (Knowles, 2008, p. 2) and thus can be incorporated into an HGIS. Examples of historical data commonly used include censuses, city directories, historical maps and social surveys. HGIS allows one to visualise the geographic patterns embedded in historical evidence, examine evidence at different scales, aggregate data on-the-fly into various units, and integrate a nearly limitless range of material from the narrative to nominal. As Knowles (2000, p. 453) points out, "Historical GIS computerizes much that is basic to historical geography". It may be this inherent familiarity that has encouraged even the most senior of historical geographers to say that "historical GIS is an exciting and challenging development" (Baker, 2003, p. 44) and to encourage their peers "to be open to the dazzling array of new ways of seeing, and imaging, the past" (Holdsworth D. , 2003, p. 491). Knowles's equally prolific colleague, Ian Gregory has gone so far to claim that "in less than a decade, historical GIS has emerged to become an accepted and evolving part of both the

quantitative and qualitative spheres of historical geography" (Gregory & Healey, 2007, p. 649).

From the literature, there appears to be quite a fervour surrounding HGIS. Knowles, in the opening line of her introduction to an influential special issue of Social Science History devoted to HGIS, proclaimed that "people love new tools that enable them to do what they have dreamed of doing" (Knowles, 2000, p. 451). Is HGIS truly an epistemological advance of historical geography, or is it just an analytical tool? Gregory and Healey (2007) argue that HGIS can aid in the advancement of historical geographical scholarship in three ways: First, by providing revisionist studies that challenge existing orthodoxies. Examples of such work include investigations of patterns of social change, such as racial and ethnic segregation in North American cities (Gilliland & Olson, 2010); (Hillier, 2003). Secondly, by tackling questions that have not been resolved to date, such as the origins and patterns of the American Dust Bowl in the 1930s (Cunfer, 2008). Thirdly, Gregory and Healey argue that HGIS provides a new way of knowing the past, which enables historical geographers to ask completely new questions.

One of the earliest and still most utilized strengths of HGIS is its ability to easily visually represent historical data through the creation of maps. Orford (2005) argues that maps help researchers synthesise spatial patterns and relationships that may not be obvious or intuitive. Maps represent an inductive epistemology that is important in the formation of geographic theories and the generation of hypotheses. Krygier (1997) calls this way of knowing a scientific "visual epistemology". Siebert (2000) also argues for this inductive approach; however, she stresses the need for a progression from a visual epistemology to the interpretation of findings and the creation of knowledge. While not

historical geographers, Knigge & Cope (2006) and Steinberg & Steinberg (2005) suggest that the intuitive model that 'grounded visualization' affords can ground the multiple interpretations and partial vantage points that the HGIS based approach to historical geographical scholarship offers.

This current dialogue echoes the discussions of the 1960s that pitted description against interpretation; however, it is just one of the debates found within the young sub-disciplinary approach of historical GIS.

2.1.3 Historical GIS- Epistemological and Methodological Debates

HGIS has seen a host of debates emerge since its founding in the late 1990s. Siebert's stress on the interpretation of findings is one of these debates. Gregory and Healey (2007, p. 650) acknowledge Siebert's concern but also attempt to moderate it: "historical GIS studies...are better at identifying and describing patterns that they are at explaining them. Nevertheless, the ability to be able to recognize patterns will clearly lead to more robust explanations." Baker (2003) reminds us that spatial analysis will provide the answer to 'where?' a particular historical event or process took place but it will not tell us 'why there?' Baker goes on to also support this type of inductive work, suggesting that it is the mapping of historical processes that itself raises new questions. Rose-Redwood (2009) suggests that this insistence on moving beyond the descriptive demonstrates the growing influence of critical GIS on the development of a post-positivist historical GIS.

Although Gregory and Ell (2007, p. 161) postulate that "the quantitative nature of spatial data does not mean that spatial analysis is necessarily positivist", others, including

Anne Knowles, a staunch supporter of historical GIS, have concerns that this new epistemology is causing a rebirth of the criticisms of the quantitative revolution. Figure 2.1 is adapted from Knowles (2000) and it compares the criticisms of the 1970s and 80s and the criticisms of GIS in the 1990s.

Criticisms of quantitative history, c. 1980	Criticisms of GIS, c. 1995
It's a passing fad	Academics are embracing GIS uncritically
The world needs "essential narrative," works of synthesis, not "research reports"	GIS is merely a tool
It has not fulfilled its promise. It is dull, local, and technical and has confirmed what we already know	Geostatistics are still crude. GIS advocates are recycling the failed approach of 1960s spatial analysis
It examines only questions for which quantitative data exists	GIS handles qualitative data poorly
History must be accessible to all and therefore should not use complex statistics	GIS is too difficult for the masses. Its users are creating a technocracy
Historical information is too imprecise for sophisticated methods and theory	GIS enforces consistency and logic that do not inhere in many data sources
Computer-based analysis is uncreative	GIS too narrowly serves the immediate needs of policy makers
It assumes one can determine truth	GIS divorces information from the context of its social creation

Figure 2.1 – Criticism of quantitative history and GIS

There are also epistemological debates in historical GIS related to the kinds of information that can be analysed. Pickles (1999) notes that GIS is better-suited to some types of data than others. GIS does well with nominal data such as census data, historical city directories and business records but it does not handle qualitative data, such as personal diaries and newspapers, with the same degree of authority. Consequently, work in historical GIS is likely to emphasize sources and subjects that are well-suited to particular representations of the world (Gregory & Ell, 2007).

The lack of temporal functionality in GIS is often criticised by historical geographers who have not embraced GIS (O'Sullivan, 2005). Progress has been slow in implementing temporal functions into the software as GIS software vendors do not see this as a particularly important development priority for their primary market—municipal governments and industry. However, historical GIS users have adopted a number of ad-hoc solutions such as time-stamping, which involves the inclusion of a database of temporal references related to a particular point in space. Bodenhamer (2008) points out that such a solution can be cumbersome to build. Time references are not always an issue in GIS, however, particularly when a researcher is building a database of stand-alone features, such tenants of a building. The building is static, so the attributes of time can be easily assigned to the building.

Debates also surround the use of inherently incomplete historical sources in an environment that demands a high level of certainty in the data inputted. Incomplete, inaccurate and ambiguous sources are a common problem for historians, but history has embraced this ontological issue by making it an epistemological challenge (Evans, 1997). For historical GIS, the issue is more methodological: how to take such ambiguous sources and bring them into a strict coordinate system. Gregory and Healey (2007) offer three approaches: mathematical, representational and documentary. The mathematical approach uses fuzzy logic, which assigns a coordinate based on a mathematical calculation of the most likely expected location of a given attribute. The representational approach involves the researcher aggregating the data into a raster which is projected using blurred lines and colours to represent areas of uncertainty. The documentary approach is adopted from traditional narrative historians, who through the use of

footnotes systematically address each ambiguity found in their research. Historical GIS accomplishes this through the use of metadata, data that describes data. Contemporary geographic information science scholars such as Yao and Jiang (2005) are also tackling these issues and their findings are providing important guidance to the qualitative GIS community.

2.1.4 Finding a Home within the Debates

The studies that make up this dissertation do not claim to resolve all of these complex debates, but they do offer some progress. In particular, are the debates suggesting that HGIS is a return to the decontextualized histories and quantitative traditions of the 1980s. At its origin, GIS is a numerical tool, driven by coordinates of latitude and longitude, capable of very complex mathematical computations. This numerical basis however does not predetermine the output of research that results from its use. If careful concerns for the origins and contexts of the source material are maintained, a GIS approach to history can add important contextual cues to historical records that would otherwise be cost prohibitive or impossible to accomplish otherwise. Positioning the traditional quantitative historical sources, such as censuses, against qualitative sources such as diaries and newspapers (as outlined in chapter 3), allows researchers to conceptualise and criticise their quantitative findings and provide the context need to create a spatial narrative, rather than a purely quantitative assessment of the patterns and processes observed.

These studies also address the debates by Pickles and others that methodologies are needed over limitations GIS has for integrating qualitative sources. In addition to the traditional sources that have been widely used in historical GIS databases for other cities,

these studies illustrate methodologies and case studies for using qualitative archival sources in a GIS. Diaries and school records are used to conceptualise, criticise and illustrate quantitative findings. This use of qualitative sources requires a subjective approach to analysis, helping to suppress criticisms that HGIS research is purely positivist in nature. The textual analysis of qualitative sources is in itself an interpretive exercise which would certainly please Siebert and others who call for more interpretation in historical GIS.

These studies embrace Knigge & Cope's (2006) 'grounded visualization' as an analytic base for studying the nineteenth century city. This answers the debates in historical GIS that calls for an interpretive epistemology. Though not challenged explicitly, attempts are made in these studies to illustrate ways to overcome some of the temporal limitations of GIS. Though much more work and emphasis is needed by scholars in the area of temporal GIS, the studies here illustrate that the temporal limitations of the software are not slowing the field from advancing and producing knowledge.

2.2 THE CHALLENGE OF HISTORICAL SOURCES

A historical geographer's object of study is rooted in the past. Thus to commence any investigation he must turn to the historical record and rely upon the documents that have survived in the world's archives, libraries, museums and personal collections. However, there are methodological difficulties that a scholar must address when working with historical sources. First, the scholar must evaluate the source critically as well as place the source within its historical context. Perhaps the most critical methodological

challenge is the issue of authenticity (Black, 2010). Scholars must determine if the source is original, or, if a duplicate, how has it been modified from the original.

Secondly, it is necessary to critically evaluate how the original purpose for the creation of a historical source has influenced the information contained within it. For example, any source that is collected by a third party, such as the census, municipal tax rolls and city directories, has an inherent bias in who is and who is not captured in the register. Censuses have received the most attention of the three sources noted above; however, the scholarship on the reliability of the census is somewhat limited given the wide use of the census. Steckel (1991) notes that there are three types of errors that affect the reliability of census data: underenumeration, overenumeration and misreporting. Underenumeration has been noted by Miller (1922) for African Americans in the US South and Curtis (2001) for Lower Canada in the 1851-71 censuses. The underenumeration of aboriginal populations has been discussed in Baskerville and Sager (1990), Curtis (2001), Hamilton (2007) and Hamilton and Inwood (2011). Davenport (1985), Dunae (1998), and Galois & Harris (1994) have discussed underenumeration in remote or secluded areas, while Dunae (2009), Dunae et al. (2013), Knights (1969), Katz (1975) and Olson & Thornton (2011) have hinted at underenumeration in urban areas. Overenumeration has been tackled by Curtis (2001) in discussing double-counting in the 1861 census and by Curtis (1995), Dunae (1998) and Furstenberg et al. (1979) in their reviews of municipal check censuses in Montreal, Victoria and Philadelphia.

Misreporting or misrepresentation has also been identified as an issue with censuses. This includes how occupations are represented, as examined by Baskerville (1993), Baskerville and Sager (1998), Bradbury (2007), Curtis (2001), and Dunae (2009).

Inwood & Reid (2001) review both gender and occupation. Darroch (2000) reviews the issues with the representation of family previous to the 'relation to household head' question in 1901. How ethnicity and language are identified have been critical to the studies of Dillon (2002), Gaffield (2007), Hamilton & Inwood (2011), and Lutz (2008).

Beyond sources that are enumerated, scholars also use textual and oral sources, which are created by (in)direct testimony of witnesses to historical events. Sources such as diaries and letters can help overcome the problem of aggregation and the recording of the 'official' rather than personal view of the world (Black, 2010). They provide an intimate, personal view of the past. McCulloch (2004) warns that they can be very biased and subjective, although he notes that if a record is written immediately after an event, it can be especially reliable, and can be very telling if used in concert with other sources (Black, 2010); (Hoffman & Taylor, 1996). Oral histories can be used to gain insight into the nature of past personal relationships and the significance of past events to the participants, as well as for the re-creation of life courses. However, the degradation of time has a strong effect on the accuracy and reliability of memories and perceptions (Hareven, 1982).

Despite the lengthy list of concerns in using historical sources, Baker reminds us that "no study in historical geography can be better than the sources on which it is founded" and that the best studies rely upon a wide range of sources that reinforce each other or perhaps even speak to each other (Baker, 1997, p. 234). As Dennis (2000) argues, the 'triangulation' of sources can create a deep and fluid re-creation of a past reality.

Although the benefit of studying the past with a broad range of historical sources is evident, historical geographers have been slow to embrace the use of GIS. For those who have begun to use GIS, the census has been the most widely used historical source because of its familiarity, comprehensiveness, and ease of access. Many models of using the census in a GIS exist in the form of national historical GIS's. Among the earliest projects was the Great Britain HGIS, started by Southall and later joined by Gregory et al. (2002). There are also national projects in the US (Fitch & Ruggles, 2003), China (Bol & Ge, 2005), Russia (Merzlyakova, 2005), and South Korea (Kim, 2005). Other uses of census data are at the local urban scale. Among the earliest urban projects was Montreal, spearheaded by Gilliland and Olson (2003). Others include Philadelphia (Hillier, 2002), Tokyo (Siebert, 2000), Hartford (Schlichting, Tuckel, & Maisel, 2006), Victoria (Dunae, Lutz, Lafreniere, & Gilliland, 2011), and Alexandria, Virginia and Newport, Kentucky (Debats, 2008)

Lastly, there have been a number of scholars who have attempted to use other historical sources in a GIS, such as Fyfe et al. (2009) with their use of hotel registers, Lafreniere and Rivet (2010) with disparate cartographic sources, Gilliland and Novak (2006) with fire insurance plans, Debats (2009) with voting records, Travis (2010) with literary novels, Gregory and Cooper (2009) with travel diaries, and Gregory and Hardie (2011) with newspapers. Many of these uses of non-tabular data are in their infancy and have inspired the need to create the detailed methodology outlined in chapter three for qualitative sources.

2.3 UNDERSTANDING COMMUNITY AND NEIGHBOURHOOD

George Hillery sent us a cautionary reminder that community is indeed an area of little agreement. In a broad review of the early literature on both rural and urban definitions of community he found ninety-four different definitions, bounded within sixteen different concepts. His summary concluded that most scholars in the first half of the twentieth century had the basic agreement that community consisted of "persons in social interaction within a geographic area and having one or more additional common ties" (Hillery, 1955, p. 111). Although geographic and sociological thought on community has progressed since Hillery's writing, many of the themes he identified, such as common life, consciousness of kind, possession of common norms, and a collection of institutions still emerge in more contemporary scholarship on community.

At the risk of not being chronologically consistent, we need to step back before we can march forward in this review. Much of Hillery's appraisal included the work of Robert Park and the rest of the Chicago School of Urban Sociology. Park's work includes the now well-known concept of *human ecology*, the idea that the urban experiences of humans are divided along the lines of community and society (Park, 1925) (Park, 1952). Community was theorized by Park as being a 'natural' process that occurs through the interplay of market competition for rents, human adaption to these forces and spatial interaction. His concept of 'natural communities' inspired his colleague Ernest Burgess to develop the concentric ring model of urban development. It illustrates how communities (or what we may think of now as neighbourhoods of socially segregated peoples) emerged in cities but were generally stable and homogenous, although susceptible to invasion and succession by new groups over time.

This early work by the Chicago School sociologists, which influenced the later work reviewed by Hillery, was based on Park's notion that community is built because "social relations are so frequently and so inevitably correlated with spacial [sic] relations" (Park, 1925, p. 18). Despite the many issues identified with the Chicago School conception, such as the issues surrounding the use of behavioural and mental disorders to delineate natural communities within the city, many geographers of the latter half of the twentieth century accepted this notion that propinquity equaled or led to community and neighbourhood.

Geographers such as John Clarke embraced models that were developed with obvious roots in Burgess' concentric ring model. Clarke, embracing the Steevian Scheme of structured social spaces, conceptualizes 'community' as "the proximity of individuals one to another in absolute and social space, together with those bonds which are forged between individuals living beside one another, bonds of inter-marriage and of kinship, of common ancestry and common experience and of friendship and co-operation…" (Clarke, 1991, p. 390). Richard Dennis (1984) also embraces this conceptualization of community by arguing that social interaction is critical to community, and given that his studies were preoccupied with the 'walking city' of the middle nineteenth century, propinquity was necessary. Dennis argues that any type of community, whether delineated along class lines, ethnicity or common interest, is more likely to exist "where families have lived and worked in the same area for a long time, and where neighbours are also kin." (Dennis, 1984, p. 250) And much like others who follow the propinquity-equals-community conceptualization, Dennis argues that one can measure and map community through an examination of the density of kin or residential tenure.

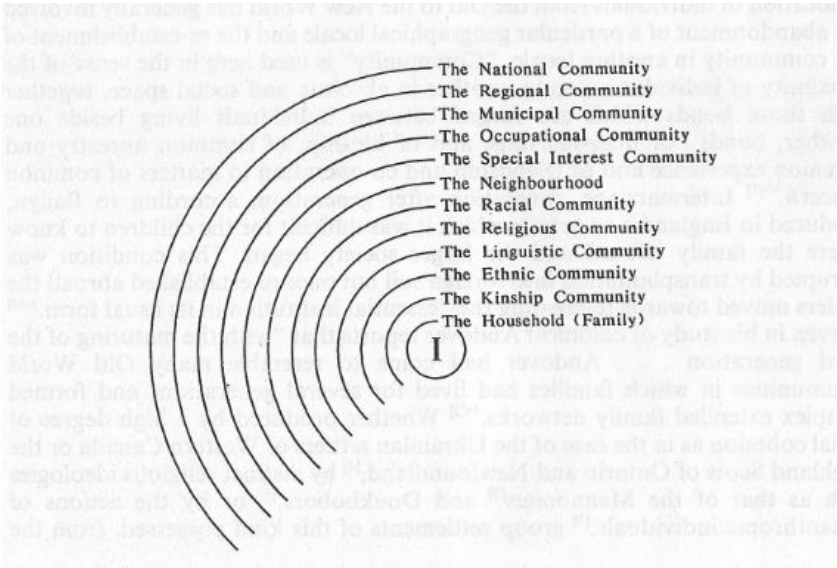

Figure 2.2 – The Steevian Scheme of Community (from Clarke 1991)

Dennis, in a separate article, also suggests that the social identities of marriage partners can be used as an acute indicator of community. He argues that relationships are consummated by proximate individuals and thus aggregate marriage patterns can hint at community formation and location (Dennis, 1977). Van Leeuwen and Maas (2005) echo a similar argument. The French philosopher Mayol (1998) also conceptualizes community as necessarily having propinquity. He argues that the practice of being in community "introduces gratuitousness instead of necessity", that your daily social interactions or 'social commitments' with everyone from your neighbours to the local shopkeeper and your child's school teacher are dependent on proximity and repetition. These scholars conceptualize 'community' interchangeably with the idea of 'neighbourhood', following the shared understanding that propinquity-equals-community.

Following the Chicago School's teachings on the importance of proximity to community building came Melvin Webber's countering assertion that there can be 'community without propinquity' (Webber, 1963). Webber saw how the advancements in communications and transportation diminished the importance of space in community building. He demonstrated how friendships could be maintained from a distance and how community can be created based on professional or other relational groupings, as well as neighbourhoods. Although not specifically theorizing on the conceptualization of community, Torsten Hägerstrand's (1970) lessons on the importance of considering individuals with widely varying space-time paths follows much of Webber's inferences because communities can be created beyond the sphere of one's residence. Scholarship that Hägerstrand inspired, such as the early work of Goodchild & Janelle (1984) and later Mei-Po Kwan (1999), have further elaborated on these ideas.

A shared identity is among the most influential factors in the production of a community without propinquity. Any shared activity or affiliation can create a sense of community. It may be membership in a fraternal society or club association such a writers guild, Shriners or Scouting. It may be through a professional organization such as the CAG or AAG, a term coined by Wenger (1998) as a 'community of practice'. A shared identity within a specific genre of occupation often produces a community. For example, Perkins & Metz (1988) found that sixty-seven percent of volunteer firefighters found their membership and affiliation with the fire department was more important to them than their church community. Sports team affiliation can also manifest itself as community (Jacobson, 2003). Religious affiliation is often linked with a strong community, as noted by Tom Bulten (2002) in his study of community among Christian

Reformed church members. Butlen found that propinquity had little influence on the ability of congregations to experience a sense of community. Ethnic or racial identity can also produce communities without a residential base. Examples are often seen in large urban centres where an ethnic group may have a wide residential distribution across the urban area. The Chinese community of the Greater Toronto Area is an example of this. Although there is some residential propinquity around Spadina Avenue and Dundas Street in what many refer to as Chinatown, there is a larger ethnic community of Chinese that includes those that live in the greater metropolitan area. Ethnic communities can also been seen to be completely non-geographic, in which having an ethnic identity, thus a shared identity, allows one to claim oneself as a member of a potentially world-wide community.

Experiential communities exist among those who share an event or history. The experience of serving for the armed forces, the experience of deployment during a time of war, the loss of a loved one due to a specific disease or misfortune (such as drunk driving), or participation in a notable event (whether tragic or positive) can create strong non-place-based communities. Common stages in the life course can also create community, such as the common bonds felt by senior citizens or by parents who reach broadly to create communities with others who also have children with special needs, have adopted children, or are home schooling their children.

Many of these communities without propinquity have been created or exist only with the aid of modern communication technologies, most notably the internet. Kitchin (1998) coined the term ‘virtual communities’ to describe the new forms of social relations being created by these new technologies. Technologies like the internet allow

for close interaction between people with similar interests, concerns or experiences, overcoming the barriers of distance. The internet (or its early variations in landline modem-based bulletin boards) was not the first iteration of virtual communities. Amateur radio operators, using radio frequencies that permit worldwide communications, had created a vibrant virtual community as early as the 1930s. Haring (2006) describes how hundreds of thousands of predominantly middle to upper class men formed an identity and community through their shared recreational interest in electronics and radio communication. However, it was the internet that sparked the interest of more scholars in the production of virtual communities. Among the types of virtual communities that can be found on the internet are support groups (like many listed above), task-related groups (petitions or political action groups), interest groups (e.g. sports fans) and in dynamic environments where a diverse array of relationships and communities can interact in tandem (eg. Facebook and Twitter). The importance of virtual communities to their participants can be seen by the proliferation of smartphones and the applications embedded within them to maintain close and near-immediate contact with other members of their community through commercial environments like Facebook and Twitter. Some scholars have argued that these virtual communities are simply extensions of 'real' geographically-bounded communities (Parks, 2011) while others (primarily those writing about the early years of the internet) question the idea of virtual communities altogether.

The conceptualization of community is also a concern of urban planners, as they see a proliferation of propinquity without community. Work such as that of Jane Jacobs and Andres Duany professes that there is a need for well-functioning neighbourhoods in order to re-establish a sense of community and ultimately strengthen urban places.

Community activists have attempted to artificially create community by naming neighbourhoods. In Indianapolis, neighbourhood residents were encouraged to develop names for their neighbourhoods in the hopes that it would create a shared identity and foster community attachment (Levitz, 2012). Historic preservationists see this pattern as well and claim that the creation of heritage districts can create a shared neighbourhood and community identity (Tyler, Ligibel, & Tyler, 2009).

Yet a fourth conceptualization of community exists which has been theorized by Benedict Anderson. He argued that a nation was an imagined political community whose members "will never know their fellow-members, meet them, or even hear of them, yet in the minds of each they carry the image of their communion" (Anderson, 1983, p. 15). This imagined community can be seen through the perceived close bond that citizens have with each other when travelling abroad. For example, Canadians often sew small flags on their backpacks when travelling in Europe; other Canadians who notice these flags will extend a friendly acknowledgement or a kind gesture to their perceived community member. Imagined communities can also be seen in international sporting competitions such as the Olympics when national pride and community engagement overcomes other social barriers such as class or ethnicity. Gillian Rose (1990) extended Anderson's understanding of imagined communities and theorized that they can exist on more than just a national scale. She argued that imagined communities are "a group of people bound together by some kind of belief stemming from particular historical and geographical circumstance in their own solidarity" (p.426). Her work focused on the neighbourhood of Poplar in London, England, where she used oral histories to capture two contrasting politicized views of community. Rose's work inspired other geographers

to think about imagined communities, such as Gill Valentine, who examined the geographies of sexuality (Valentine, 1995).

2.3.1 Conceptualizing Neighbourhood in the Nineteenth Century City

This section has outlined how the conceptualization of community and neighbourhood is complex and can be interpreted in a myriad of ways. The studies in this dissertation conceptualize 'community' interchangeably with the idea of 'neighbourhood', following the propinquity-equals-community model. This conceptualization is driven by the historical nature of the studies. The subject of these studies, the Victorian city, was primarily a walking city and thus propinquity was critical to the production of community. The transportation and communication networks needed to create and sustain communities without propinquity did not yet exist. I take notice of Robert Park's assertions that social relations are correlated with spatial relations because of who he was studying and the time in which he was theorizing his understanding of communities. Park was a student of Georg Simmel, who was even more concerned with geometric distances than Park. Simmel tells us that society is made up of the interaction between individuals. He observed the smallest of social interactions to see how larger scale institutions, such as schools and churches, emerged from them (Farganis, 1996). Although, Simmel did not theorize community directly many of the 'institutions' he saw created through interactions are familiar to those hallmarks of community and neighbourhood building described earlier in this section. I see Simmel's (and later Park's) assertions as, in some ways, as a historical source. Simmel was observing social interactions and their impacts during the same time period that is the focus of this dissertation. Although it may be seen as an antiquated perspective on community and

neighbourhood, it is tantalizing to have a perspective that was developed through observations of temporally similar populations and by a scholar with a firsthand understanding of live in the nineteenth century.

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CHAPTER THREE

All the World's a Stage: A GIS Framework for Recreating Personal Time-Space from Qualitative and Quantitative Sources

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3.1 ABSTRACT

This article presents a methodological model for the study of the space-time patterns of everyday life. The framework utilizes a wide range of qualitative and quantitative sources to create two environmental stages, social and built, which place and contextualize the daily mobilities of individuals as they traverse urban environments. Additionally, this study outlines a procedure to fully integrate narrative sources in a GIS. By placing qualitative sources, such as narratives, within a stage-based GIS, researchers can begin to tell rich spatial stories about the lived experiences of segregation, social interaction, and environmental exposure. The article concludes with a case study utilizing the diary of a postal clerk to outline the wide applicability of this model for space-time GIS research.

Keywords: Qualitative GIS, Narrative, Space-Time, Historical GIS, Contextualizing Data

3.2 INTRODUCTION

Set design is an important consideration for any play, movie, or theatrical endeavor. Visual imagery is critical to capturing the audience's attention and placing them within the scene created for them. A well-designed set allows an audience to apprehend important contextual clues about the world view being presented. If a film maker were telling the story of the First World War's Battle of Polygon Wood, the backdrop would include a vivid recreation of the fallen woodlot with its miles of trenches and mud, not the modern four-lane A19 motorway that traverses much of the former Ypres Salient.

As geographers, we find it important to tell not only where an event occurs, but how the space in which a geographical phenomenon operates can influence outcomes. We need an understanding of the environment in which an activity, event, or phenomenon occurs. In geographical research, the environment may be social, physical, or ecological, and often is a combination of these.

Human geographers find it fundamental to have an understanding of the social environment — be it sociological, economic, or political. We often begin by creating a profile of the demographic characteristics and composition of the population we are studying. The demographic profile typically includes a combination of variables extracted from a census sample or similar survey that represents the nocturnal population. To adhere to the demands of research ethics, these samples are traditionally aggregated to arbitrary geographies such as census tracts.

However, neither environments nor actors are static. Environments are created and continually modified, both physically and socially, by the actors who use them.

Actors are mobile, not only residentially mobile, but continuously mobile as they move through their daily lives. These daily time-space patterns have provided countless lines of enquiry for geographers over the past half-century, with topics ranging from racial and ethnic segregation to labour markets, and from health outcomes to community cohesion.

Kwan (2013) has recently argued that we need to expand our analytical focus from the static residential spaces captured in census-based studies to other places and times in people's daily lives. She suggests that a deeper understanding of a population's spatio-temporal experiences could be established if we study 'where and when people work, eat, play, shop, and socialize' (Kwan, 2013, p. 6). Congruent with her theoretical framework, this paper will outline a methodological framework to study the space-time patterns of everyday life using a wide range of qualitative and quantitative sources.

We argue in this paper that when studying the spatio-temporal patterns of individuals, a stage must first be set in which to place and contextualize the space-time paths and social interactions. This means going beyond merely putting one layer of space-time data atop another, or placing the paths against a backdrop such as Google Earth, as these common approaches decontextualize the data. Instead, we argue that space-time data should be contextualized on a set of rich environmental stages constructed using a wide-range of qualitative and quantitative sources such as temporally-representative maps, social surveys, photographs, and local property data. We advocate for the creation of a GIS where sources are fully integrated with the contextualizing stage, going beyond the simple recognition that they share the same geographic and temporal space.

This paper provides a detailed framework for the creation of two environmental stages, built and social. A built environment stage comprises of data sources that allow for the modelling of the human-made spaces in cities, including the structures, land uses, transportation systems and parks. These are the physical spaces in which people live, work, play, and the domain that researchers of individual space-time patterns have largely been concerned. A social environment stage comprises a dataset of all residents of the city, at the scale of the individual, complete with their full socio-demographic characteristics. It includes their familial, workplace, school, and religious affiliations and networks. This allows for the modelling of the social structures and social relations that shape the everyday lives of individuals. The social environment is also their community, the racial ghetto, the effects of living 'on the wrong side of the tracks', or their 'hood. It allows for the uncovering of the socially-constructed places in the city such as 'eastside', 'westside', or 'uptown'. It also encompasses micro-scale social environments such as families, co-workers, classmates, and congregations.

In addition to laying out the framework for a stage-based GIS, this paper makes an attempt to integrate narrative sources in a GIS. By utilizing data-rich environmental stages, we have created a methodology that allows narrative sources to be used in a GIS in concert with, and contextualized by, traditional quantitative data. This framework affords researchers the ability to not only georeference non-tabular sources, such as narratives, within a GIS but also to maintain and even add important contextual clues. Additionally, by integrating this approach with the environmental stages, a deeper understanding of the spaces recorded in the narrative can be achieved than by examining the text alone. We can interrogate both the physical and social spaces occupied by not

only the writer, but also each and every person he mentions within his daily account of life in the city. We can map not only the physical spaces occupied by diary writer and his relations, but also the social networks of friendship, family, and business. This new framework for a space-time GIS allows for the creation of rich spatial stories and a more robust and accurate interpretation of the space-time patterns of past populations, the places they created, and the larger social environments present in urban areas.

3.3 RELATED WORK

In recent years, an interdisciplinary mass of scholars has turned its attention to the use and potential of GIS as a research tool to dissect and analyze qualitative sources (Kwan & Ding, 2008; Jung, 2009; Jung & Elwood, 2010; Cooper & Gregory, 2011). This attention can be attributed to both the increasing data-handling abilities of a desktop GIS and the potential for spatially statistically rich mixed-methods insight that can be acquired through the use of a GIS. To date, the use of qualitative sources in a GIS has centred primarily in participatory GIS (PPGIS), where the prime concern has been to enfranchise local knowledge (Corbett & Rambaldi, 2009; Cowan, McGarry, Moran, McCarthy, & King, 2012; Craig, Harris, & Weiner, 2002; Loebach & Gilliland, 2010; Rambaldi, Kwaku Kyem, McCall, & Weiner, 2006) or as an epistemology for capturing non-cartographic forms of spatial information (Elwood, 2009a; Dennis, Gaulocher, Carpiano, & Brown, 2009; Koti, 2010; Kwan, 2007). The potential of qualitative GIS has begun to catch the interest of a range of scholars who have embraced the ‘spatial turn’ in the social sciences and humanities (Bodenhamer, Corrigan, & Harris, 2010; Dear, Ketchum, Luria, & Richardson, 2011).

This newest crop of spatial thinkers has been inspired by the possibilities promoted by those who have adopted GIS for historical research. Early work in the blossoming discipline of Historical GIS (HGIS) was focused largely on the creation of national HGIS datasets that spatialized aggregated collections of tabular government sources such as censuses (Gregory , Bennett, Gilham, & Southall, 2002; McMaster & Noble, 2005; St-Hilaire, Moldofsky, Richard, & Beaudry, 2007), administrative boundaries (Bol, 2008; De Moor & Wiedemann, 2001; Kunz & Boehler, 2005) and toponyms (Berman, 2004; Mostern & Johnson, 2008; Southall, Mostern, & Berman, 2011). Other projects utilized individual-level nominal sources such as city directories, censuses, and tax rolls to create datasets at the local scale (Debats, 2008; 2009; Dunae, Lutz, Lafreniere, & Gilliland, 2011; Gilliland & Olson, 2003; 2010). Only recently have HGIS scholars attempted to incorporate written texts, such as travel diaries or recollections of an event in a newspaper, into a geospatial environment. Most notable is the work by Ian Gregory and his colleagues, who have begun to extract spatial and temporal cues from corpuses of newspapers and travel accounts (Cooper & Gregory, 2011; Gregory & Cooper, 2009; Gregory & Hardie, 2011). These early efforts show that the incorporation of written texts into a GIS is of interest to humanities researchers; however, they involve little more than mapping place names with the aid of a gazetteer.

It has been noted that there is a "challenge of including local knowledge in GIS-based data structures and GIS-based analysis, because it is often represented in forms such as texts…" (Jung, 2009, p. 118). We suggest that a deeper understanding of space- and place-making can be captured from a corpus of written texts. It requires an integration of the spatial cues found within a text with a deep understanding of the local

environment to which the text refers. A further challenge is georeferencing textual data that is expressed solely using situational relationships, such as the "new mill near where the river bends" or "the vacant lot on First Street by the abandoned factory". Yao and Jiang (2005), Yao and Thill (2006), and Jung and Elwood (2010) have pioneered techniques for such 'qualitative locations', allowing for the visualization of textual sources that do not have absolute Euclidean geometries. These important methodological contributions will aid researchers in using GIS to visualize, quantify, and interrogate constructions of place and time.

What is missing from current qualitative GIS research, and is of interest to researchers both within and outside of traditional GIS circles, is the maintenance of the contextual cues that lie within many textual sources. What we present here is a framework for using a GIS for the contextualization of qualitative sources, particularly texts, beyond just locating their point or extent on a map. We see this integration of texts as allowing researchers to not only fully utilize the data-handling and analytical capabilities of a GIS for qualitative sources, but to recreate the space-time paths, or spatial stories, of a large number of individuals with relative ease.

3.4 BUILDING GEOSPATIAL STAGES

This paper outlines the GIS framework and data structures created during the nearly decade-long creation of the Imag(in)ing London Historical GIS Project. Our HGIS, spanning 1871-2013, has been built to be robust and flexible in both the sophistication of the spatial analysis techniques that can be employed as well as the range

of sources that can be incorporated. This allows for a deep contextualization of both the quantitative and qualitative sources that are brought into the system.

Our HGIS is comprised of two stages, a built environment stage and a social environment stage. Each stage is designed and built to be independent from the other, both spatially and temporally, but are used in concert to perform queries and analysis. Each is built using the spatial references from a specific temporal period recorded in an archival cartographic source. Further, each stage is comprised of many 'scenes', or temporal periods represented. We have built environment 'scenes' that represent the entire city of London, Ontario and its suburbs for 1855, 1881, 1888, 1907, 1915, 1926, 1958, and 2008-2013.

3.4.1 The Built Environment Stage

The foundation of a built environment scene could be any historical source or combination of sources that captures a comprehensive representation of the past landscape, such as a topographic map, geodetic survey, or fire insurance plan (FIP). Our first built environment scene began with the 1881 FIP of London created by the Charles E. Goad Company. Goad produced FIPs for most major cities in Canada and Great Britain from 1878-1970 (Goad, 1984). Similar to those produced by the American Sanborn Map Company, the plans were created to aid fire insurance companies in assessing risk. FIPs have long been recognised for their accuracy and immense detail on the built environment of the city (Bloomfield G. T., 1982; Krafft, 1993; Oswald, 1997). Each building's use, number of floors, construction material, and position within the lot are documented with a cartographic precision of 1:6000. The height of larger buildings is often recorded, along with the use of individual rooms and the location of fire hazards

such as furnaces, wood piles, oil tanks, and generators (Figure 3.1). This impressive cartographic record provides researchers who study the late nineteenth to mid-twentieth century an ideal source for the construction of a built environment scene.

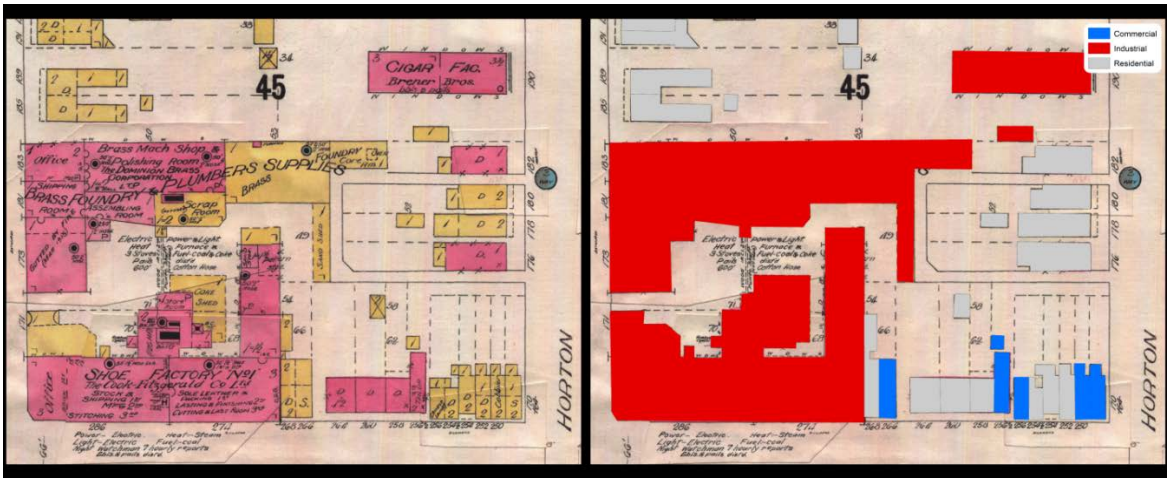

Figure 3.1 – 1915 Fire Insurance Plan of London. On the left is the original map, on the right the vectorized building polygons with embedded attributes

Our work began with the digitalization of the historical cartographic sources using a large format scanner at a resolution of 1200 DPI (see Figure 3.2). The images were then georeferenced to a modern GIS of the city using ArcGIS 9.2. To include the built environment variables found on the FIPs, each building needed to be vectorized by hand. This time-consuming step was critical so we could perform spatial analytic queries on the built environment and allows for the contextualization of space-time data that we are advocating (Figure 3.1). Thankfully, several researchers are developing techniques to automate the extraction of built environment variables from cartographic and remotely sensed images (Aldred & Wang, 2011; Carneiro, Morello, Voegtle, & Golay, 2010; Marciano, Allen, Hou, & Lach, 2013). Despite recent advances in auto-vectorization,

there is still the need to assign the environmental attributes noted on the FIPs to each feature in the geodatabase. To facilitate comparison across multiple temporal periods, the variables needed to be normalized using common categories. Once loaded into the geodatabase, the temporal scene was complete and ready to be added to other scenes in the built environment stage of the HGIS.

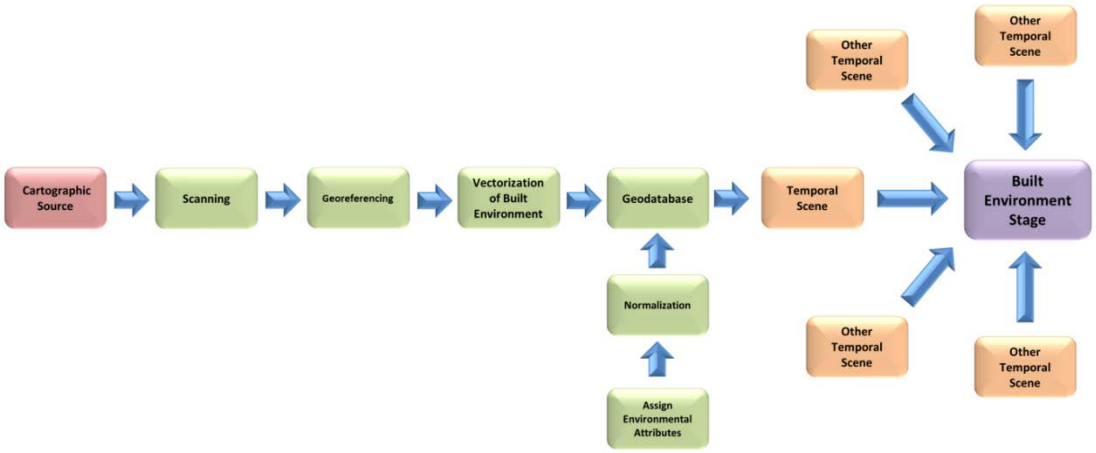

Figure 3.2 – Built Environment Stage workflow

Of equal importance to the creation of a contextually rich stage-based historical GIS is the civic addressing that is found within the FIPs. Each property is noted with a precise civic address that can be used as a common spatial identifier, facilitating an easy integration of a wide range of sources into the GIS. Of particular interest to Canadian scholars is how this addressing can be used to facilitate the geocoding of the decennial census of Canada prior to 1901, when no addresses are listed in the manuscript records. This would also be of interest to other scholars who have access to individual-level data that is devoid of a fine-grained spatial identifier.

3.4.2 The Social Environment Stage

A social environment stage can be created using any combination of sources that, when record linked, provide a rich dataset outlining the many social indicators found in the geographic area of interest. Annual city directories and the decennial census of Canada are the cornerstones of our social environment stage. We elected to use the decennial census as it provides the most reliable record of nineteenth and early twentieth century urban populations (Curtis, 2001; Olson & Thornton, 2011; Sager & Baskerville, 2007).

We desired to have as rich a social environment stage as possible. The combination of decennial censuses and annual city directories provides not only the name, age, occupation, birthplace, ethnicity, and marital status of each individual, but also the relationships found within each family unit or domicile, the tenancy of each residential unit, and the place of work for those employed both within and outside the home. We have benefited from the valiant efforts of the Canadian Century Research Infrastructure Project (Gaffield, 2007), the 1881 Canadian Census Project (Dillon, 2000) and the Historical Data Unit at the University of Guelph who have each assisted in the creation of a complete count of the entire population of the city of London from 1871-1901. This has allowed us to map every individual to their exact residential unit, including children, a population that is rarely captured in geo-demographic studies. The city directories, geocoded on an annual basis, allow us to understand the social environment between the census years, including residential mobility, changing social mobility, and property ownership. We can even follow as domestic scenes change, such as when teenagers leave their parents' homes to start their own households.

A historical city directory typically consists of four sections. There is an alphabetical listing of each resident in the city which includes their full name, residential address, housing tenure, occupation, and workplace. A business directory lists all commercial and industrial operations in the city. It is sorted by the primary service provided or good produced, and includes the name, full address, and in some cases the owner and/or partners of the business. A street directory provides a detailed geographical record of each street. Every address in the city is recorded along with the head of household or business located at that address. Each address is placed in order as if you were walking down the street and notations of proximity to cross streets and vacant land are included. Finally, the miscellaneous directory lists the churches, schools, post offices, and other similar public buildings located throughout the city.

The creation of the social environment stage began with the semi-automated transcription of the city directories (Figure 3.3). All four sections of the directory, for every year between 1871 and 1901, were run through an optical character recognition (OCR) procedure in Adobe Acrobat. The OCR is imperfect, so each record was reviewed by a researcher who made corrections or manual transcriptions where needed. The file was then text parsed and imported into a MS Access database. Using the temporally-corresponding built environment stage, we created an address point locator and geocoded the directories. This overcame most issues that are associated with geocoding historical records, such as street name changes or additions, and changes in residential buildings and lots. 71% of the city directory entries across all years were geocoded through the automated functions within ArcGIS. A combination of factors prevented the remainder from being completed with the point locator. In 1871-1883, some addresses were

indicated with street intersections or by vernacular names given to major commercial buildings such as ‘Union Block’ or ‘Albion Buildings’; these entries were manually geocoded. Entries for boarders or hotel dwellers often included the name of the owner of the lodging place rather than an address; these entries were researched further and manually georeferenced. The final geocoding capture rate was 97.2% of city directory entries across all years, with the lowest single year (1879) being 94%.

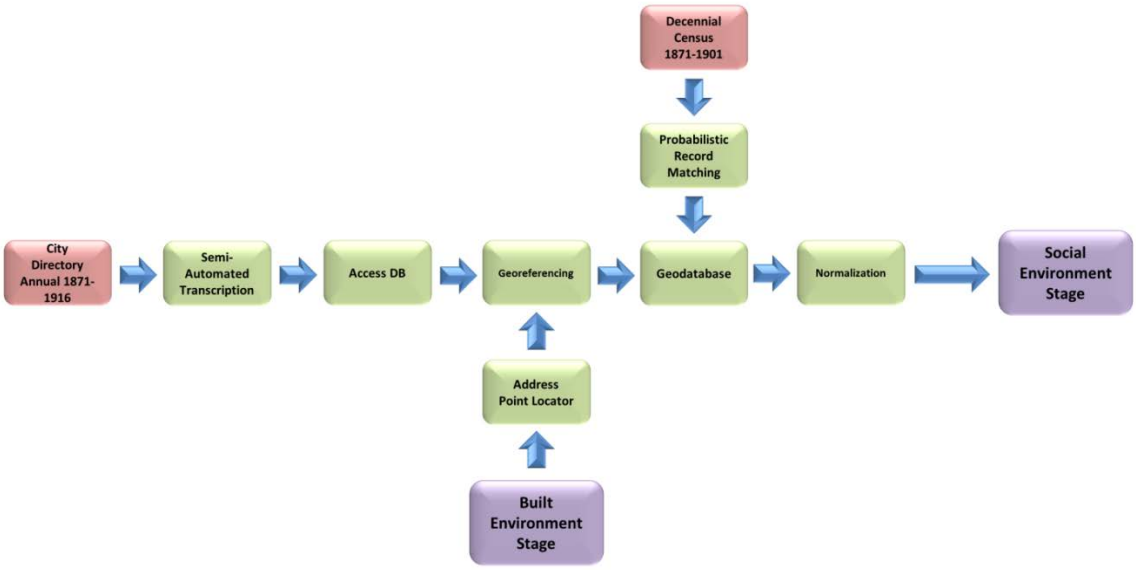

Figure 3.3 – Social Environment Stage workflow

To facilitate the georeferencing of the decennial censuses of 1871, 1881, and 1891 (which provide a geographic reference to a district but no civic addresses), we used a customized version of LinkageWiz, a probabilistic record matching software, to record link the census to the city directory of the same year (LinkageWiz, 2011). The records were blocked using enumeration areas and last names. Last names were blocked with various phonetic algorithms and string comparisons applied. Matching was then performed using match weights for first name, gender (derived from a lookup table of

first names), and occupation. Occupation also included a lookup table of similar occupational titles derived from the Historical International Standard Classification of Occupations (HISCO) (van Leeuwen, Maas, & Miles, 2002; 2004). Only the most probable matches (90% threshold) were automatically matched; the remainder were manually reviewed by the researchers before inclusion in the geodatabase.

Historical demographers are acutely aware of the issues that have resulted from the change in the census questions from enumeration to enumeration. The final step in the creation of the social environment stage included our attempts to normalize the census and directory variables for easier comparisons year over year (see Figure 3.4 for the variables found within the social environment stage geodatabase). We have largely followed the lead of the researchers involved in the North Atlantic Population Project (NAPP) (Ruggles, 2002; Roberts, et al., 2003). Relevant variables such as the number of rooms and state of construction found within the 1891 census were extracted and included in the built environment stage.

The result is a robust geodatabase, or social stage, that affords us a completely new way of looking at a city and its population. For the better part of the twentieth century, researchers have followed the model of the Chicago School of Sociology, studying urban populations by placing them within the arbitrary boundaries and hard edges of the census tracts. Much like the pioneers Charles Booth (1889) and Herbert Ames (1897), we can now map and analyze social patterns at the scale of a single block. We can see that a new Irish Catholic immigrant, his wife, and eight children live in the back lot behind an English Protestant industrial capitalist who employs three servants. At

an even finer scale, we can see the merchants' wives who may share a friendly salutation from porch to porch and the young single factory worker who rents a room above the living quarters of a bourgeois insurance agent. A myriad of possible research topics may be interrogated in a social environment stage built at this micro-scale. Rich individual-level data allows a researcher to ask questions and discern patterns that are lost in aggregated census data.

Researchers also benefit from the flexibility and adaptability of having a GIS built upon a set of two or more spatially-linked, multi-temporal stages. The system can combine any range of data included within the stages' geodatabases, and additional 'bricks' may be added to the foundation of the GIS as new research questions arise. We found ourselves doing so as we moved from projects focused on urban morphology to those more demographic in nature.

We can combine the spatial accuracy of civic addresses with the cartographic record of businesses, buildings and lots found on the FIP to map nearly any archival source with the most subtle reference to an individual, business, event, or street corner. This allows the unique opportunity to incorporate into the HGIS seemingly aspatial archival sources such as payroll records, newspapers, or police digests, with all people and events placed in their exact historic spatial locations. Researchers thereby have a novel perspective on the past, allowing us to pose new questions and guiding us toward more robust answers. This also allows for a deeper contextualization of sources, as each source can be viewed within its appropriate temporal scene as well as in its spatial relation to other actors or events.

Variable Name	*Description*	*Source Derived From*
LAST_NAME	Last Name of Individual	City Directories
FIRST_NAME	First Name of Individual	
INITIAL	Middle Initial of Individual	
OCCUPATION	Occupation	
WORKADD	Workplace Address	
WORKPLACE	Workplace Name	
TENURE*	Home ownership or renter	
STREETNUM	Street Number	
STREETNAME	Street Name	
SUBURB*	Suburb if applicable	
BUILDING	Name of building residence is located within, if applicable	
HOTEL	Name of hotel resident is living in, if applicable	
WORK_ID	Unique ID linking to business directory extry for place of work	
WARD	Municipal Ward	
CENSUS_ID	Unique ID created during census manuscript transcription	Decennial Census
FAMILY_ID	Unique ID for each family in census	
INST	Type of instiution resident resides in, if applicable	
DwSize	Number of persons in the dwelling	
Fsize	Number of persons in the family unit	
NAMELAST	Last Name of Individual	
NAMEFIRST	First Name of Individual	
SEX*	Gender	
AGE*	Age	
MARST*	Marital Status	
RELATE*	Relationship of Individual to Household Head	
BPL*	Birthplace	
FBPL*	Father's Birthplace	
MBPL*	Mother's Birthplace	
RELIGION*	Religion	
OCC*	Occupation	
EMPLOYER	Indicates if the individual was an employer	
WageEarner	Indicates if the individual was a wage earner	
UNEMP	Indicates if the individual was unemployed	
EMPHANDS	Indicates the average # of people employed by the individual during the year	
CANREAD	Indicates if the individual can read	
CANWRITE	Indicates if the individual is can write	
BLIND	Indicates if the individual is blind	
DEAF	Indicates if the individual is deaf	
UNSOUND	Indicates if the individual had an unsound mind	
REL_STAT	Normalized field for Religion	Normalized Fields for statistical and longitudinal use
SEX_STAT	Normalized field for Gender	
AGE_STAT	Normalized field for Age	
BPlaceSTAT	Normalized field for Birthplace	
EthnicSTAT	Normalized field for Ethincity- derived from Father's and Mother's birthplaces	
MARST_STAT	Normalized field for Marital Status	
OCC_STAT	Normalized field for Occupation	
Wk_STAT	Normalized field for whether workplace is known	
NapHisco	Normalized field for NAPP-modified HISCO Code	
OccClass	Normalized field for Occupational Social Class	
NapHisOcc	Normalized field for HISCO-derived Occupational Title	

Figure 3.4 – Example of variables included in the 1891 social environment stage geodatabase. The * indicates the presence of a corresponding numeric variable to facilitate statistical analysis

To illustrate, we have harnessed the built and social environment stages to explore the potential exposures to noxious industrial environments during children's daily journey to school in the 1880s (see Figure 3.5). We record-linked to the social environment stage an attendance register of pupils that enumerated all of the students (n=699) from the three primary schools in the suburban town of London East. The register only included each student's name, age, parent's name, and daily attendance at school. The demographic robustness of the social environment stage allowed us to locate these children through their parents and place them within their homes. Using the road and pathway network in the built environment stage, we calculated their likely journeys to school using a shortest path analysis. The routes are aggregated in figure 3.5 to illustrate the number of children who traveled on any given street segment in a day. By calculating a weighted interpolation of the SQ footage of each industrial building and railyard, we created a surface that represents the industrial areas of the city and juxtaposed it with the journeys to school. We see that over half of the students (n=354) were traversing an industrial area, representing on average 371 metres of their journey and approximately five minutes of walking time, depending on the age of the student (see Figure 3.6). Further analysis with the social environment stage shows us that children of semi-skilled or unskilled workers had the least exposure and children of parents in professional occupations had the most. This pattern is likely a reflection of the difference in housing patterns of the industrial suburb, with lower cost housing nearer to the core, and thus the school, and more elaborate housing built at the city's fringe. This short example illustrates how the contextualization of historical sources within a stage-based

GIS can lead to new perspectives—in this case, on the 19th century time-space paths of children and the environments they traversed on a daily basis.

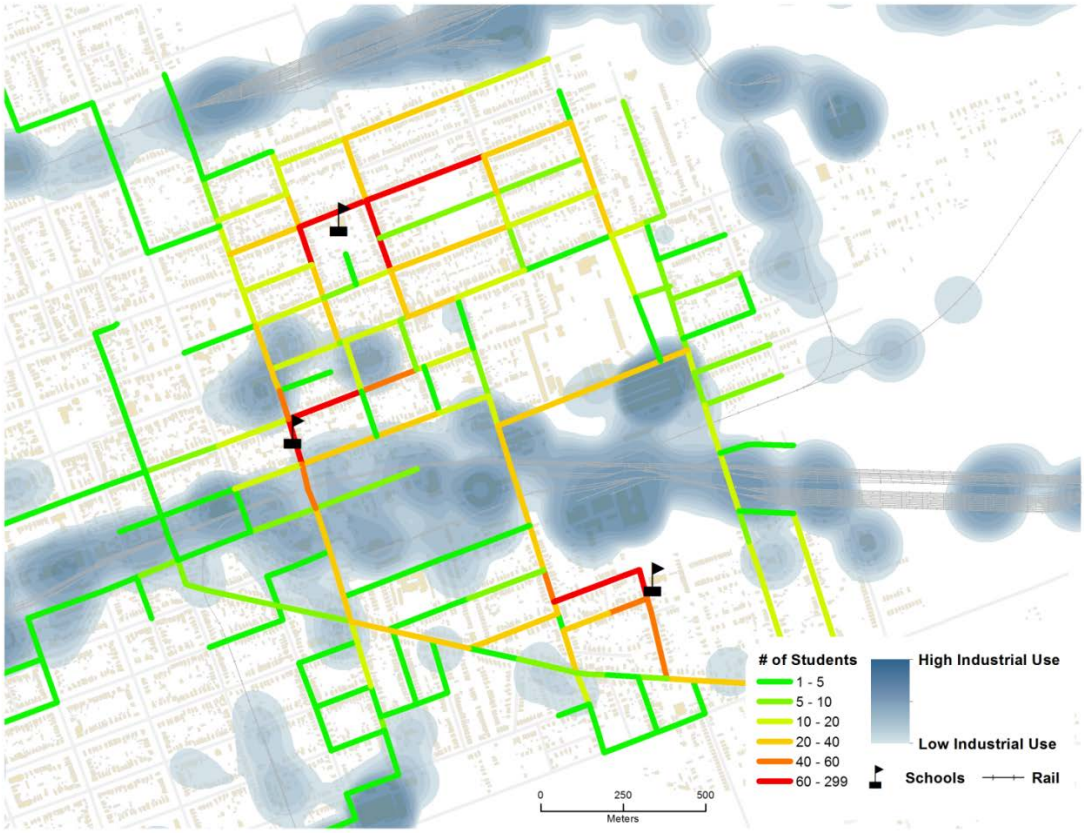

Figure 3.5 – Built and Social Environment Stages used together to explore children's potential exposure to noxious environments on their journey to school

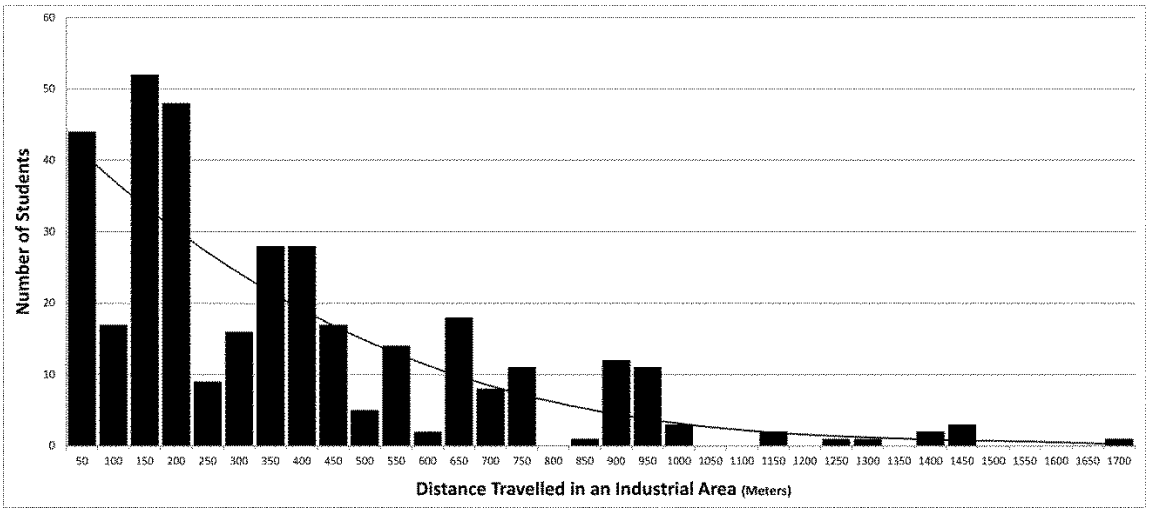

Figure 3.6 – Distances travelled within an industrial area by children on their daily journey to school

3.5 INTEGRATING AND CONTEXTUALIZING NARRATIVES

Our interest in spatializing narratives stems from a larger research program that is exploring the social structures of nineteenth century cities through the lens of spatial mobilities. We wish to understand the true impact of segregation on the creation of community by looking at the extent of social interaction through the re-creation of individual space-time paths, what we call the *spatial stories of urban life*. We quickly determined that the best sources of such fine resolution data on social interaction are personal diaries. Nineteenth-century personal diaries vary widely in the type of information that was recorded in them. Culley outlines that most diaries served not only as a method of private personal record keeping (i.e. personal finances, illness, and appointments) but also as semi-public records of life (Culley, 1989, pp. 15-17). Culley, as well as Adams and Gossage (1998), argue that men wrote about their public activities

and women about family and community events. Our experience with urban diaries confirms this.

3.5.1 Digitalization and Text Parsing

To date, we have incorporated twelve diaries that have overlapping spatial and temporal extents. The diaries were located in a regional archive and first had to be digitalized in preparation for inclusion in the GIS. The diaries were scanned page by page and transcribed manually. Attempts were then made to parse the text using a number of automated text mining methods including natural language processing (Piotrowski, 2012), named entity recognition (Nissim, Matheson, & Reid, 2004), and feature selection algorithms. We had limited success; even with the use of disambiguation techniques, we found that less than 40% of the text was able to be identified satisfactorily. A host of reasons influenced this low capture rate, such as the wide use of shorthand, nicknames and archaic terms. Foremost was the heavy use of vernacular terms used for locations or events. For example, “went to 7’oclock (sic) prayer meeting at the sabbath school” or “met at the gallery building before heading to tea at Old J Weston’s”.

Automated text segmentation and event generation is an area of significant interest to computational linguists who are intrigued by the challenge as well as the research possibilities available if we could harness the vast archive of data stored in texts, especially the limitless textual archive of the internet. Interest in historical texts has been limited until very recently. Notable efforts are underway by Michael Piotrowski (2012) to tackle the challenges of applying current natural language processing techniques to historical corpora. Further work has begun by Ian Gregory and others as part of a larger

project in the spatial humanities (Gregory, 2013). Despite these recent efforts, no universally applicable technique for parsing and identifying historical texts is currently available. Piotrowski argues that most successful natural language processing projects for historical texts have taken place with tools built specifically for a historical corpora representing a specific time and place (Piotrowski, 2012, p. 100). We did not have the resources to create a tool specific to our corpora and thus found it more effective to parse the text manually.

3.5.2 Creating Events from Texts

A primary concern among qualitative social scientists is how to maintain the important contextual clues about the people, places, and events that are embedded within a written narrative. The benefit of a manual approach to text parsing when combined with a stage-based GIS is the ability to tease out not only subtle or incomplete references to people, places, and events, but also to be able to extrapolate time, relationships, and spatial mobilities.

We started by first parsing out unique socio-spatial events (Figure 3.7). An event can take two forms. First, it can be a temporally specific mention of someone who was spatially mobile. This can be obvious, such as “left for work at 7am”, or more subtle, such as “We had dinner & supper at 438” (438 is the address of the diarist’s in-laws, thus we can infer movement). The second type of event is one that involves a social interaction, even if we are unsure of the extent of the spatial mobility present. For example, “last evening Dick was with us for tea”. We do not necessarily know where tea took place but we are still able to parse out this interaction.

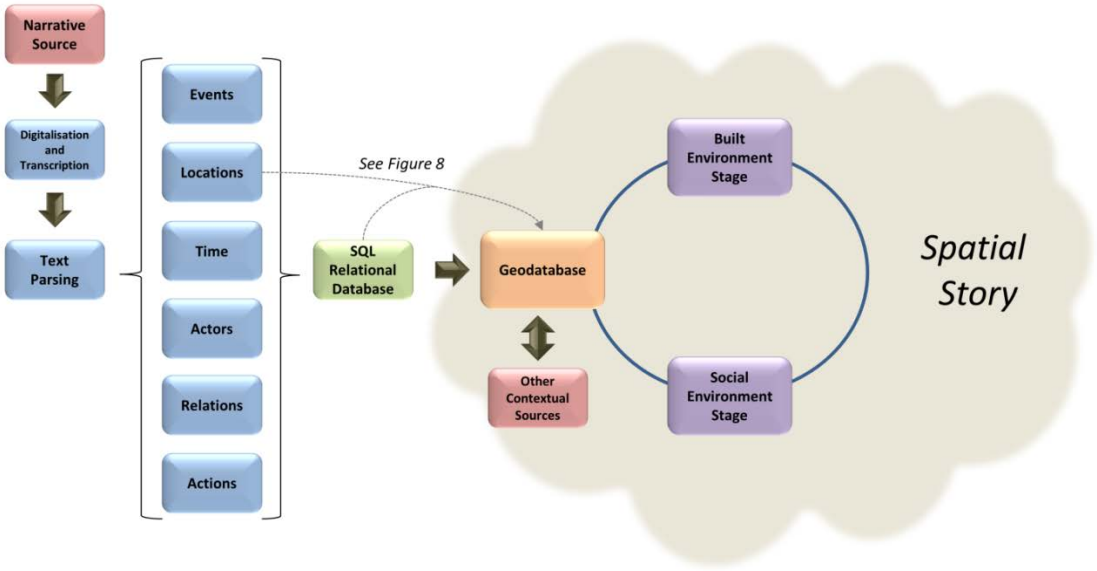

Figure 3.7 – Workflow to integrate and contextualize qualitative sources in a GIS. The example is a written narrative. This method allows us to create a rich spatial story of a given time and place.

Locations were then extracted in a similar manner; the details of this process are outlined in section 3.6. Time was recorded for each event at the finest resolution possible (both absolute and deictic) in addition to where an event fit in the sequence of socio-spatial events in any given day. This notation in the relational database is needed for the re-creation of spatial stories. A record of all actors, or people recorded in the diary, complete with their full geo-demographic record from the social environment stage, was created. The relationships between each actor and the diary writer, as well as the relationships between all actors to each other, were extracted from the diary. We also used the various temporal scenes available in the social environment stage to create a web of social relations beyond what is immediately obvious from the diary (Figure 3.7). We can thus see not only familial branches but also economic, social, political and

employment-based relations. In essence, we have captured a comprehensive social network of the entire city, centred on individual diary writers.

Actions were the final element of our relational database to be parsed out of the narrative. Actions include a number of elements such as the direction of travel, origins, destinations, and waypoints, or stops along the way. Each event was codified using an index of 'why' codes to indicate whether it was work-related, social, educational, religious, for commerce, or otherwise; multiple reasons could be indicated. Finally, the complete passage from the digitalized narrative was included so researchers can view the original event in context.

3.6 GEOREFERENCING QUALITATIVE SOURCES

The spatialization of historical sources is still in relative infancy. Most projects georeference historical sources using modern spatial datasets and address locators, as the time and resources needed to create temporally-specific geolocators is enormous. Notable exceptions include the pioneering project *Montréal l'avenir du passé* (Gilliland & Olson, 2003). Others include the recent efforts of the Urban Transition Historical GIS Project (Logan, Jindrick, Shin, & Zhang, 2011), which has successfully geocoded the 1880 US census to a resolution as fine as the street segment, and the historical GISes of Alexandria, Virginia and Newport, Kentucky created by Debats (2009). Another approach advocated by Southall et al (2011) has been to utilize databases of historical place names and digital gazetteers. Their methods have made the geocoding of locations somewhat less taxing; however, they do not serve to map qualitative spatial relations at the scale of everyday life, such as the location of the "coloured barber near the market". Our interest in qualitative sources, including their incomplete spatial references,

demanded the creation of the stage-based GIS outlined here. We see this as the most complete gazetteer available for a single city, where we are able to map every subtle event or mention of a person or place with relative ease.

The locations fields that are parsed out of a narrative source represent not only locales directly or indirectly mentioned by the diary writer, but also any spatial references that can be inferred by the actions, events, or actors mentioned in the diary. That is, every actor's actual location at a specific time is georeferenced, as well as their home location, workplace, and any other locations available through the built and social environment stages. The source-based contextualization also allows a researcher to map locations that are not absolute, such as the extent of what individuals refer to as 'downtown', or the scale of a neighbourhood as seen through the eyes of the writer.

The georeferencing of narrative sources is a semi-automated procedure. It begins by running the parsed location attributes from the written narrative through an automated record linking procedure to records found within both the built and social environment stages. The record link may include a partial civic address or may be a link to a name, business, or building. The civic address, as discerned from the stages, is then added to the record in the relational database (Figure 3.8). The address-linked records are geocoded using the address locator created during the construction of the social environment stage. Successfully geocoded records are then added to a new geodatabase. The remaining records are reviewed manually and linked to multiple entities in both the relational database and other contextual sources in the HGIS that may provide spatial references.

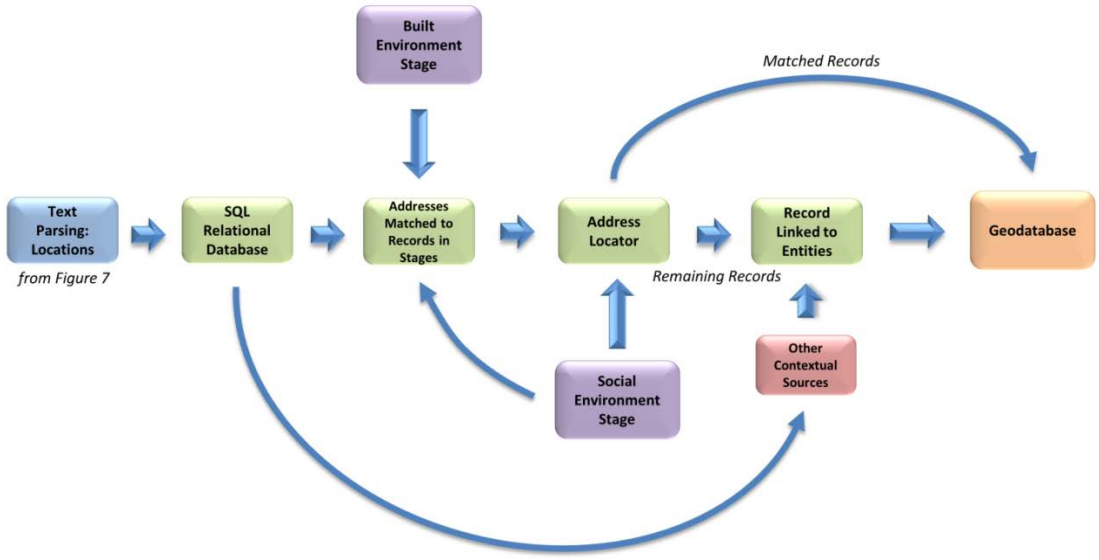

Figure 3.8 – Georeferencing workflow for narrative sources

The ability to contextualize the sources within a large spatially and temporally referenced database is vital to being able to precisely georeference a narrative source. One of the diaries included within our larger project is that of Richard Matthews. Matthews' diary spans thirty-six years, 1863-1899. We have thus far focused on two years of his life, 1881-1882, when he was a married father of six and a clerk at the city's post office. Nearly one thousand events involving just under two hundred actors in 269 unique locations were geocoded from his diary using this methodology. Table 3.1 outlines the results of the geocoding procedure by each intermediary step. For both events and actors, only 2% of entries could be geocoded using the addresses written directly in the diary. However, once the entries were record linked to addresses captured in the two stages, we were able to geocode 90% of the events and 70% of the actors parsed out of Matthews' diary.

	Number of Events/Actors	Using address found in diary	Using address captured from stages	Contextual manual geocodes	Not mapped	Final geocode rate
Events	927	19	786	30	92	90%
Actors	192	4	125	5	58	70%

* Diary of Richard Matthews, 1882, B4242, Archives and Research Collections, UWO
* 27 of the not mapped actors were family, preachers, or politicians who reside outside of London

Table 3.1- Number of Actors and Events Mapped by Geocoding Procedure

Some record links were direct 1-to-1 matches of an actor's name to their corresponding entry in the social environment stage, while others were matched through a combination of multiple variables. For example, we return to the case of the 'coloured barber near the market' that Matthews mentions visiting in the spring of 1882. Using the built environment stage, we can perform a simple spatial buffer of a short walking distance around the market. Then, within the buffer, we can perform a SQL query for Occupation = Barber AND Ethnicity = African within the social environment stage. The result is the discovery of Matthews' barber as a single, recently immigrated, 30-year-old American man named William Berry. He operates his business on the first floor of a rented shop at 10 Market Lane, just steps away from the market square. From here, other contextual sources could be referenced, such as Matthews' financial record books to see how much he paid for a haircut, or newspapers for advertisements or stories about the barber shop.

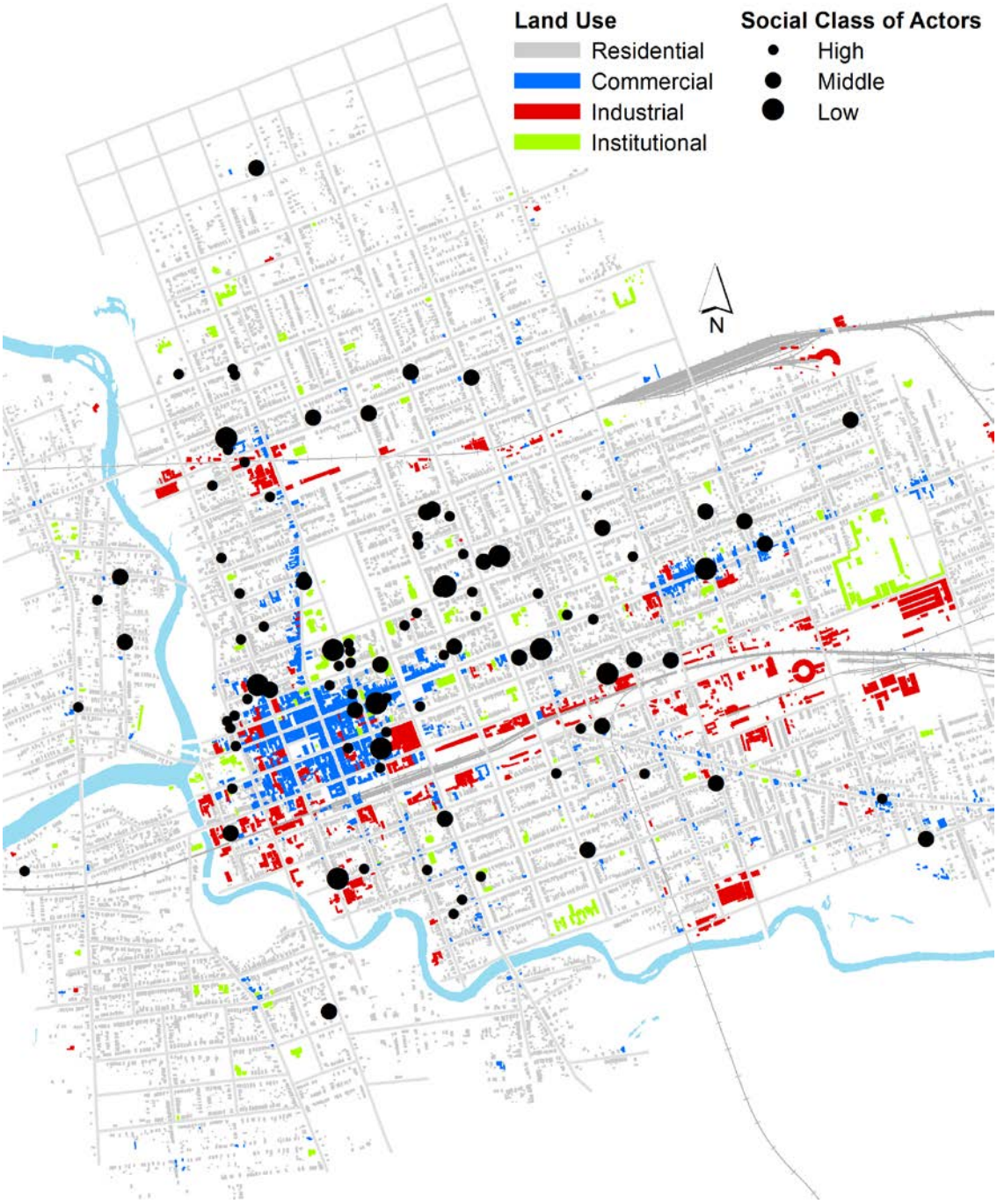

Figure 3.9 – Built and Social Environments used to spatialize Actors in Richard Matthews diary

As an example of what is possible, Figure 3.9 outlines the spatial distribution of actors in Matthews' diary contextualized within the two environmental stages. We have

included land use characteristics from the built environment stage as it provides a clear image of the delineated spaces in the city. Using a simplified version of the Darroch and Ornstein (1980) occupational class scheme we aggregated the actors in Matthews diary into one of three social classes. The result is a spatial view of the diversity of individuals Matthews interacts with throughout his daily life. No one social class dominates and we see that actors live in a range of residential situations from single unit detached homes in the suburbs, to small bungalows and residential hotels in the industrial areas of the city. We see relations in both in the wealthy 'Woodfield' district north-east of downtown and in the working class 'London East' neighbourhood. These are patterns that would not be possible to discern without the ability to place the narrative within the context of the rich built and social environment stages.

3.7 TOWARDS SPATIAL STORIES- THE CASE OF RICHARD MATTHEWS

Utilizing a stage-based GIS provides not just the ability to georeference qualitative locations but also the ability to recreate the space-time paths and the ensuing social interactions that are otherwise hidden within qualitative sources. A simple comment about getting a haircut deepens our understanding of activity spaces and the distances urban residents would travel in the walking city to complete their personal and household chores. It provides us a taste of how racial differences were experienced during the day when residents left their segregated neighbourhoods. It may be a launching point for enquiries into the economic opportunities and experiences of new immigrants. We recognize that no single case will lead a researcher to in-depth

conclusions, but this simple example, grouped with thousands of others, provides the script for the creation of a rich spatial story.

Our current research interests are focused on developing a better understanding of the impact of diurnal segregation (or integration) on the everyday lives of individuals, both past and present. Who Matthews does and does not visit on his weekly Sunday stroll provides only a limited view of the social structures impacting his life. Utilizing the two environmental stages and the twelve diaries, we have recreated the time-space paths of Matthews, as well as hundreds of other urban residents, for various time periods between 1881 and 1901. These spatial stories shed light on the true social distances that influenced the lived experiences of residents as they traversed the city to work, school, church, and play.

Time geography and time space modelling has a deep scholarship. Inspired by the pioneering work of Hägerstrand (1970) on space-time paths and prisms, scholars continue to work towards effective geovisualization techniques that overcome the interpretive difficulties of three dimensional geographic data (Kwan & Lee, 2004; Nakaya, 2013; Yu & Shaw, 2011). While others are developing new models that can be used to interrogate spatio-temporal mobility data (Chen, Shaw, Yu, Lu, Chai, & Jia, 2011; Shaw & Yu, 2009; Stewart, Fan, & White, 2013; Yu, 2006). However, with only one notable exception (Mennis, Mason, & Cao, 2013), the space-time patterns observed are not placed within a rich, multi-variant environmental framework like what we present here.

Our approach to the geovisualization and analysis of spatial stories is to immerse the narrative source within a three-dimensional model of the city created using the two

stages described above. Using the 3D capabilities of ESRI's ArcScene 10, we have created a 'Google Street View-like' representation of the city. Figure 3.10 represents a recreation of the morning journey to work for Richard Matthews on April 12, 1882 as he described it in his diary. His time-space pattern is highlighted by the brown arrow that shows his departure at 8:15am and his arrival 10 minutes later at Fred Wheeler's home to borrow a copy of *David Copperfield*. He continues on to work, arriving at 8:50am. This rather routine journey to work becomes a spatial story when we not only contextualize the interaction between the actors in time-space, but set the route within the larger environment that influences how the space is used and experienced. Here we have utilized the social environment stage to symbolize each building polygon from the built environment stage by ethnicity of the head of household. Labelled atop each polygon is the value of each property in dollars per square metre as derived from the total building value found in the municipal tax roll. Vegetation, telegraph poles, and gas street lamps are included; their locations were identified using period photographs and a later geodetic survey which mapped individual trees. Photographs of buildings are available through hyperlinks embedded within the built environment stage. Thumbnails are provided below the scene and change as you modify the extent of the map. Many other built and social environment variables are available to be viewed and analyzed by the researcher but the limitations of a paper map restrict us from illustrating them here. Through this 3D representation, we have an enlightening view of the physical and social landscapes actors experienced and interacted with in their daily space-time rhythms.

Figure 3.10 – ArcScene 10 provides the ability to model the built and social environments of the city in three-dimensions. The Stages are used in concert to recreate this time-space path of a postal clerk's morning journey to work

3.8 CONCLUSION

This paper has outlined a new conceptual framework and methodology for the study of urban environments. Whether the enquiry is the influence of the built environment on personal mobility or the relationship between residential tenure and social segregation, it is critical to set the scenes upon a spatially and temporally accurate representation of the spaces studied. To accomplish this, we argue for moving beyond the use of generalized geospatial platforms such as Google Earth, or the use of census tracts or similar aggregated units. By operating at the scale of the individual, be it

buildings or actors, we can not only overcome the modifiable areal unit problem, but we can perform multi-scaled analysis and aggregation that cannot otherwise be done. This approach makes possible, for the first time, the realization of the promise that draws many scholars to GIS—that by "assigning a geographic reference to data…it then becomes possible to compare that characteristic, event, phenomenon etc. with others that exist in the same geographic space. What were previously seemingly unrelated facts become integrated and correlated." (Kemp, 2010, p. 32)

This paper has also provided a methodology for the recreation of individual space-time paths using narrative sources within a stage-based GIS. Core to this approach is the ability to parse narrative sources into six parts, each reflecting either a spatial, temporal, or social relationship found within the narrative. Then using temporally-specific attributes from the built and social environment stages we georeference the narrative to the exact locations noted within the urban fabric. Although we preserve access to the original narrative via a hyperlink in the attribute table we recognize that by segmenting the narrative in this way much of the qualitative-nature of the source is lost. We see this as a small price to pay for the new perspectives that can be seen when you integrate a narrative within the stage-based GIS. By harnessing the spatial precision, analytical capabilities, and contextual cues available through the stage-based GIS, researchers can now better understand the role that environmental interactions play on the quantity and nature of human daily mobility. This is approach is congruous with Kwan's (2013) call for a temporally-integrated approach to the study of social geographies.

Further, this paper has outlined the need to place both the source data and the space-time patterns observed within their larger environmental contexts. We advocate

for the creation of a ‘full city view’ or ‘real world’ within a geospatial environment however has Black (2010, p. 478) reminds us “the past can never be recovered as a solid whole, as history is always fragmented”. We must acknowledge that when working with any historical sources there are inherent inaccuracies, biases, and omissions thus limiting the assumptions and potentially the analysis one can perform. Additionally, we face many of the challenges outlined by Elwood (2009b) such as how to manipulate and represent such complex data and how to overcome the heterogeneity that is intrinsic to such representations. We also recognize some of the limitations that Sheppard (1995; 2005) outlines when attempting to represent qualitative information in the Boolean logic and map algebra of the raster and vector GIS.

Although our case study uses historical sources, we see these approaches as being applicable to a wide range of contemporary lines of enquiry. Scholarship ranging from impact of the built environment on individual health to how complex social structures influence the settlement patterns of new immigrants can benefit from this approach. Although a significant investment of time and resources is needed to build a stage-based GIS, we see the rewards to be great. The diversity of enquiries that are possible is only limited by the imagination of the researcher.

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CHAPTER FOUR

Revisiting the Walking City: A Geospatial Examination of the Journey to Work

Don Lafreniere and Jason Gilliland

4.1 ABSTRACT

The daily commute to work and its related social histories have long been of interest to historical geographers and urban historians. This article revisits the existing scholarship on the nineteenth-century journey to work and outlines a new methodological framework that uses a historical GIS to overcome many of the challenges identified in previous studies. These challenges include a reliance on small, atypical samples of workers, approximations of the spatial relationship between home and work, and unrealistic interpretations of journeys travelled by employing only Euclidean paths. Combining city directories and decennial censuses through the use of probabilistic record linkage techniques uncovers the relationship between work and home for over 5,000 workers in London, Ontario in 1881. A GIS network-derived journey to work model recreates more realistic journeys that considers the many natural and built environment barriers that influenced the paths and distances workers travelled on a daily basis. Empirical results of the journey to work along lines of occupational class, coincident home-work location, and gender are presented and contextualized to studies in other cities. The results highlight that experiences of commuting differ widely along lines of social class and gender.

Keywords: Journey to Work, Space-Time, Historical GIS, Census, Mobility

4.2 INTRODUCTION

The rapid industrialization and urbanization experienced in the late nineteenth century affected many aspects of daily life. For adults, one aspect that bridged all socio-demographic and economic groups was the journey to work. This unifying experience of daily life was a result of the growing spatial separation between home and the workplace due to changes in the nature of work, from primarily home-based artisanal work to wage labour. The journey to work also reflected larger evolving urban processes, such as suburbanization and segregation. In the second half of the nineteenth century, mid-sized Canadian cities were still largely dominated by commuters who travelled to work by foot, either on the streets, alongside the horse-drawn carts used for heavy or bulky loads, or on the rapidly-emerging network of sidewalks. Commuters were closely connected to the physical and built environments they traversed, enjoying the pleasant fragrance of flowers wafting from the gardens of well-built homes or subjected to the foul odours that emanated from the breweries and cigar factories. They had to cope with the elements that the glass and steel of our modern automobiles shelter us from, such as July's intense sun and January's blowing snow and sleet. The daily commute provided individuals an intimate scale by which to experience the social environments present in the city. In the walking city, everyone else on the street was within earshot as well as within an easy visual distance, making the journey to work one of the periods with the highest potential for social interaction during an individual's daily time-space rhythm.

This paper revisits the late nineteenth-century journey to work in the industrializing city, an area of research that has had little attention since the 1990s. Using the mid-sized Canadian city of London, Ontario as a case study, this paper extends the

existing literature by exploring the spatial and temporal pattern of work at a scope and scale unprecedented in earlier studies. Through the use of a full count of the city's population in 1881 and 1891, which includes the workplace of nearly every male (and many female) workers, we can, for the first time, establish the relationship between home and work for an entire urban population. The dataset is interrogated using the spatial analytic capabilities of a GIS to recreate the daily time-space patterns of individuals from every socio-demographic and economic group in the city.

This study of the journey to work was undertaken for an important methodological purpose – to recreate the spatial relationships between work and home. By having a sound methodology with which to recreate these relationships, other scholars can then re-examine the roles played by transportation, residential segregation, land use policies, and restrictive covenants on access to employment and its impact on demography, social mobility, and housing choice. This study looks to create a methodology that overcomes the many limitations noted in the literature of previous journey to work studies.

4.3 RELATED WORK

The study of Canadian work history saw a resurgence in the late 1960s thanks to British historian E.P. Thompson's call to recover the lives and experiences of working-class people "from the enormous condescension of posterity" (Thompson, 1980 [1963], p. 12). This call was answered by the likes of Kealey (1980) and Bradbury (1996), who both described the changes in working life during periods of industrialization in large Canadian cities (Toronto and Montreal, respectively). Several edited collections have

been compiled, with chapters on the working lives of everyone from shantymen and railway workers to boys in mining camps and girls in textile shops (Craven, 1995; Cross, 1974; Opp & Walsh, 2006). This scholarship provides a rich and invaluable narrative, used by students of Canadian labour history across the country. However, the spatial relationships between work and home are less known.

While there is little empirical evidence, especially for Canada, setting out details of the journey to work before 1900, the importance of the geography of the home-work relationship has been considered for several non-Canadian cities. The greatest attention has come from scholars who studied the dominant industrial cities of Britain, especially London (Green, 1988; Lees, 1969; Pooley & Turnbull, 1997; 1999; 2000), as well as Birmingham (Vance, 1967), Huddersfield (Dennis R. , 1984), Liverpool (Pooley C. , 1984), and Newcastle (Barke, 1991). In North America, work has been concentrated in large metropolitan areas such as Philadelphia; the journey to work was one of the areas of interest of the twelve year (1969-1981) Philadelphia Social History Project led by Theodore Hershberg (Greenberg, 1980; Hershberg T. , 1976; Hershberg, Light, Cox, & Greenfield, 1981). For Canada, Montreal has been the most productive laboratory, though we find the concerns of the relationship between work and home to be secondary to wages (Hoskins, 1989), the process of industrial suburbanization (Gilliland, 2004; Lewis, 2000), segregation (Gilliland & Olson, 2010; Gilliland, Olson, & Gauvreau, 2011; Olson & Thornton, 2011), and the nature of the work itself (Bradbury B. , 1996). An important exception to the gulf of empirical research on the journey to work in Canada prior to 1900 is Peter Goheen's study of Toronto (1970). Goheen uses the daily commute

to illustrate the extent of residential segregation among differing social classes in Victorian Toronto.

There has been more interest in the Canadian experience of the journey to work after the turn of the 20th century. Richard Harris and Victoria Bloomfield took on the topic while exploring the processes of decentralization of workplaces and the broader suburbanization of cities (Harris & Bloomfield, 1997; Bloomfield & Harris, 1997). Their landmark paper (Bloomfield & Harris, 1997) outlined a methodology that has served as the inspiration for much of this paper.

4.4 IDENTIFYING METHODOLOGICAL CHALLENGES

Despite what may appear at first blush to be a wealth of previous research, the study of the daily commute to work has not received significant attention. Geographer Richard Dennis suggests that one of the reasons may be that "data for studying journeys to work are exceedingly scarce, particularly for quantitative research in which a single source records both place of residence and place of work" (Dennis R. , 1984, p. 132). As a result, previous research on the nineteenth-century city has utilized sources (data) that either represent a small, non-random, possibly atypical sample of workers or only allow for the inference of home and work, rather than absolute spatial links (Dennis R. , 1984, p. 132). For example, Green (1988) uses only a wage book for a single employer, as did Hoskins (1989) for his study of railworkers in Montreal. Barke (1991) used city directories to capture a set of nearly two thousand workers over four time slices. However, his sample only included middle-class business owners because he did not have the workplaces of non-owners, so it only represented 4% of the middle-class

population of Newcastle. Dennis (1984), though recognizing the limitations of his methodology and calling for alternatives, elected to use the census returns for only one industry, silk manufacturing. Industry-specific studies have also been completed by Pred (1966) for five industries in New York City. The Philadelphia Social History Project also used five industries, derived from the Census of Manufacturing, though this sample was still robust with over 3700 workers represented. Bloomfield and Harris (1997) concerned themselves with a similarly small sample of employers.

Methodological decisions surrounding how to best recreate the needed home-work links have typically been constrained by limitations in the sources or lack of resources necessary for compiling and analyzing a more comprehensive database of employees and employers. These limitations have led authors of most previous studies to use methods of approximation. Vance (1967) saw the need to combine the census along with a comprehensive source of workplaces—the business directory. However, the 1851 British census he utilized did not include workplaces for those enumerated, so he was unable to match individuals to their specific places of work. Vance instead created labour sheds, or areas where workers reside, and employment fields, areas of workplaces, and compared the distances between them. Dennis (1984), using the same sources as Vance, was likewise restricted to only inferring home-work links in his study of Huddersfield's silk industry. The Philadelphia Social History Project (Greenberg, 1980; Hershberg, Light, Cox, & Greenfield, 1981) also inferred the workplaces of its city's workers by creating arbitrary labour shed boundaries for each industry and then matching an individual's occupational title to the product manufactured within individual businesses. Pooley, in his study of the journey to work in late-nineteenth century

Liverpool, used a ten percent census sample and calculated distances from an individual's residence to the nearest potential workplace. He explains that 'for dock workers this is defined as the nearest operational dock; all office workers are assumed to work in the C.B.D. [central business district]" (Pooley C. , 1984, p. 134).

The impact of a lack of quality sources has resulted in other difficulties for scholars of the nineteenth-century journey to work. Many authors are interested in evaluating the differences in how the journey to work was experienced by members of various ethnic or racial groups. Mayer (1977), in his study of Milwaukee, used individuals' surnames, as recorded in the city directory, to infer their ethnic affiliation. Mayer acknowledges the difficulties of this approach, suggesting that even in the best of cases only seventy-percent accuracy can be expected (Mayer, 1977, p. 54). Deskins (1972) used directories in a similar manner to examine the racial differences in the journey to work in Detroit in the late 19th century. He derived race by a "colored" notation within the alphabetical directory rather than utilizing the more authoritative and complete decennial federal census. His decision not to use the census was not explained, nor did he compare the aggregate population totals by racial affiliation between the two sources to gauge the reliability of the "colored" notation in the directory. From these assumptions, significant historical generalizations of race-based behaviour were generated. These criticisms were noted by his colleagues and resulted in a heated debate within the pages of the *Professional Geographer* (Deskins, 1975; Gale & Katzman, 1975).

Deskins' work has other methodological limitations, ones shared with nearly all previous journey to work studies – poor spatial accuracy in locating home and workplace

as well as the methodology used to calculate the actual journey to work. Deskins' work, separate from his controversial derivation of race, suffered the greatest shortcomings. He was unable to link individuals to their workplaces, nor did he have the resources needed to map individuals to their specific residences. To compensate, he elected to approximate the location of work and home by using the mean centre of residences and the mean centre of workplaces while controlling for the extremes by calculating the standard distance around each mean. The resulting 'worktrip vector' is nothing more than a measure between the residential areas of Detroit and the non-residential areas. Other studies suffer from similar limitations, though not as severe. Green (1988) attempted to map each worker in Henry Poole's bespoke tailor shop to their exact residence, but found that addresses in London (UK) during the later decades of the nineteenth century were haphazard. His efforts were limited by a combination of address changes, street name changes, and sources that did not coincide temporally. His solution was to estimate each street's addressing by assigning civic address #1 at one terminus of the street and assigning numbers at equal intervals moving down the street (Green, 1988, p. 186). Both Goheen and the Philadelphia Social History Project elected to use arbitrary grids to map residences and workplaces. The Philadelphia Social History Project created 660 x 775 foot grids and measured from centroid to centroid to calculate the length of the daily journey (Hershberg, Light, Cox, & Greenfield, 1981, p. 131). Additionally, as discussed earlier in this section, several studies have assumed that workers were employed at the closest workplace for which they were qualified. This assumption skews the results to indicate shorter daily commutes than may have been realized.

Due to the lack of computational power and robust data sets, all previous nineteenth-century journey to work studies elected to use Euclidean, or straight-line, distances in their calculations, rather than taking into account the actual distances that would have been traveled on the existing roadways. Even the most contemporary of studies, those that are beyond the scope of my current research, rarely utilize existing geospatial technologies to recreate more realistic paths (Corcoran, Chhetri, & Stimson, 2009; Sultana & Weber, 2007), and one of the only exceptions uses hypothetical journeys (Bousssauw, Neutens, & Witlox, 2011).

This paper first overcomes the limitations outlined above that have influenced the results of previous journey to work studies. Secondly, it extends the existing journey to work methodologies by utilizing the spatial analytical capabilities of GIS and computer-based probabilistic record matching algorithms. Lastly, this paper will outline some of the journey to work experiences along lines of socio-economic class, gender, and age.

4.5 CASE STUDY: LONDON, CANADA

Previous journey to work studies have been primarily concerned with large urban centres, rarely concerning themselves with the more common medium-sized nineteenth century towns. Debats (2009) outlines how studying large urban centres is not practical when the scale of analysis is the individual. We heed his advice in this study and apply the same 'small city research strategy' he extols. This case study is the mid-sized Canadian city of London, Ontario, Canada. London provides a classic example of a city that was changing from a commercial to an industrial town. London is located half-way between Toronto and Detroit, an advantageous position that was quickly recognized by

many investors and industrialists. Several major companies began to employ Londoners in the last two decades of the nineteenth century. The Grand Trunk Railway built its train car factory in London East in 1887, which added over a hundred jobs to its already large operation in the city. Imperial Oil commenced refining in London East in 1880. Established companies such as the brewers Labatt and Carling, the confectioner McCormick, and McClary's foundry increased their workforce during this era as the demands for their goods grew faster than the efficiencies of mechanization. Despite these increases, London continued to be a diverse commercial city with most of its workers employed at small or medium sized firms in a wide range of industries. In 1881, there were an average of 2.5 workers per business; by 1891 it had risen to nearly 4 workers per firm.

The London of 1881 was a quintessential British town on Canadian soil. Both the established citizenry and the waves of recent immigrants were predominantly from the British Isles, and Protestant faiths dominated the religious composition of the growing city. With a population of 19,746 at the time of the 1881 Census of Canada, London ranked 8th among Canadian cities and 86th in North America, making it comparable to cities such as St. John, NB, Lancaster, PA, and Des Moines, IA. For this study, I also included the three major suburbs of London: Petersville (aka London West), the Village of London East, and the urban section of Westminster Township (aka London South). Together these suburbs totaled 3,890 residents. It is critical to include these suburbs as they contributed significantly to the available employers and the diverse workforce found about the city. Additionally, suburban populations and industries are often overlooked in

other studies, mostly because the census separates them from the urban core when disseminating their enumerations.

4.6 OVERCOMING LIMITATIONS

4.6.1 Larger Samples and Absolute Workplaces

To overcome the limitations of small sample sizes and the lack of representativeness found in previous studies, this paper utilizes the robust built and social environment stages outlined in paper 1 of this thesis. Specifically, this study harnesses the geocoded decennial census that was captured through the creation of the social environment stage. As outlined by Figure 3.3, the census was record-linked to the city directory, which facilitated the geocoding of nearly all individuals to their residential location. This dataset locates nearly 90% of the population in London and suburbs in 1881 and provides the needed variables to determine the home residence for each worker in the city.

No other journey to work study has captured what is arguably the whole of the workforce in an urban location. Various methods of sampling have been utilized and rarely, with the exception to a certain extent of Deskins and Mayer, have researchers compared the distribution of their samples to the total enumerated population. It is generally accepted by historical geographers and historians alike that the federal census represents the gold standard record of a past population, though there are critics (Curtis, 2001). Table 4.2 compares the geocoded population used in this study to the full census enumeration collected in London for the year 1881. To illustrate how representative the 90% sample is, the population has been disaggregated using key demographic variables. It is observed that along lines of religion, gender, and marital status, the variances are no

more than 1%. For ethnic origin, we see an equally representative sample, with only a 2.55% overrepresentation of those of Irish decent and a 1.44% underrepresentation of Scottish in the geocoded sample versus the total population. Birthplace is also representative, with only a 1.92% underrepresentation of those born in Ontario. The representativeness of the sample population is without question. There are no concerns of an ecological fallacy, as the sample is not only representative, but is also disaggregated to the level of the individual.

Religion 1881			
	Geocoded Population	Census Population	Variance
	n = 21246	n =23636	
Protestant	83.46%	84.74%	-1.28%
Catholic	14.37%	13.33%	1.04%
Other	1.77%	1.45%	0.32%
Unknown	0.40%	0.48%	-0.08%

Gender 1881			
	Geocoded Population	Census Population	Variance
	n = 21246	n =23636	
Female	50.46%	50.45%	0.01%
Male	49.54%	49.55%	-0.01%

Marital Status 1881			
	Geocoded Population	Census Population	Variance
	n = 21246	n =23636	
Married	32.88%	33.49%	-0.61%
Single	62.68%	62.07%	0.61%
Widowed	4.44%	4.44%	0.00%

Origin 1881			
	Geocoded Population	Census Population	Variance
	n = 21246	n = 23636	
English	46.84%	46.61%	0.23%
Irish	28.81%	26.25%	2.55%
Scottish	17.69%	19.13%	-1.44%
German	2.02%	2.45%	-0.42%
French	0.96%	0.95%	0.01%
African	0.96%	0.94%	0.02%
Other European	0.70%	1.49%	-0.80%
Other	0.55%	0.49%	0.06%
Unknown	1.47%	1.69%	-0.22%

Birth Place 1881			
	Geocoded Population	Census Population	Variance
	n = 21246	n = 23636	
Ontario	57.60%	59.52%	-1.92%
England	18.78%	17.91%	0.87%
Ireland	8.81%	8.12%	0.69%
Scotland	5.52%	5.50%	0.02%
Canada	4.51%	4.16%	0.01%
United States	3.55%	3.49%	0.06%
Europe	0.77%	0.81%	-0.04%
Rest of World	0.29%	0.32%	-0.03%
Unknown	0.16%	0.18%	-0.02%

Table 4.2 – Geocoded Census Population Compared to the Total Census Population: London City and Suburbs, 1881

To overcome the limitation of previous studies that assumed workers were employed at the closest facility for which they were qualified, it was necessary to first establish the spatial link between each individual's home and their exact workplace. Workplaces varied widely in the industrializing nineteenth-century city, with many people still employed at home in semi-skilled trades and services, while others commuted daily to the factory or foundry. As London was a commercial town, there was yet another significant cohort who travelled to work as clerks and support staff in the city's

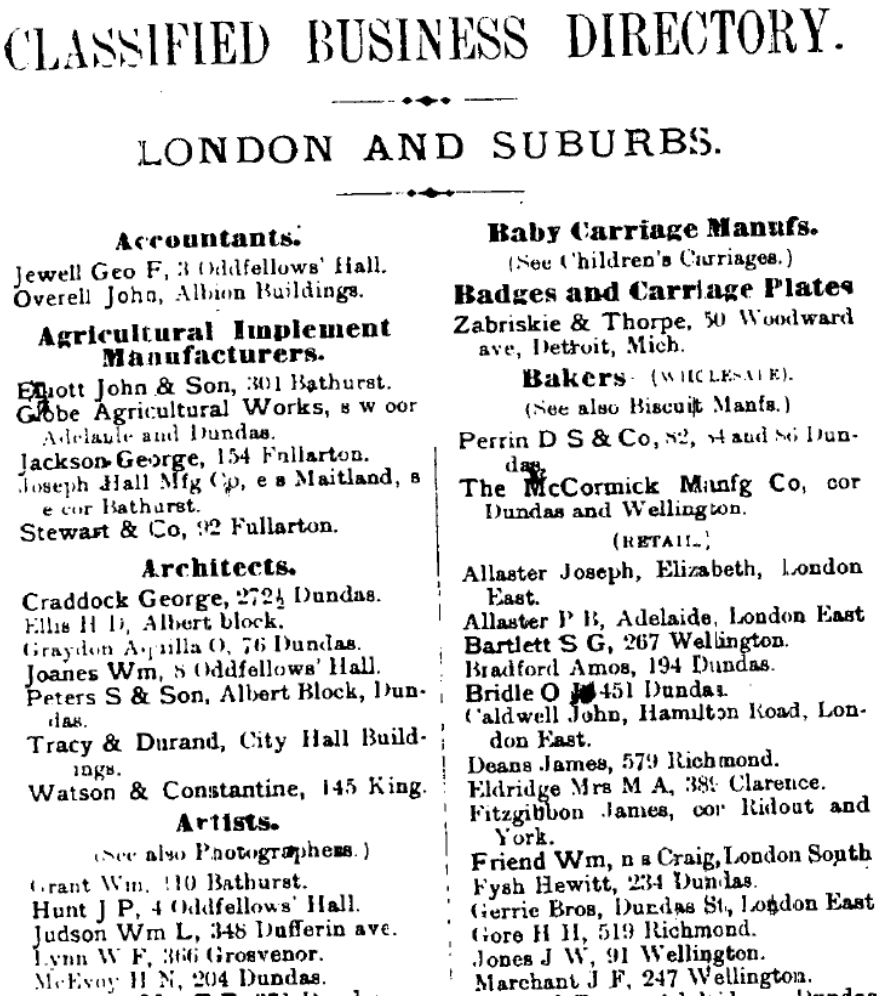
law offices, insurance companies, and financial institutions. Regrettably, an individual's specific workplace was not, and continues to not be, a question asked in the federal census. Occupation has been recorded since the first national census in 1871, but no question on workplace was asked until 1971. The modern questions on the journey to work are imprecise, with options such as 'worked at home', 'usual place of work', 'no fixed workplace address', or 'worked outside Canada'.

Rather than a national enumeration, we instead turned to a local one, the city directory. City directories have been used, in some form, in many of the previous late nineteenth or early twentieth century journey to work studies, including Barke (1991); Bloomfield and Harris (1997); Deskins (1972); Goheen (1970); Harris and Bloomfield (1997); and Mayer (1977). As with any source, they do have limitations. Harris (1986) reminds us that city directories were compiled for business purposes and likely underrepresented those who move often, including tenants and the poor. Bloomfield and Harris (1997) observe that working women are slightly underrepresented, a pattern I also observed in the London directories. Regardless of these limitations, Harris (1986) and Harris and Moffat (1986) support that city directories are arguably the most complete source of information on the specific employers of individuals.

This study benefits from a complete collection of the London city directories that has been preserved in the Archives and Research Collections Centre at the University of Western Ontario and the London Room of the London Public Library. Four different publishers produced city directories between the years 1881 and 1891, with the London Publishing Company producing the directory for 1881 used in this study. The London

alphabetical directories include the name, residential address, tenure, occupation, and employer for each private citizen and business firm in the city. For widowed women, the name of their late husband is also noted. Those workers who did not work outside of their homes were also enumerated; the directory lists only a residential address or in some instances denotes this relationship between home and work with the word ‘same’. These variables are captured from the social environment stage and used to establish the needed home-work link in this study.

The geocoded business directory was utilized to determine the specific worksite of each employed person in the city (these details are outlined in chapter 3). The business directory lists both major and minor employers, as well as sole proprietors, classified by their predominant industry or service (see Figure 4.1). The name of the business and/or proprietor, along with a business address or the name of a significant commercial building is included in each listing. For those companies who paid an additional fee, a larger advertisement was included with some details of the services or wares for sale.



CLASSIFIED BUSINESS DIRECTORY.

LONDON AND SUBURBS.

Accountants.

Jewell Geo F, 3 Oddfellows' Hall.
Overell John, Albion Buildings.

Agricultural Implement Manufacturers.

Elliott John & Son, 301 Bathurst.
Globe Agricultural Works, s w cor Adelaide and Dundas.
Jackson George, 154 Fullarton.
Joseph Hall Mfg Co, e s Maitland, s e cor Bathurst.
Stewart & Co, 92 Fullarton.

Architects.

Craddock George, 272½ Dundas.
Ellis H D, Albert block.
Graydon Aquilla O, 76 Dundas.
Joanes Wm, 8 Oddfellows' Hall.
Peters S & Son, Albert Block, Dundas.
Tracy & Durand, City Hall Buildings.
Watson & Constantine, 145 King.

Artists.

(See also Photographers.)

Grant Wm, 110 Bathurst.
Hunt J P, 4 Oddfellows' Hall.
Judson Wm L, 348 Dufferin ave.
Lynn W F, 366 Grosvenor.
McEvoy H N, 204 Dundas.

Baby Carriage Manufs.

(See Children's Carriages.)

Badges and Carriage Plates

Zabriskie & Thorpe, 50 Woodward ave, Detroit, Mich.

Bakers (WHOLESALE).

(See also Biscuit Manfs.)

Perrin D S & Co, 82, 84 and 86 Dundas.
The McCormick Manfg Co, cor Dundas and Wellington.

(RETAIL.)

Allaster Joseph, Elizabeth, London East.
Allaster P B, Adelaide, London East
Bartlett S G, 267 Wellington.
Bradford Amos, 194 Dundas.
Bridle O J, 451 Dundas.
Caldwell John, Hamilton Road, London East.
Deans James, 579 Richmond.
Eldridge Mrs M A, 389 Clarence.
Fitzgibbon James, cor Ridout and York.
Friend Wm, n s Craig, London South
Fysh Hewitt, 234 Dundas.
Gerrie Bros, Dundas St, London East
Gore H H, 519 Richmond.
Jones J W, 91 Wellington.
Marchant J F, 247 Wellington.

Figure 4.1 – Excerpt of the London Classified Business Directory, 1881

With the relationship between home and work established, it was necessary to record-link the combined city directory/census geodatabases with those of the business directory. To facilitate the record linkage across sources, I used LinkageWiz, a probabilistic record-matching software (LinkageWiz, 2011). Records in both datasets were given a unique identifier, *WORK_ID* for the individual and *BusinessID* for the business. Records were blocked using the municipal ward boundaries (captured through a spatial join with a temporally representative ward shapefile derived from a period map)

and last names. Last names were blocked with various phonetic algorithms and string comparisons applied. A lookup table was created due to the heavy use of short forms or nicknames used in the city directories for individuals' first names; examples include 'Wm' for William, 'Jn' for John, and 'Thos' for Thomas. Matching was then performed using match weights for last name, first name, gender (derived from a lookup table of first names), occupation, and workplace (Table 4.3). Last names had a variable weight determined by the number of instances within the dataset; this was used to overcome issues with commonality of certain last names. For example, 'Smith' carries less weight than does 'Fowler' because there are 332 Smiths in the dataset versus 7 Fowlers. One-to-one matches were forced to ensure that a worker was linked with only one employer. A low minimum score of 10 for potential matches was maintained and only the most probable (over 16) were accepted as true matches. The potential matches were reviewed manually and adjustments to links made before they were included in the geodatabase.

Variable	Match Weights
Last Name	Jaro-Winkler Variable
First Name	Exact Match: 5 Phonetic Match: 3 Nickname Match: 3
Gender	Exact Match: 1 Disagree: -1
Workplace	Exact Match: 8
Occupation	Exact Match: 5

Table 4.3 – Match Weights Used to Record Link Census/City Directory Database to Business Directory

For workers who were employed by a large company with multiple worksites, such as the railway workers of the Great Western Railway, I used the occupation to estimate the most appropriate worksite. For example, engine builders were assumed to work in the engine house and wood and coal workers to work in the wood and coal yards. For complete unknowns, the main office was used, as it was assumed they would traverse there regularly for instructions and supplies or to retrieve wages. Each of these entries received a new record in the business directory geodatabase. For those who worked for an individual, such as gardeners or domestic servants, a new record was created in the business directory geodatabase for the home residence of the employer as listed in the city directory. To facilitate analysis, the field *WkPlaceID* was created to differentiate the worksites from the businesses.

The result is a robust sample of 5081 workers matched to their specific workplace out of the 2295 workplaces in the city. In previous studies, the largest sample of workers reported was 800, all from a single workplace (Harris & Bloomfield, 1997). There were 14,707 adults between the ages of 17 and 63 in the city of London and its suburbs who were considered available for work. Age 63 was used as the upper limit as the number of individuals listed as 'gentlemen' was observed to increase significantly after this threshold. The reverse was observed for teenagers, with the rise in employment coming between their 16^{th} and 17^{th} year. It must be considered that 7,504 of the available workforce were women and this study is during a period where wage employment for women outside the home was still very low. I estimate that 12% of working-aged women were engaged in wage labour or as proprietors in a home-based cottage industry. Frances, Kealey, and Sangster (1996) found 11% of women were engaged in wage labour

in Canada in 1891, while Costa (2000) found the number closer to 18% for the US in 1890. Bradbury (1984), on the other hand, estimates that 37% of Montreal women were engaged in wage labour during the same period. The numbers found for London appear to be in line, and any underrepresentation of women is likely an effect of the collection standards of the city directory enumerators. Finally, there were approximately 600 working-aged adults who lived in the city's asylum and old age homes who were included in the larger census but would be considered unfit for work because of various infirmities. The result is that the sample of 5081 workers used in this study represents 72% of the available workforce in the city of London and its suburbs in 1881, and although not as complete as the 90% sample of the total population, it can still be considered the most robust ever compiled for a study of the home-work relationship in the late nineteenth century.

Differences in the journey to work along ethnic and gender lines has been an area of considerable interest in the past, but little concern has been given to the representativeness of the samples which have been used to draw conclusions. So with the same concern as put forth previously for the representativeness of the geocoded 90% census sample, we must look to establish the reliability of the 72% workforce sample. These interrogations are critical, as sub-sampling inherently reduces the reliability of the inferences made about the larger population (Dixon & Leach, 1977). This is particularly important in geo-demographic studies where understanding the difference in behaviour or experiences across demographic variables and geographic space is the primary concern. Table 4.4 provides a comparison between the working-aged population enumerated in the city directory and the workforce sample created in this study. Overall the sample is

representative, with significant variances being found in a select number of variables. For example, Ontario-born workers are overrepresented while those born in England are underrepresented. Single workers are overrepresented while those who are widowed are underrepresented.

A brief explanation is in order for the occupational class variable outlined in Table 4.4. To facilitate the comparisons of the journey to work across the large number of occupations found in the sample, I elected to use a modification of the occupational class scheme developed by Darroch and Ornstein (1980) for their study of the occupational structure in Canada in 1871. The scheme was modified by Lisa Dillon (2008) for use with the 1881 census and was provided to me for use in this study. The occupational class scheme is used as a proxy for socio-economic status since no wage information is available at the scale of the individual until the 1901 federal census (Table 4.5). A copy of the full conversion chart from the North American Population Project's modified Historical International Standard Classification of Occupations (NAPP-HISCO) to the Darroch and Ornstein occupational class scheme is located in Appendix A of this dissertation.

Birthplace (% of Population)

	Geocoded Population	Directory With Workplace Link	Variance
Ontario	36.2	42.2	6.0
England	30.3	25.7	-4.6
Ireland	14.5	12.5	-2.0
Scotland	9.2	8.9	-0.3
Canada	4.2	4.8	0.6
United States	3.8	4.0	0.2
Europe	1.2	1.1	-0.1
Rest of World	.3	.4	0.1
Unknown	.2	.2	0.0

Occupational Class (% of Population)

	Geocoded Population	Directory With Workplace Link	Variance
1	11.3	14.8	3.5
2	6.2	7.5	1.3
3	10.3	14.7	4.4
4	42.7	44.0	1.3
5	6.4	5.6	-0.8
6	8.5	5.0	-3.5
7	4.5	6.9	2.4
8	.6	.1	-0.5
9	2.6	.9	-1.7
Unknown	7.9	.4	-7.5

Ethnicity (% of Population)

	Geocoded Population	Directory With Workplace Link	Variance
English	46.7	43.8	-2.9
Irish	29.1	30.9	1.8
Scottish	18.1	19.2	1.1
German	1.8	1.9	0.1
Unknown	1.3	1.2	-0.1
African	.9	.6	-0.3
French	.9	1.0	0.1
Other European	.7	.9	0.2
Other	.5	.6	0.1

Marital Status (% of Population)

	Geocoded Population	Directory With Workplace Link	Variance
Married	59.2	56.1	-3.1
Single	31.4	39.7	8.3
Widowed	9.4	4.2	-5.2

Gender (% of Population)

	Geocoded Population	Directory With Workplace Link	Variance
Male	81.2	85.8	4.6
Female	18.8	14.2	-4.6

Religion (% of Population)

	Geocoded Population	Directory With Workplace Link	Variance
Protestant	84.6	84.7	0.1
Catholic	13.1	13.2	0.1
Other	1.8	1.6	-0.2
Unknown	.5	.5	0.0

*Significant variances are highlighted

Table 4.4 – Comparison of Geocoded City Directory Sample to Journey to Work Sample, 1881

Occupational Class	Description
1	Merchant/Agent/Manufacturer
2	Professional
3	White Collar
4	Artisan
5	Semi-Skilled & Unskilled
6	Labourer
7	Servant
8	Farmer
9	No Occupation or Ambiguous *Note that this class includes students and gentlemen.

Table 4.5 – Modified Darroch and Orenstein Occupational Class Scheme

In addition to the lack of concern for representativeness in the sample data sets of previous studies is a complete lack of care to ensure adequate spatial coverage. No other study has considered whether the journey to work experiences they describe are representative of what individuals would have experienced across the urban fabric, from workers who lived in downtown residential hotels or above a store front, to those in the city's posh residential suburbs. Table 4.6 outlines the spatial distribution of the workforce sample compared to those in the geocoded census with an occupation listed, by census geography, for each occupational class. Most of the variances are insignificant, with the major exception being that in Westminster Township artisans are overrepresented and farmers are underrepresented. This is due to the rural nature of the township and the methodology used in creating the social environment stage, which

used fire insurance plans as the base dataset to capture civic addressing. This methodology suffers from a boundary effect between the edge of where coverage ceased for fire insurance plans and where the county atlases, which captured rural populations, began. Regardless, the sample used in this study is shown to be very representative of the overall population of London and its suburbs.

Workforce Sample vs. Total Working-Aged Population							
By Census Geography							
		Ward/Quartier No. 1			Ward/Quartier No. 2		
		Workforce Sample Population	Total Population	Variance	Workforce Sample Population	Total Population	Variance
occlass	1	11.19%	12.64%	-1.45%	15.99%	17.96%	-1.97%
	2	4.10%	3.97%	0.13%	8.15%	9.18%	-1.03%
	3	12.72%	13.36%	-0.63%	16.30%	14.04%	2.27%
	4	42.61%	43.32%	-0.71%	32.21%	33.13%	-0.92%
	5	9.05%	6.86%	2.19%	3.61%	4.33%	-0.73%
	6	9.56%	11.31%	-1.75%	4.70%	6.40%	-1.70%
	7	9.48%	7.22%	2.26%	15.52%	10.94%	4.58%
	8	0.09%	0.12%	-0.03%	0.55%	1.14%	-0.59%
	9	1.20%	1.20%	-0.01%	2.98%	2.89%	0.09%

		Ward/Quartier No. 3			Ward/Quartier No. 4		
		Workforce Sample Population	Total Population	Variance	Workforce Sample Population	Total Population	Variance
occlass	1	9.83%	11.20%	-1.37%	12.98%	17.11%	-4.14%
	2	4.62%	4.70%	-0.08%	12.98%	12.16%	0.81%
	3	9.56%	8.53%	1.03%	16.61%	15.05%	1.56%
	4	49.27%	51.88%	-2.61%	32.01%	33.40%	-1.40%
	5	8.42%	8.09%	0.33%	4.84%	4.33%	0.51%
	6	8.20%	7.59%	0.62%	2.77%	2.68%	0.09%
	7	7.71%	5.20%	2.51%	16.09%	13.81%	2.28%
	8	0.27%	0.72%	-0.45%	0.35%	0.62%	-0.27%
	9	2.12%	2.10%	0.02%	1.38%	0.82%	0.56%

		Ward/Quartier No. 5			Ward/Quartier No. 6		
		Workforce Sample Population	Total Population	Variance	Workforce Sample Population	Total Population	Variance
occlass	1	7.73%	8.16%	-0.43%	8.04%	10.01%	-1.97%
	2	4.84%	3.87%	0.98%	10.35%	11.28%	-0.93%
	3	10.39%	9.88%	0.51%	12.31%	12.92%	-0.61%
	4	48.82%	50.89%	-2.08%	42.03%	46.22%	-4.20%
	5	8.68%	7.73%	0.95%	6.22%	5.10%	1.13%
	6	11.69%	13.03%	-1.34%	6.85%	7.10%	-0.24%
	7	5.49%	4.58%	0.91%	10.56%	4.46%	6.10%
	8	0.59%	0.86%	-0.27%	0.28%	0.55%	-0.27%
	9	1.77%	1.00%	0.77%	3.36%	2.37%	0.99%

		Ward/Quartier No. 7			London (East/Est)		
		Workforce Sample Population	Total Population	Variance	Workforce Sample Population	Total Population	Variance
occlass	1	6.36%	6.14%	0.22%	7.62%	8.33%	-0.71%
	2	12.37%	13.05%	-0.68%	7.20%	2.78%	4.43%
	3	9.54%	9.40%	0.14%	5.05%	4.92%	0.13%
	4	38.52%	37.62%	0.90%	55.46%	61.41%	-5.95%
	5	7.60%	6.33%	1.26%	4.64%	3.85%	0.79%
	6	13.78%	16.31%	-2.53%	15.07%	15.13%	-0.06%
	7	8.48%	6.91%	1.57%	2.15%	2.06%	0.09%
	8	1.94%	3.07%	-1.13%	0.99%	0.72%	0.28%
	9	1.41%	1.15%	0.26%	1.57%	0.81%	0.77%

		Petersville (Village)			Westminster		
		Workforce Sample Population	Total Population	Variance	Workforce Sample Population	Total Population	Variance
occlass	1	7.11%	5.43%	1.68%	11.73%	5.34%	6.39%
	2	3.88%	3.04%	0.84%	7.62%	2.94%	4.67%
	3	10.56%	11.30%	-0.74%	9.79%	4.04%	5.75%
	4	53.45%	61.09%	-7.64%	36.03%	18.18%	17.86%
	5	9.05%	6.52%	2.53%	6.29%	2.67%	3.62%
	6	10.13%	8.70%	1.43%	11.61%	8.68%	2.93%
	7	2.37%	0.87%	1.50%	8.59%	4.24%	4.34%
	8	3.23%	3.04%	0.19%	3.14%	45.07%	41.93%
	9	0.22%	0.00%	0.22%	5.20%	8.83%	-3.63%

*Significant variances are highlighted

Table 4.6 – Comparing Spatial Distribution, by Census Geography, of the Workforce Sample to the Geocoded Total Population Dataset Distributed Across Occupational Classes

4.6.2 Calculating the Journey to Work

As illustrated in the introduction, most existing journey to work studies have suffered from significant limitations in the calculation of the journey to work. This paper has thus far outlined a methodological framework for capturing a large sample of individuals at both their specific residential location and their specific daily worksite. Some studies have accomplished this feat, though not with the sample size and confidence we present here. What has limited all studies is the spatial accuracy of the calculated daily commute. Previous studies have used centroids of workplace and residential clusters, or arbitrary grids, and calculated the distances between them. Those studies that managed to map actual residences to workplaces used Euclidean distances rather than the more realistic street and pedestrian network paths. This straight-line approach removes the journey from the environment in which it took place and thus does

not consider factors that may have influenced the commute. We know that the built form (building density, size, fencing), transportation networks (rail lines, roads and pedestrian pathways), and natural barriers (rivers/lakes, elevation changes) influence the routes that individuals elect to take as they traverse the city (Ewing & Cervero, 2010; Hanson, 2004; Larsen K. , et al., 2009; Larsen, Gilliland, & Hess, 2012). This study considers these environmental influences, providing a more reliable image of the daily commute to work in the late nineteenth century.

To begin, I harnessed the built environment stage to extract the 1881 road network for use in ArcGIS's Network Analyst. Possible pedestrian paths were added to the road network geodatabase by creating segments across obvious open space as denoted in the fire insurance plans. Two types of networks can be created for use in ArcGIS: a network dataset and a geometric network. I elected to create a network dataset because it is optimized for undirected flow, whereas the geometric network is best used for directed systems such as rivers or utility lines. Default connectivity options were used and global turns were enabled as pedestrians are expected to be able to walk where they want and not have to follow restrictions typically imposed on vehicle traffic such as one-way streets (although there were no one-way streets in London in the nineteenth century). Length, expressed in meters, was the only cost calculated in the network; estimates of travel times were not added as they were is too unpredictable to estimate for the 1880s because of poor roads and differences in personal behaviour.

To calculate the path and distance to work, I used the shortest path route tools within the Network Analyst extension of ArcGIS 9.3 (and later version 10). The first step was to use the Calculate Locations tool within Network Analyst to calculate and

create a network location field for each business in the business directory shapefile extracted from the social environment stage. This is similar to snapping or linking the business to the road network, thus allowing the shortest path tool to more quickly and accurately locate the workplaces as stops. The distance from the centre of the businesses building polygon to the network was captured (an average of 24 metres) to be added to the final calculated journey to work distance. The network dataset was used as the input analysis network. The search tolerance was set to 200 meters in order to capture the few businesses that are far from the road network, such as the Great Western Railway and the Imperial Oil refining facility.

Numerous barriers to pedestrian travel were added before routes were calculated. These included dense multi-track rail yards and the two branches of the Thames River. Tolls existed on the many routes that emanated in and out from London's city limits, especially on bridges such as Clarke's Bridge on present-day Wellington Road. Diaries of the period suggest that these costs influenced travel paths for some of the lower income residents of the city and suburbs. While they may have had an impact on journeys, I elected not to include these tolls as barriers because of the difficulty in determining a toll's influence on a given individual.

The workforce sample geodatabase and the business directory (with the newly created network location fields) were joined and a new route started in Network Analyst. The workers were loaded as stops using the default geometry search options. The businesses were then loaded as stops using the network location fields. The routes were solved, resulting in 4,945 routes calculated, and the distance to the network was added back to produce a final journey to work distance (Figure 4.2). These routes represent the

journeys of 97% of all workers. An examination of the failed routes showed that there were two workplaces, the insane asylum and Huron College, that were beyond the extent of the road network derived from the fire insurance plan and thus the routes to them were not able to be calculated. These workers were removed from the study. The final routes were then joined back to the original workforce geodatabase to allow for a socio-demographic relationship analysis.

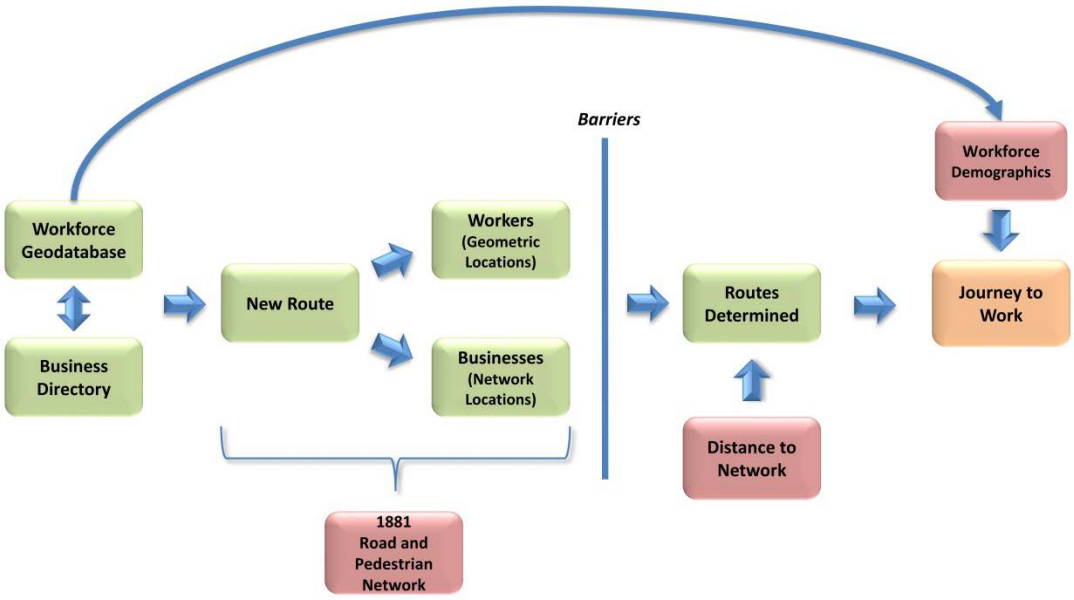


Figure 4.2 – Network Derived Journey to Work Scheme

The result is a reconstruction of the daily journey to work for some 5,000 workers from across the urban fabric of London and its suburbs. Figure 4.3 outlines the distribution of commutes from the shortest to the longest. We see that the average commute for all workers is 1,071 metres (the median is 954). 53% of workers travel more than 1 kilometre but 88% travel less than 2 kilometres. Figure 4.4 illustrates the completed journeys aggregated to each individual street segment. This provides a unique

view of the daily commuting patterns in a nineteenth-century city. We can see the density of workers on street segments in the city's downtown core and the heavy use of arterial streets such as Richmond, Hamilton, King, and Queen. As we may expect, the pattern thins along the tentacles of the street network that reach out to the suburban fringe. In our largest contemporary cities, real-time traffic flow data is fed to our smartphones and vehicle GPS units or announced to us over the radio. This view is the closest we have thus far to the same type of information for the pre-automobile city.

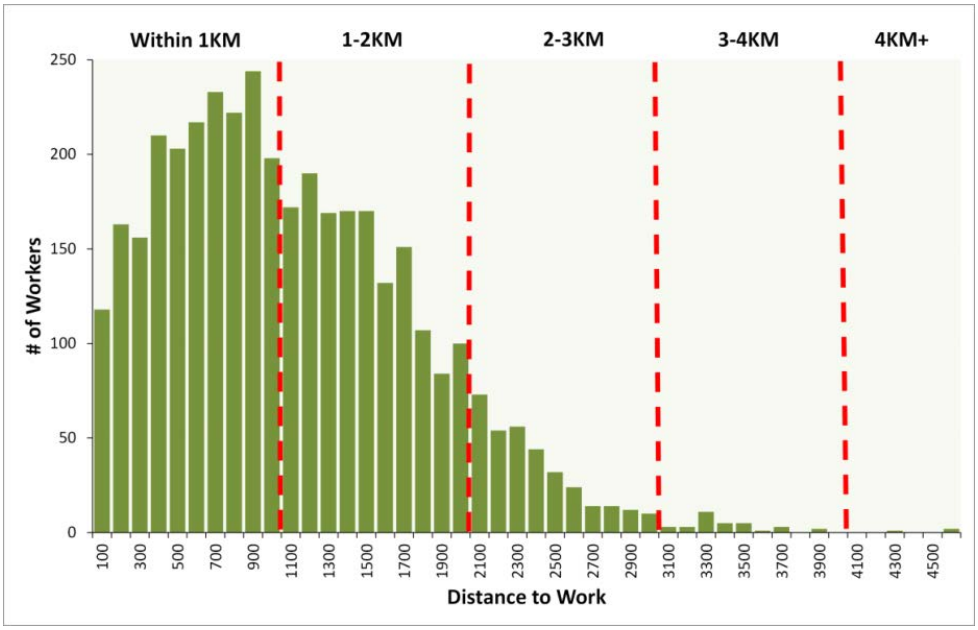


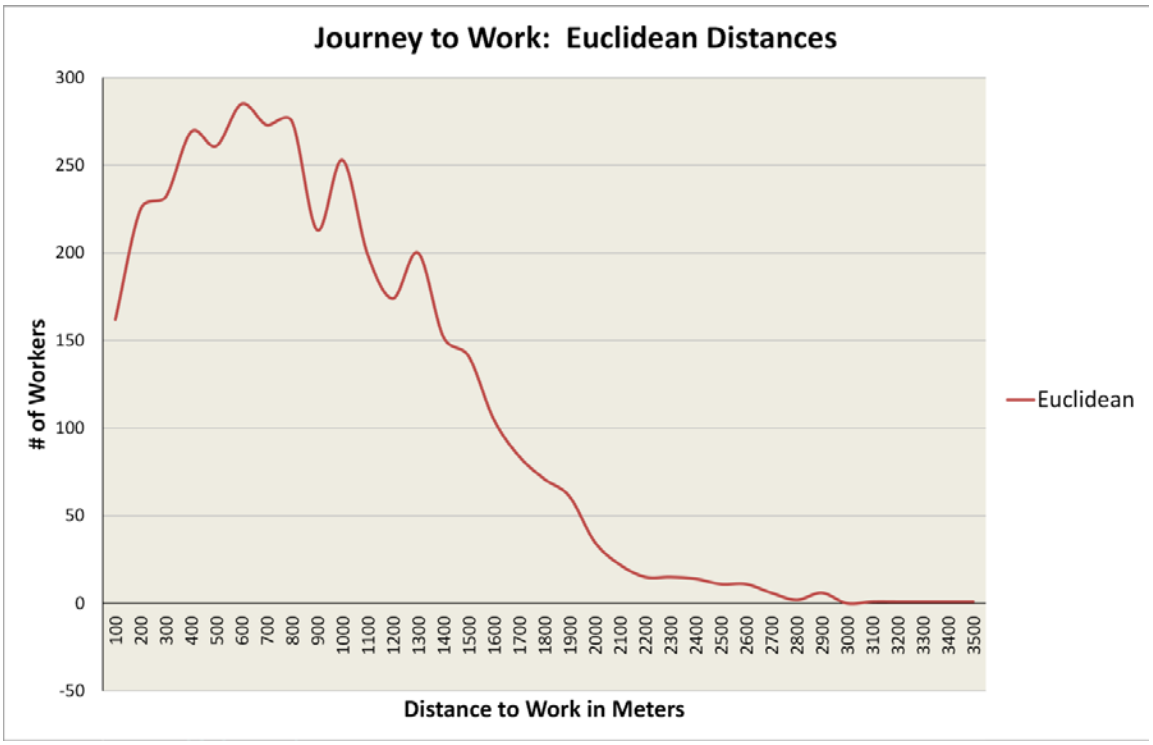
Figure 4.3 – Distribution of Distances Traveled to Work

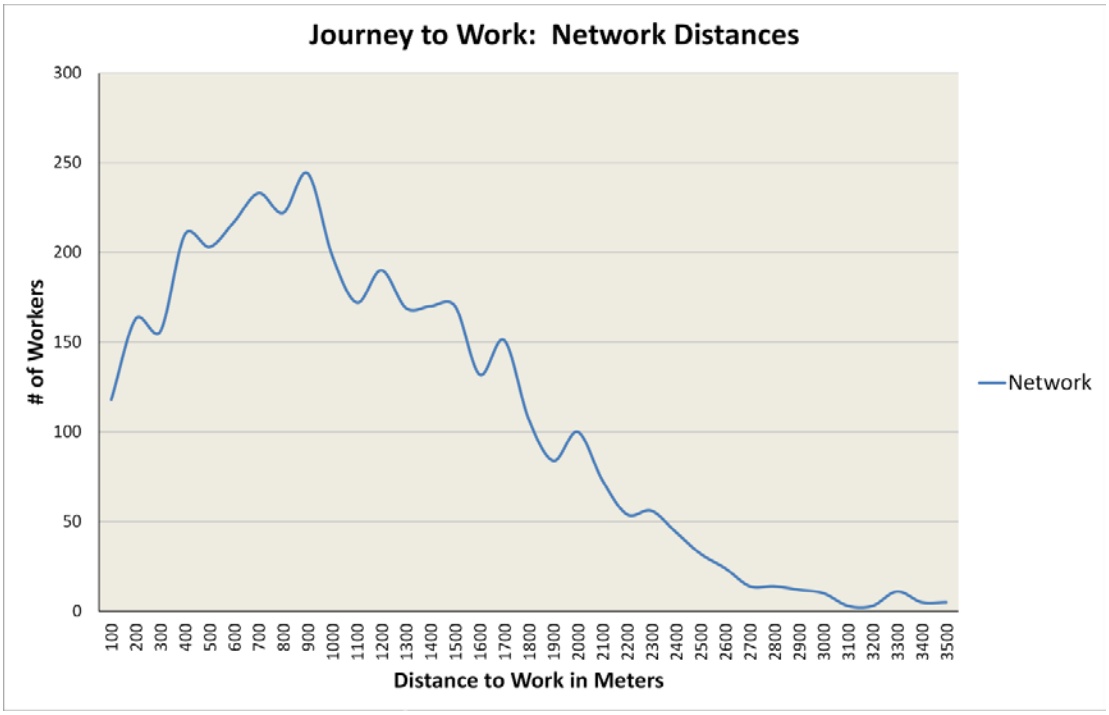
Figure 4.4 – Daily Traffic Patterns in London and Suburbs, 1881

4.6.3 Comparing Euclidean and Network Methods

This study has depended upon the re-creation of daily journeys based on network distances rather than the Euclidean distances used in all previous studies. The use of network paths places the commutes in a more representative environment and allows for a deeper understanding of the role that natural and man-made barriers played on the routes individuals had available to them. But do the distances really change between the two methods of calculation? Figure 4.5 illustrates that there is an overall average of a 20.8% underrepresentation when using the Euclidean method used in all previous studies versus the network method described here. We see that the Euclidean distance method

used in previous studies has less effect on results as the journey lengthens; for the shortest journeys, distances are significantly underrepresented when the Euclidean method is used (Figure 4.6)





* Euclidean mean is 848m, Network 1071m

Figure 4.5 – Differences between Euclidean and Network Distance Methods

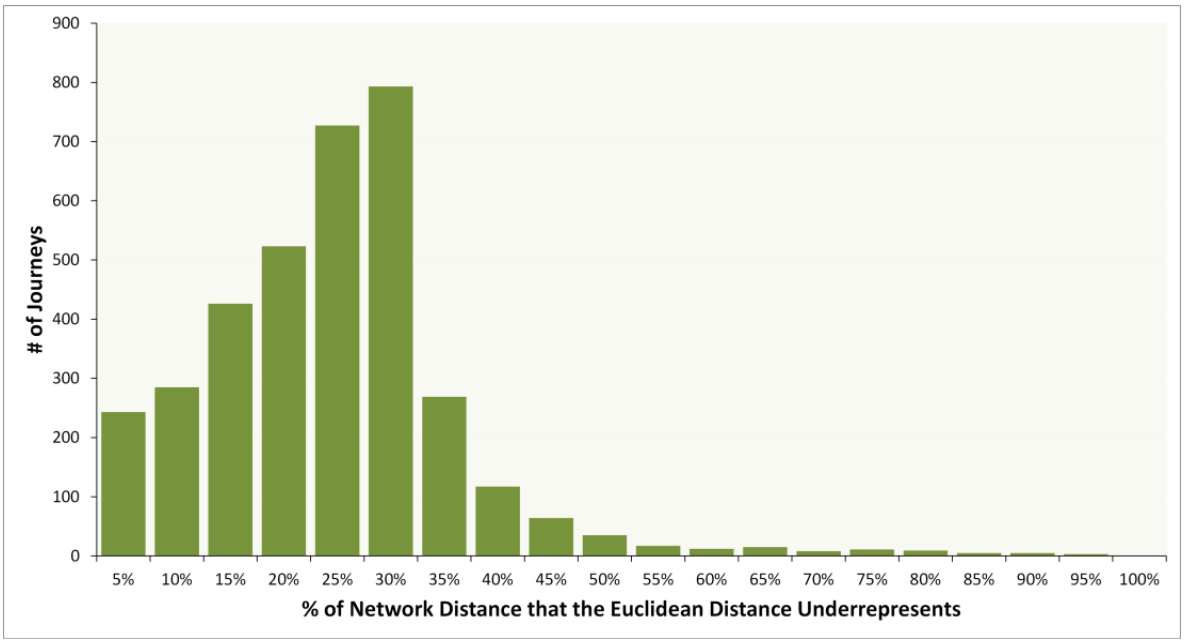


Figure 4.6 – Percentage of Network Distance that is Underrepresented when the Euclidean Method is used – by Number of Journeys

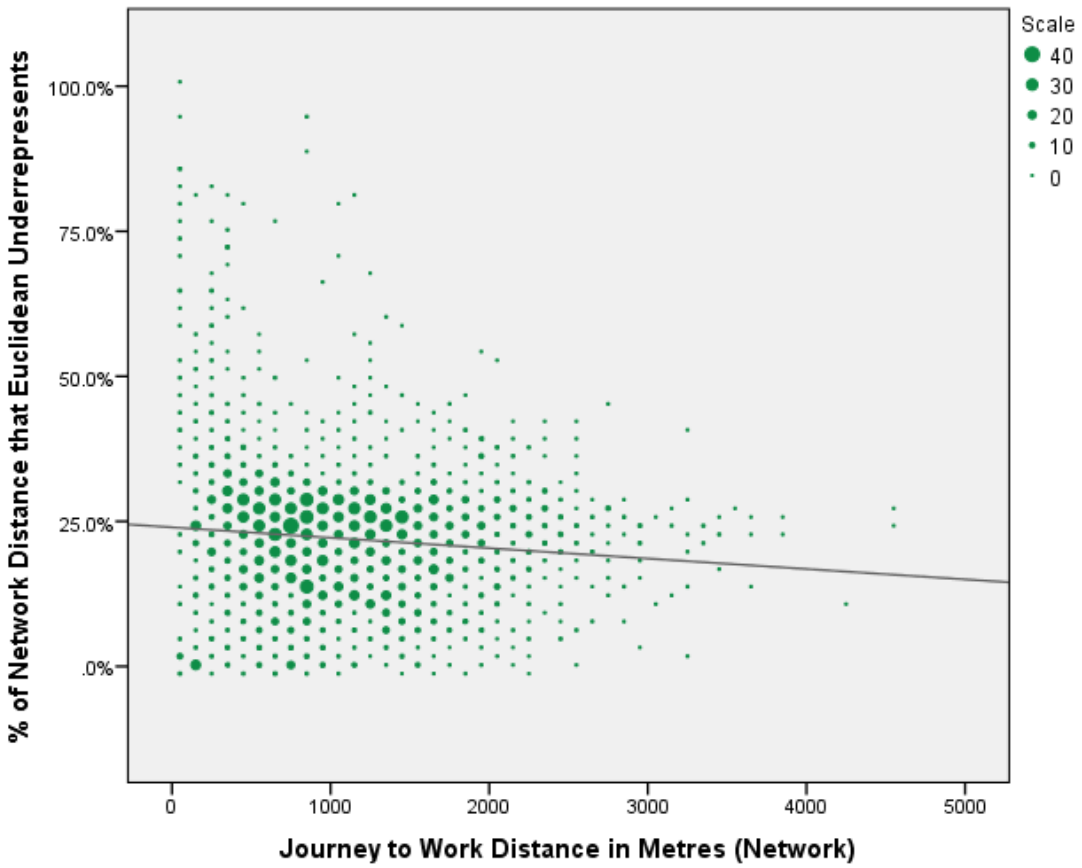


Figure 4.7 – Percentage of Network Distance that is Underrepresented when the Euclidean Method is used as related to Network-Derived Distance

The observed differences between the Euclidean and network-derived distances is a result of the aforementioned natural and man-made barriers. To illustrate, Figure 4.7 outlines the difference between the Euclidean and network-based journeys of Ernest Smith, a bookkeeper who lived in the suburb of London South. His 1.5 kilometre commute took Ernest across the iron York Street Bridge over the southern branch of the Thames River each day to his job at the Bank of Montreal. Figure 4.8 illustrates that not only was a Euclidean journey literally not possible, but the difference between a Euclidean journey and a network one is substantial. What Figure 4.8 does not show is the steep banks of the river that would have made it difficult to traverse any available

shortcuts or alternative river crossings. If we look closer (Figure 4.8), we see the inability to continue with a more straight-line journey after crossing the river, as the density of the urban core of London restricted travel to the established roadways. These barriers resulted in a commute that was over 25% longer than the Euclidean distance, resulting in an extra 5-15 minutes' walk, depending on the weather and other factors.

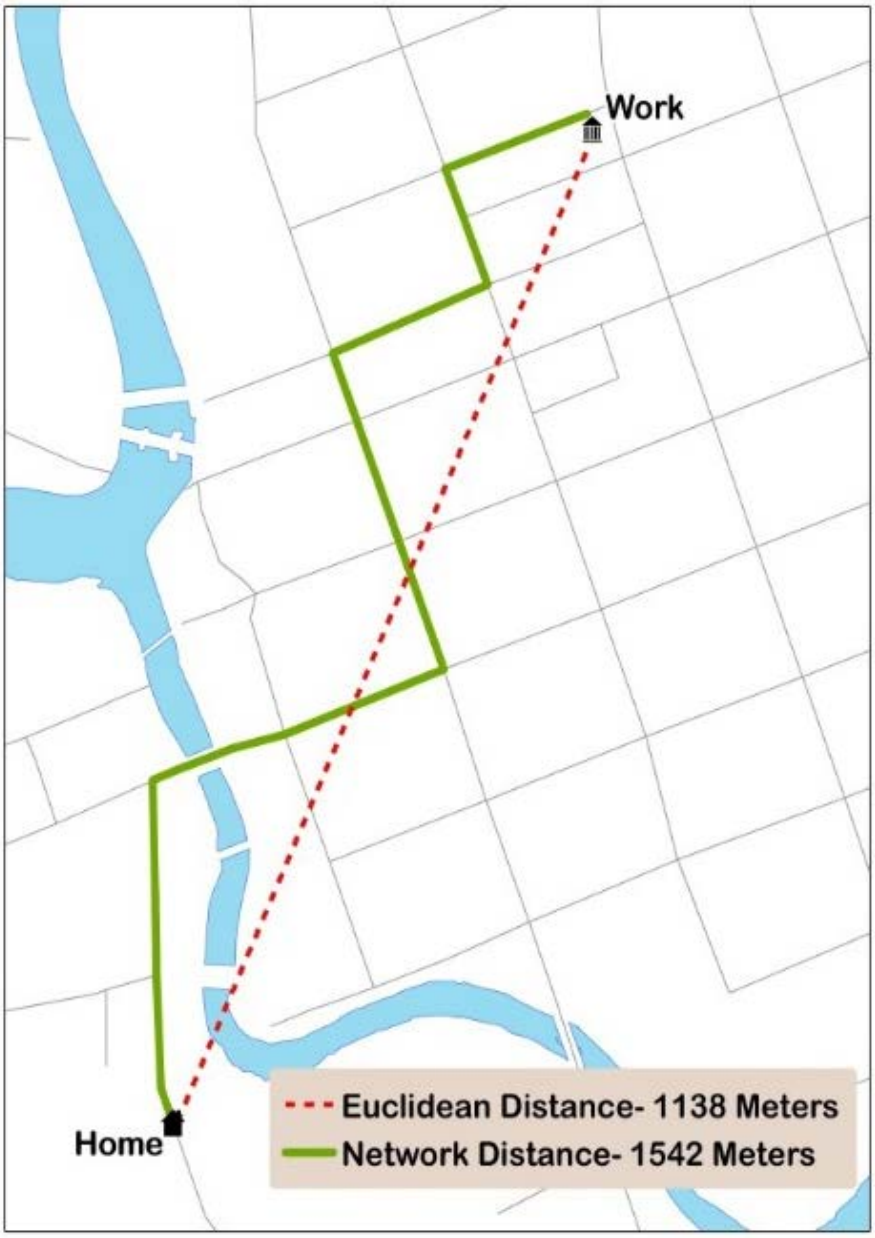


Figure 4.7 – Ernest Smith's Journey to Work Using Euclidean and Network Methods

Figure 4.8 – Closer look at Ernest Smith's Journey to Work in the Dense Urban Core

4.6.4 Comparing to Assumed Workplaces Method

Many of the most influential studies of the nineteenth century journey to work utilized a method of approximation that assumed that workers were being employed by the closest employer for which they were deemed qualified to work (Dennis R. , 1984; Deskins, 1972; Greenberg, 1980; Hershberg, Light, Cox, & Greenfield, 1981; Pooley C. , 1984; Vance, 1967). This paper suggests that this method of approximation leads to a significant misrepresentation of the true relationship between work and home, leading to an underestimation of the time spent traveling to work each day. A framework to overcome these assumptions has been outlined above, but the improvement has yet to be demonstrated.

To perform a comparative analysis between the two methods, I needed to find the closest workplace to each worker's home that would employ a worker with a related occupation, then compare that distance to the actual distance the worker was travelling to work each day. To estimate what would be the closest workplace for which a given worker was qualified, I first needed to link each worker with his/her industry of employment. However, due to the large number of industries (158) and workplaces (2295) — each of which would require a separate analysis — I elected to use a sample. I chose two types of workplaces representing two different industries, breweries and cigar factories. They were chosen because they represent workplaces that were not listed in multiple industry categories in the business directory, and thus provide a more direct relationship between home and a potential closest employer. Additionally, while they are both medium-sized industries in which workers commuted from a wide geographic area, they have differing levels of skilled labour and industrialization. Breweries employed 95 workers, a mix of skilled and semi-skilled labour, in a heavily mechanized environment. Maltsters, brewmasters, and coopers made up the skilled class, while semi-skilled workers included bottlers, packers, warehouse clerks, and teamsters. Some unskilled positions were also found in the city's breweries, such as those whose tasks were to shovel grain, load wagons, or clear rodents out of vats and barrels (Phillips, 2000). Cigar manufacturing, a rapidly growing industry in 1881, was a modest operation with products made by hand by individual workers using a limited number of simple tools such as a rolling board, knife, and wrapping leafs. A total of 118 workers in our database were working in cigar factories. The 1889 Royal Commission on Labour and Capital includes testimonies from Londoners that suggest that many more individuals were employed in

cigar making. They were primarily young women and children, recent immigrants who were 'secured by indenture' and paid the lowest of wages to complete the simple task of rolling tobacco leaves into cigars (Canada, Royal Commission on the Relations of Labor and Capital, 1889). We do not capture many of these indentured workers in this study. Those we do capture, however, represent a sample similar to that discussed in the Royal Commission reports, comprised of unskilled cigar makers, packers, and wood planers, including many who are women and teenagers.

To find the closest potential workplace on the road and pedestrian path network, I utilized the Closest Facility Analysis tools in Network Analyst. Workplaces were loaded as facility locations using the network location fields created for the journey to work analysis. The workers were loaded as incident locations, again using the default geometry location functions. Routes were calculated between each worker's residence and the closest workplace within their industry. The exported result has a name field that indicates both IDs from the facilities (workplaces) and incidents (workers) separated by a hyphen (eg. 125 – 50). These IDs needed to be separated so the distance calculations to the closest facility could be joined to the dataset with the worker's actual distance to work. To facilitate, a new field was created and the following VBScript run in the field calculator: *Left([Name] , ((InStr (1, [Name] ,"-",1) -2)))*. The difference between the actual and potential distances was calculated with a 0 difference denoting that the worker was working at the closest employer and any positive number reflecting the difference in metres. Table 4.7 charts the results, while Figures 4.9 and 4.10 provide graphic representations of the differences between closest and actual employer for brewery workers and cigar makers, respectively.

	Total Workers	Work at Closest	Actual Workplace	Mean Difference in Meters
Brewery	95	19	76	496 Meters
Cigar Factories	118	13	105	528 Meters

Table 4.7– Working at Closest Workplace vs. Actual Workplace: Brewery and Cigar Factory Workers

It is observed that only 19 of 95, or 20%, of brewery workers are employed at the closest brewery to their residence, resulting in a difference of nearly half a kilometer in their average journey to work. A closer look reveals that of the 19 workers who did work at the closest brewery, 10 were employed as maltsters, a job that requires careful attention to the germination of the cereals used to create the malt for beer production. Grains had to be crushed, weighed, and boiled into mash, then cooked, filtered and drained, and boiled again with hops before fermentation (Phillips, 2000). This delicate chemical process required constant attention and maltsters were on call seven days a week, living near their workplace in case they were needed to suddenly stop a malting that might finish early. Of the remaining nine workers, two were watchmen and another two held positions of responsibility as 'engineer' and 'foreman'. For cigar factory workers, only 13 of 105, or 12%, were employed at the closest factory to their residence, resulting in a difference of a half a kilometer in their average journey to work, similar to the brewery workers. With the exception of one foreman, a John Gerlach of WT Rutherford & Co's, the availability of inexpensive, convenient accommodations appears to be have influenced the housing decisions of those who worked at the closest employer. All of the other cigar workers who worked at the closest factory were boarding either in a residential hotel or in a dwelling with non-related individuals. More than half of the women were under the age of 20, and another two were fifteen-year-old boys who were

neighbours and worked together at William Kelly and Sons cigar factory, suggesting that we are picking up a few of the underrepresented workers in the city directory. Most of the city's cigar factories were located in the downtown core among other medium-sized factories that used paper and wood products, such as furniture manufacturers, carriage factories, and paper bag makers. Rents were low in this district of the city with most residential offers being in hotels or above storefronts, thus allowing an opportunity for the lowest paid cigar factory workers to find accommodations close to work, reducing their commutes to help compensate for the long work shifts that were demanded of them. It is recognized that many factors go into residential and workplace choice; however, these two examples, each with their peculiarities in occupational demands or residential needs, help illustrate that there are significant errors and omissions if one assumes that people work for the closest employer for which they are qualified. By establishing true home-work links, we can not only better understand what was a more realistic daily journey to work, but can also begin to provide some insight into residential choices made by workers in the nineteenth-century walking city.

Figure 4.9 – Brewery Workers: Differences between Closest and Actual Employer

Figure 4.10 – Cigar Factory Workers: Differences between Closest and Actual Employer

4.7 THE WALKING CITY OBSERVED

The robustness of the sample, the spatial accuracy of the geocoding, and the sophistication of a GIS-based approach to the historical journey to work allows researchers to interrogate the daily commute in ways other studies could not. The socio-demographic variables available in the social environment stage can be extracted and used with the home-work linked sample to interrogate the commuting patterns along lines

of ethnicity, age, gender, occupational class, or any combination of these that may be of interest. This section illustrates the possibilities by interrogating the journeys by occupational class, workplace location, and gender.

Before completing the socio-demographic analysis, it was necessary to first separate out those workers who were working at home and those who had a commute. Those who lacked a commute to work were as important to the social geography of the industrial city as those who had a daily journey. Although many records in the city directory directly indicated that work was taking place in the home, there were numerous individuals for whom the information was either vague or missing. The expectation would be that the geocoding of home and work would then intersect; however, due to occasional imprecisions in digitization or geocoding, some people who were indeed working at home were shown to have short commutes of anywhere from a fraction of a metre to twenty or thirty metres. A decision was made to consider anyone working less than 50 meters from home to be working at home. This threshold was selected based on the trend seen in the chart in Figure 4.12 and also because 50m covers the maximum distance seen in the city lots from the front yard to a rear tenement, the residential experience for some of London's domestic servants.

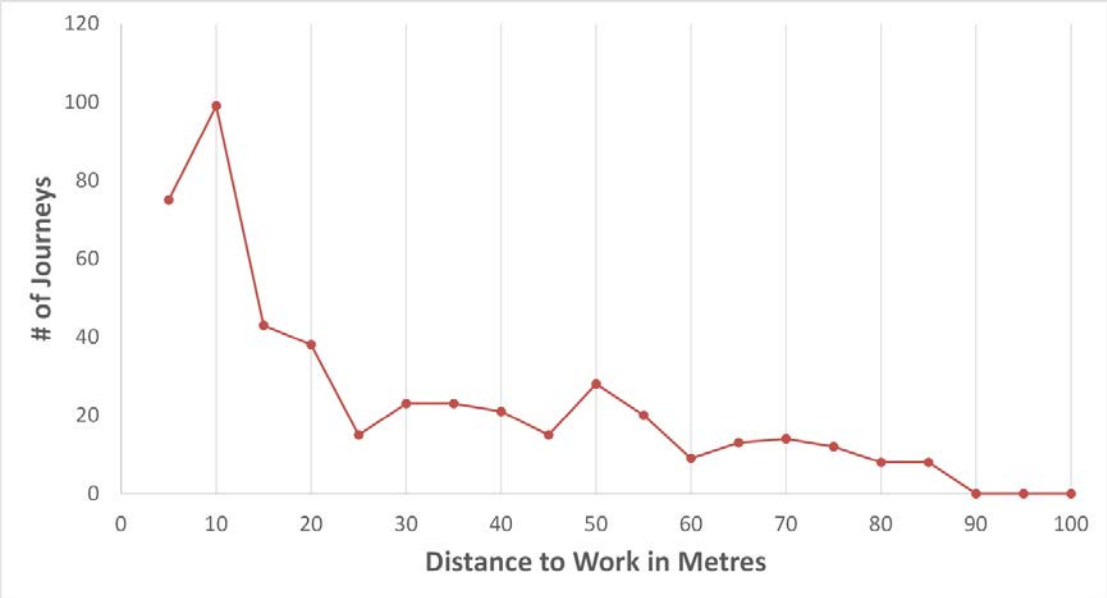


Figure 4.11 – Used to Determine Work at Home vs Work Outside of the Home Status

4.7.1 Differing Commutes by Occupational Class

Interrogating how commutes vary across occupations, industries, or various occupational groups is a frequent and natural interest for researchers who examine the journey to work. Most of the studies outlined in the beginning of this chapter dissected the aggregate patterns of commuting along occupational lines. Goheen (1970), examining the journey to work in Toronto in 1860 and 1890, sampled select occupations to represent differing occupational sectors. For example, he uses a brewery and piano manufacturer to illustrate the industrial journey to work, and a retail outlet and life insurance company for the clerical journey. Lawton and Pooley (1976) followed a similar model using dock workers, shipbuilders, and office staff for their study of 1871 Liverpool. Aggregating individual occupations into three classifications is common in many studies, though the categories are not. Bater (1974) divided workers in St.

Petersburg, Russia into managerial and professional, workshop owners and artisans, and factory workers. Barke (1991) divided his sample for Newcastle upon Tyne into the categories of professional, which included occupations such as accountants, lawyers and architects, producer-retailer, which included blacksmiths, watchmakers, and bakers, and finally retailers, which included pawnbrokers as well as those who sold fish, glass, or poultry. Taking a different approach, Hershberg et al. (1981) used industries to select their sample, starting first with ship building, sugar refining, iron rolling, banking, and morocco leather finishing. They were selected for their spatial coverage across Philadelphia, the ethnic composition of their workforces, and their respective longevity as industries in the city. To supplement their sample, they also used seven occupations to represent the swath of social classes, with physicians and lawyers representing the professional class, confectioners and bookbinders the small proprietors, and blacksmiths, cabinetmakers, and carpenters the artisanal proprietors. Mayer (1977) categorised all occupations into one of eight occupational classifications using a scheme developed for the 1940 U.S. census by Edwards (1940) and later modified by Thernstrom (1973) and Conzen (1976). To evaluate the differing journey to work across occupations in London, I follow Mayer's lead and utilize an occupational class scheme, though unlike Mayer, I employed one developed for the census that was used to build the dataset (see Table 4.5). This method allows us to easily examine all occupations across the entire spatial extent of the city rather than employing a sampling strategy, as done in the other studies.

As all other studies have utilized Euclidean rather than network distances, it is impossible to accurately compare distances travelled across various cities. Additionally, the absolute distance travelled is largely influenced not only by residential and workplace

choice, but by the size of the urban area, its density, the configuration of the street network, level of industrialization and commercialization, and development of transit systems, as well as barriers, both natural and man-made. Instead, patterns at the class level can be colloquially compared to previous studies by asking questions such as: Are the distributions of the journey to work travelled different between occupational groups? Were labourers living near their factories and the professional classes near their offices? Do higher status workers travel greater distances than their lower class counterparts?

Occupational Class	% combining home & work	.2	.4	.6	.8	1.0	1.2	1.4	1.6	1.8	2.0	Median (km)
Merchants/ Agents/ Manufacturer	37.1	43.3	48.4	55.7	66.5	73.7	78.6	84.5	88.9	93.5	95.4	.86
Professional	26.2	31.8	36.5	44.1	51.7	61.7	68.0	75.9	80.3	85.0	89.8	1.04
White Collar	6.8	10.7	20.9	31.9	40.9	51.0	61.1	71.5	82.6	90.6	95.9	1.07
Artisan	14.6	19.7	28.0	36.3	47.2	58.1	66.8	73.9	80.5	85.9	90.0	.98
Semi-Skilled & Unskilled	22.6	31.7	39.8	49.3	58.8	65.3	70.9	77.0	82.9	88.0	90.8	.89
Labourer	13.0	14.6	23.0	38.3	46.0	57.1	67.4	74.3	79.3	84.7	88.9	.98
Servant	83.1	91.5	94.4	95.1	95.4	95.9	97.2	97.7	97.7	98.2	99.1	.19

Table 4.8– Cumulative Percentage at Specified Distances from Workplace (in km)

Table 4.8 outlines the journey to work experience for the seven urban occupational classes in the modified Darroch and Ornstein scheme. At first glance, with the exception of the very low median journey of servants, we see little difference in the

median journey to work between the classes, with a difference of only 210 metres between the longest and shortest median distances travelled by those who were not in service. As is observed in all other studies with a predominantly British population, most servants lived in their masters' domiciles, and those who did not lived very nearby, usually in boarding houses with other servants. However, if we examine the journeys closer by looking at the cumulative percentages at distance bands from 200 metres to 2 kilometres, we reveal a more complex pattern. Excluding servants for the time being, those in the highest occupational class of merchants, agents, and manufacturers, lived overwhelmingly closer to their workplaces than workers in any other group. Nearly 50% lived less than 400 metres from work and three-quarters lived within a kilometer. They have the highest cumulative percentage of workers living close to work across every distance band but the very longest. Surprisingly, this pattern is not shared with the studies outlined above, where they found that factory owners and merchants, if they did not live at their businesses, lived a considerable distance away compared to other occupational groups. This difference may be a function of the very dense urban core of London that permitted a very short distance from the commercial and most of the industrial firms to the desirable neighbourhood on Talbot Street overlooking the Thames River and to the Woodfield neighbourhood adjacent to the city's only public park. The exception would be those industrialists involved in the growing rail and barrel works in the suburb of London East, as they lived in the same neighbourhood as their colleagues, but their businesses were significantly further away.

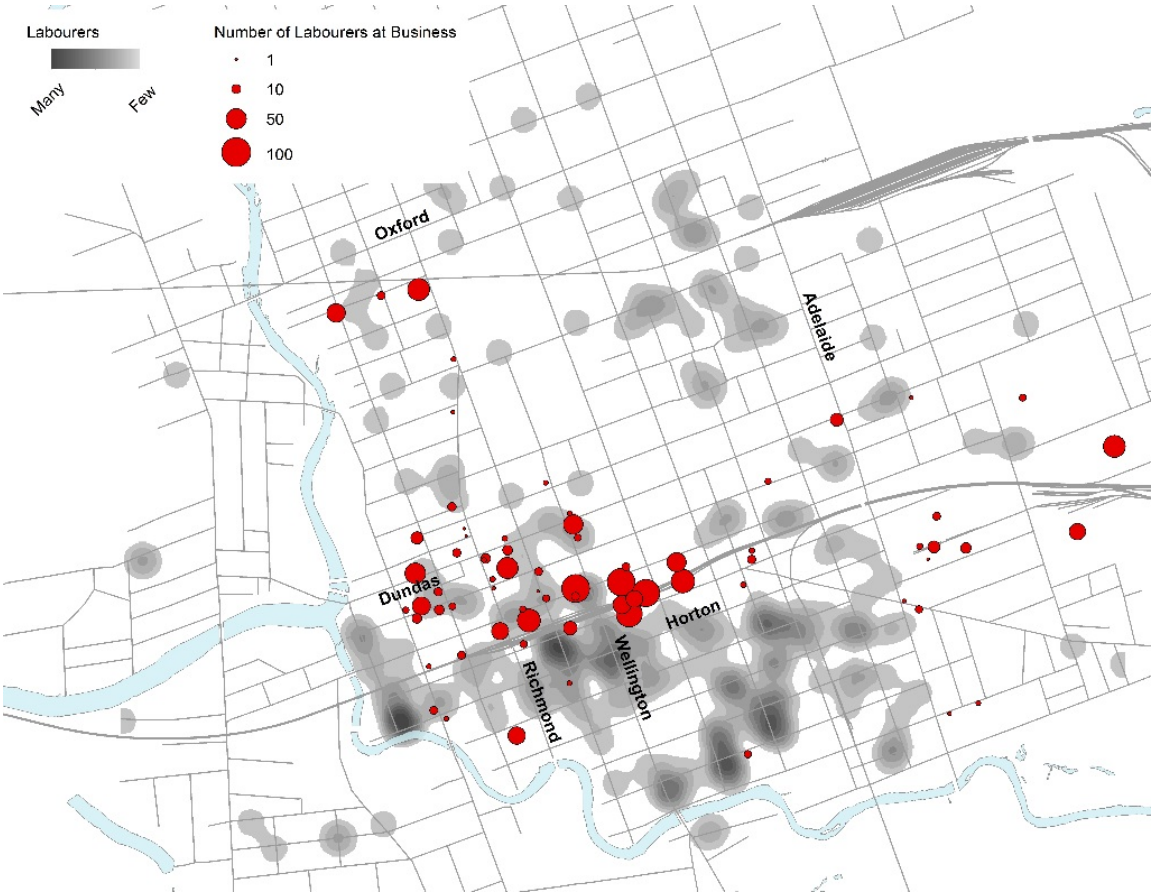


Figure 4.12 – Relationship between Labourers and their Workplaces

When we turn our attention to the experiences of professionals and white collar workers, the patterns match many other studies. For example, Hershberg found that bank employees traveled further than their blue-collar counterparts. Barke found the same in Newcastle Upon Tyne, as did Layton and Pooley in Liverpool, Goheen in Toronto, and Mayer in Milwaukee. Interestingly, in London, one sees approximately a ten percent increase in white-collar workers from one distance band to the next until 1.6 kilometres, where the percentage catches up to the other occupational classes and the rate of increase

slows. What is less pronounced in London is the number of labourers living close to their workplaces. This pattern was observed in Liverpool, Milwaukee, and somewhat in St. Petersburg. In London, however, labourers lag behind the other lower class group, semi-skilled and unskilled workers, until they meet at a 1.2 kilometre journey. This may be explained by the high demand and limited inventory of housing in the core and nearby neighbourhoods. Instead we see labourers travelling from modest homes north-east of downtown as well as from the neighbourhood along the north shore of the south branch of the Thames to jobs along the rail lines in the centre of the city as well as the new industries in London East (Figure 4.13)

4.7.2 Coincident Home-Work Locations

Studying the home-work relationship has primarily been the domain of feminist scholars who have been interested in the extent of unpaid domestic work by women and girls or the important role that piecework and cottage crafts played in supplementing the household income (Bradbury B. , 1984; Bradbury B. , 1996; Bullen, 1986). However, significant numbers of men still combined work and home. In the aggregate, we find that in 1881, 26% of London workers were combining home and work. 61% of the women worked at home whereas only 16% of men did. Women represent just over half (53%) of the work-at-home population in London in 1881.

The methodology used to determine who worked at home versus outside the home was not clearly outlined in the few other studies that have directly investigated this relationship. The most comparable studies to this one are the work done by Hershberg et al. (1981) and Mayer (1977) who interrogated the frequency of coincident home-work locations in 1880 in Philadelphia and Milwaukee respectively. Similar to this study, they

relied heavily on the workplace information provided within the annual city directory; however, neither study outlines how they deemed a worker to be working at home. Table 4.9 compares the frequency of workers who combined home and work, by occupation, for London to the case studies of Philadelphia and Milwaukee. All occupations listed in the comparable studies are included as well as select additional occupations for London. With the robustness of the London sample, we have the possibility to report every occupation, but have elected to only report some of the most notable here. Considering that each city has its own local industries that dominate the economy and the comparison cities have significantly larger populations than London (Philadelphia 850,000 and Milwaukee 115,000 in 1880), sample sizes for specific occupations are surprisingly similar across the cases.

	London		Philadelphia		Milwaukee	
	N	% Combining Home & Work	N	% Combining Home & Work	N	% Combining Home & Work
Lawyers	14	0%	40	17.6%	57	10.5%
Physicians	38	84.2%	40	95%	44	65.9%
Carpenters	143	6.9%	115	53%	31	41.9%
Confectioners	28	14.2%	765	90.6%		
Bookbinders	16	18.7%	54	9.3%		
Blacksmiths	100	8.0%	112	23%		
Cabinetmakers	56	21.7%	129	54.3%		
Agents (unspecified)	40	5.0%			9	22.2%
Clerks (unspecified)	394	7.6%			19	26%
Tavern Proprietors	8	75.0%			206	89.3%
Barbers	24	20.8%			36	55.6%
Coopers	41	24.2%			34	64.7%
Foremen	59	22.0%			23	13%
Merchants	322	43.8%			54	29.6%
Butchers	54	46.3%				
Tinsmiths	35	8.6%				
Bakers	17	70.6%				
Servants*	511	87.9%				
Dressmakers*	59	55.9%				
Cooks*	40	72.5%				
Nurses*	44	97.5%				

* denotes occupations dominated by women

Table 4.9– Percentage of Workers with Coincident Home-Work Locations for Select Occupations: London, Philadelphia, and Milwaukee, 1880-81

Examining specific occupations, we see some immediate similarities between the three cases. No lawyers in London combined their home and work, and few did in Philadelphia or Milwaukee. Lawyers depended on centralized locations near the heart of

the commercial district of the city, close to their clients in banking and insurance. However, they also had incomes that allowed for greater residential choice, with most electing to reside in some of the city's nicer neighbourhoods away from the downtown core (Figure 4.14). The result is a long median journey to work of 1350 metres, a pattern shared with the cohort in Philadelphia and Milwaukee. Unlike lawyers, in all three cities physicians rarely separated work from home. Instead, physicians operated out of their homes, in the transitional areas between the commercial core and the residential areas of the city. Two clusters are visible in London, one at the eastern edge of downtown bounded by Clarence and Colborne, largely along Dundas and Queen, and the other north of downtown between Talbot and Richmond. The five doctors who did have offices outside of their homes also located them in the same areas of the city (Figure 4.15). One of the few offices in the commercial core was operated Dr. Oronhyatekha, a famous Mohawk doctor and businessman. His one kilometre journey to work from his residence on Litchfield Street was the longest of all physicians in the city, where the median journey of physicians is a mere quarter of a kilometre. His election to operate his practice out of an office downtown on Richmond Street may be related to his appointment as the first Supreme Chief Ranger of the Independent Order of Foresters, whose offices in the Albion Buildings were a mere 150 metres north of his office.

Figure 4.13– Lawyer's Residences and Law Offices in London, 1881

Figure 4.14– Doctor's Residences and Doctor's Offices in London, 1881

Skilled workers, such as carpenters, cabinetmakers, and blacksmiths, in London had a different home-work relationship than did their counterparts in Philadelphia. In London, these skilled workers rarely combined home and work. In Philadelphia, over half of carpenters and cabinetmakers, and nearly a quarter of blacksmiths, worked out of their homes. Hershberg et al. (1981, p. 138) suggest that Philadelphia saw an increase of small firms, employing 1-5 workers, working largely at home because the small profits associated with this artisanal production would have made operating a separate workshop cost-prohibitive. In London, carpenters and cabinetmakers had moved out of artisanal work by 1881 into the industrial setting, dominated by a couple of large factories. We

find 45 (32%) of the carpenters were working at the Ontario Car Works in London East, building parlour train cars for the Great Western Railway. Another 26 (18%) were employed at Thomas Green's planing shop and sawmill. The remainder worked as carpenters in factories such as John Elliott's Phoenix foundry, where they made agricultural implements such as plows and shovels. Cabinetmakers follow much the same pattern, with over 80% being employed by three firms, the London Furniture Company, John Ferguson's coffin and cabinet factory, or the Bennett Brothers office furniture factory. London's blacksmiths were not found in a select few dominant factories, but rather spread across the industrial fabric of the city. The 100 blacksmiths in London were employed across 38 different factories, differing in form and function. Though not centralized, blacksmithing in London was still different from the more artisanal nature of blacksmithing reported for Philadelphia. The few blacksmiths who did combine home and work in London were all found in small homes with shops in the rear, located exclusively in largely industrialized areas of the city, presumably to reduce the possibility of irritating their neighbours.

Confectioners and coopers followed the same pattern, where few in London combined work and home compared to their counterparts in Philadelphia and Milwaukee. Most stark is the difference between London and Philadelphia for confectioners. A surprising 90.6% of confectioners in Philadelphia worked in their homes, versus a modest 14.2% in London. The only explanation provided for Philadelphia is that because they 'served a neighborhood market… they had little reason to separate their work and residence' (Hershberg, Light, Cox, & Greenfield, 1981, p. 137). In London, all but 7 of the confectioners were employed by one of two firms, either McCormick's

Manufacturing or Daniel Perrin's Biscuit Co. Both firms were substantial in size, employing over a hundred men, and had a large distribution of their confections across Canada. Coopers in London followed a similar pattern, with the majority working for either Seale and Child's Cooperage or that of William Hawkins. Both firms supplied Labatt and Carling the barrels needed for their beer and ale. In contrast, Milwaukee's coopers worked in a more artisanal setting, with one or two coopers working out of a home, utilizing the ready access to cheap lumber from Wisconsin's growing timber trade to supply barrels to one of Milwaukee's forty or so breweries.

Turning our attention from industrial labour to commercial work, we see an expected home-work relationship pattern in London. Tavern proprietors, like their counterparts in Milwaukee, primarily lived above or behind their pubs. Agents and clerks largely worked outside of the home, as they served the needs of either a specific organization or the public at large. Curiously, this does not correlate with the experience in Milwaukee, where a surprisingly high percentage of agents and clerks worked at their residences. Unfortunately, Mayer does not specifically address why this was observed, an omission that raises the curiosity of this researcher.

4.7.3 Women's Experiences

Women's relationship between work and home is not explicitly treated by Hershberg et al. or by Mayer, so comparisons are not possible. A glance at Table 4.9 provides some insight into the experiences of women in London. Women's paid labour was dominated by occupations that extended from their duties at home. Few married women had steady employment outside of the home and thus most did not report an occupation to a census enumerator. Bradbury (1984) outlines that women worked for

wages occasionally, taking in washing, ironing, sewing, or performing other domestic duties for neighbours, relatives, or friends. Dressmaking and tailoring in particular were popular part-time occupations for women; most women were sewing at home for their families and the more entrepreneurial also made items for sale to supplement the family income. Few of these part-time dressmakers are captured in the city directories; however, we are able to examine 59 dressmakers who appear to work on a more full-time basis producing dresses for the ladies of London. Interestingly, only 56% of them work from home, with the remainder working primarily as one of many women at a dressmaking shop, such as those owned by Lydia Crone and by Mrs. Montague. These dressmakers had the longest commute of any women working outside the home, with a median journey of nearly a mile (1.6km) (Figure 4.15). The daily newspaper, the *London Advertiser*, had a steady increase in the number of notices in the female help wanted section for dressmakers and sewing girls through the 1870s. This increased demand for 'outsourced' dresses was partially a response to the School Act of 1871 which made schooling compulsory for all children, including the young girls who would have helped with the sewing (Ross, 1896). This loss of domestic labour, combined with the increases in real wages throughout the period, meant that women began to purchase dresses rather than make them themselves. The advertisements for dressmakers in the newspaper do not list a wage, though the frequency and voracity of the want ads suggest that the wages may have been higher than women would have made sewing at home, finding employment in the cigar factories, or working as cleaners in the one of the many hotels.

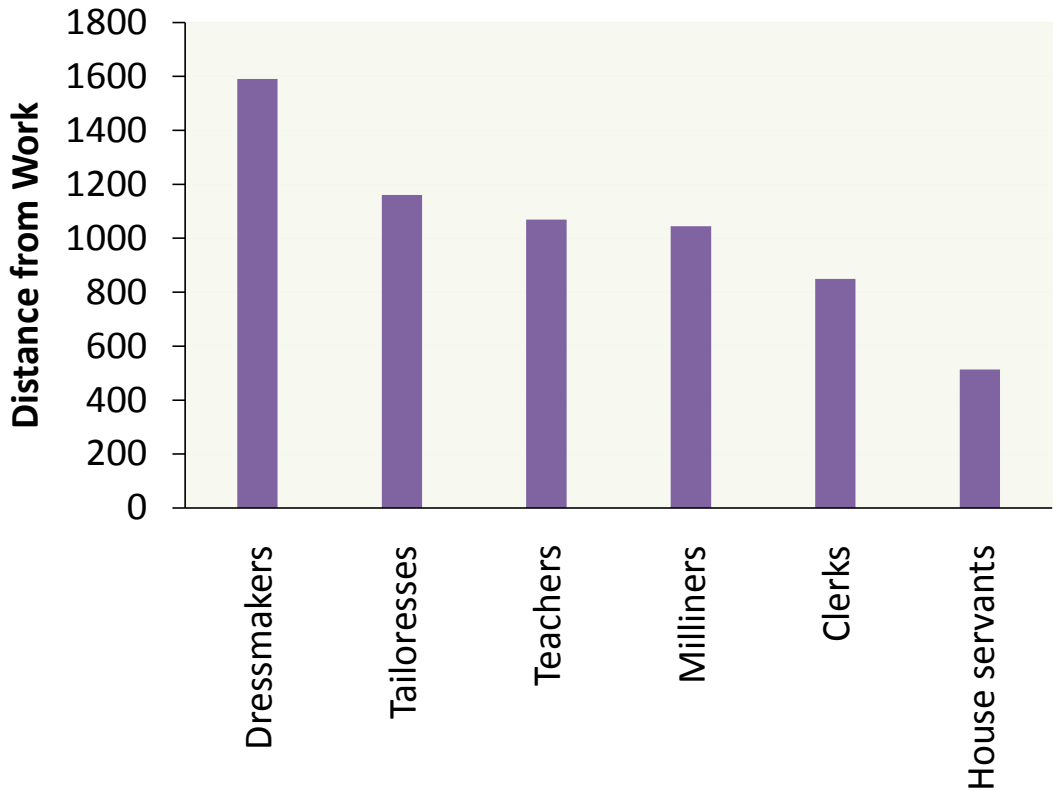


Figure 4.15– Distance to Work for Women, Select Occupations, in Metres

It should be acknowledged that the term ‘dressmaker’ in the census has been linked to prostitution in Victoria, BC. (Dunae, 2008; 2009). Census enumerators were instructed to record ‘public women’ in the census as a ‘dressmaker’. Of course, not every dressmaker was in fact a prostitute. I harnessed a geodatabase of jail records for London and suburbs created for another project to quickly examine if the euphemism was possibly used in London, following the same methodology employed by Dunae. There were 54 arrests in 1881-82 for the offence ‘house of infamy’, ‘inmate of house of ilfame [sic]’ or ‘prostitute’. Six of these women had their occupation listed in the census as dressmaker, though none are found in our sample of workers. The enumeration goals of the city directory would have encouraged the directory enumerators to turn a blind eye to houses of ill repute. Although we don’t have any ‘prostitute dressmakers’ captured in

this study, the evidence suggests that it was possible that the environment found by Dunae in Victoria may also have existed in London.

The transition of girls to school and increasing household income resulted in more than just the need to purchase dresses from a dedicated dressmaker, it also helped support an increase in employment of domestic servants in Canadian middle-class homes. We found over 500 female domestic servants in our journey to work sample; this was the largest single occupation of women in the city. Nearly all (88%) lived in their masters' homes. The domestic servant was usually a single, young woman (median age in London was 23), and was primarily of English, Irish, or Scottish descent. Being 'in service', however, came with a stigma. Some scholars suggest that those women who had a choice preferred to work in factories, offices, or shops regardless of a difference in pay (Barber, 1991, p. 8), while others argue that working-class parents preferred their daughters to work in private homes rather than being exposed to the dangers of the factory or receiving the low wages of the shops (Fahmi, 1997, p. 73). I found the frequent advertisements for reliable servants to be increasingly dominant in the help wanted section of the newspaper from 1879-1891. The advertisements also served as a public notice that a household was capable of paying for domestic help, as the live-in servant was an important status symbol in Victorian Canada.

Cooks and nurses represent another group of women who lived at work rather than working from home. London's cooks worked overwhelmingly in the city's hotels, working for both a wage and for room and board. They were older than domestic servants, with a median age over 30. The few that did not live at the hotel had a very short commute, averaging only a few hundred metres. All but a select few nurses lived at

work, either caring for children in the Protestant Orphans' Home or for the infirm at the insane asylum.

This section has illustrated the importance of interrogating the relationship between home and work, particularly for revealing the situation of a large portion of women. Women had long work days in the domestic sphere, and so did men in the factory. This was a period of industrialization when, in the aggregate, production shifted from being home-based and artisanal to factory-based. However, the decision to work outside or inside the home is still not always clear to historians and historical geographers. We need to continue to seek to understand the complexities of the geography of work in the nineteenth century.

4.8 CONCLUSION

This paper has outlined a new methodological framework for recreating the spatial relationships between work and home. The methodologies herein overcome many of the limitations of previous studies, helping to invigorate an area of research that has had little attention since the early 1990s. Although much of the data is the same as used by other researchers, by harnessing a complete digital record of the city's population and businesses, we can begin to understand the journey to work for not just a subset of the city's population, but for nearly every single individual, occupational group, workplace, or neighbourhood in the city. With a robust record linkage procedure, I have been able to make absolute links between workers and their workplaces and calculate their daily journeys on a model of the street and pedestrian paths of the city. This method

overcomes the concerns that Dennis (1984) postulated about quantitative research on the journey to work due to a lack of data that directly links work and home.

It must be acknowledged that the methodologies used herein are not perfect. Like any interrogation of the past, we are limited by the quality of the data recorded. In this case, we must remember that city directories were compiled for an explicit financial purpose, to sell advertising and subscriptions to businesses and citizens alike (H.H.B., 1913). It was very much like a paid version of the telephone book that was commonly distributed a few years ago before the creation of internet searches. The census was not perfect either, as Curtis (2001), Hamilton (2007), Steckel (1991) and many others have thoroughly outlined. Census enumerations were and continue to be wrought with imprecise methods and procedures resulting in marginalized individuals being undercounted, misrepresented, or omitted completely. For this study of the journey to work, the effects include a skew towards full-time wageworkers, rather than those who worked part-time, did piecework, or were chronically unemployed. Married women who did not work outside the home, as well as teenagers who worked after school and on weekends are also missed. These issues affect this study and must be considered when findings are analyzed.

The algorithms used may also skew results. The study utilizes shortest path techniques provided by the software company ESRI. Although the mathematical models used have been scrutinized and accepted by the larger GIS community, the assumption that individuals are most efficient in their commutes is still not confirmed. In the walking city, it would be expected that some individuals trip-chained or took differing routes to meet with a friend or relative or to patronize a preferred vendor or service provider.

As well, this study provides a methodology to study the journey to work at one point in time. We know that populations are not static and residential moves were frequent; less so were changes in employer or the specific worksite in which one carried out one's daily tasks. We know that residential mobility happens for many reasons, among them the attempt to better not only the daily commute, but also the size and quality of one's accommodation (Gilliland & Olson, 1998). A natural next step is to attempt to follow workers longitudinally across time. Other journey to work studies have looked at how patterns change over time, but no other has examined the same individuals over time. By looking at how the daily commute changed for individuals, combined with how their residential environments changed, we can begin to untangle how individuals made choices to balance the daily commute and the desire to improve the environment they and their children lived in. This will be the focus of the next chapter of this dissertation.

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CHAPTER FIVE

Following the Butcher, the Baker, and the Candlestick-Maker: Urban Environments, Social Mobility, and the Journey to Work in the Nineteenth-Century City

Don Lafreniere and Jason Gilliland

5.1 ABSTRACT

A shared experience among most adults is the exhilarating but stressful experiences of moving and changing employment. The decision or need to move afford individuals an opportunity to choose an environment that best meets their needs, desires, and hopefully improves their overall quality of life. In this article we follow a sample of workers in London, Ontario from 1881 to 1891 and evaluate how changes in their home-work relationship results in a changes in their daily journey to work. Further, we harness a robust historical GIS that models the built environment of the city to evaluate the changes in the workers residential and neighbourhood environments as a result of their moves and job changes. Six environmental indicators are measured and used as a proxy for measuring individual social mobility. Empirical results highlight the complexities of the relationship between residential needs, neighbourhood environments, and the journey to work. Findings outline that workers in the nineteenth century who were able to be upwardly socially mobile and improve their overall environment did so at the expense of substantial increases in their journey to work.

Keywords: Social Mobility, Journey to Work, Space-Time, Historical GIS, Residential Mobility, Urban Environments

5.2 INTRODUCTION

When taking a new job, either across town or across the country, individuals and families face the difficult task of balancing their residential needs while minimizing their commute to work. We know that the decision where to live is based largely on where one is in their lifecourse (Mulder and Hooimeijer 1999). Moves are triggered primarily by changes in family composition (Clark and Huang 2003, Mok 2007, Mulder 2007), job changes (Brown 1975, Dieleman 2001), economic hardship (Clark and Onaka 1983, Crowley 2003), the desire to reduce the daily journey to work (Prillwitz, Harms and Lanzendorf 2007, Zax and Kain 1991), or, often, a combination of these factors (Feijten, Hooimeijer and Mulder 2008, Gilliland and Olson 1998, Kronenberg and Carree 2012, Olson and Thornton 2011). The decision or need to move affords individuals an opportunity to choose an environment that best meets their needs or desires. It may be living in a dense, walkable urban community, on an expanse of land in a rural setting, near specific amenities, or within easy access to the school of choice for their children. With voluntary moves, individuals attempt to improve their overall quality of life through increases in earned income, job satisfaction, social/familial ties, or improvements in their dwelling or neighbourhood quality. These decisions are weighed against the cost of housing and the distance or travel time to work.

This desire to improve one's lot in life and the careful balancing act that ensues existed for the citizens of Canadian cities during the nineteenth century, as it does for people today. Indeed, the decision may have been more acute in the past, especially in the desire to improve the quality of one's residential environment. Urban residents did not benefit from the protections of modern land use planning. Residential

neighbourhoods of the late nineteenth century were not sheltered from the widespread presence of foul odours, pollutants, and noise that accompanied early urban industrialization. Municipal regulation of urban development was limited primarily to public health (specifically sanitation) and what bylaws were in place only applied to individual buildings, not land uses (Hulchanski 1982). Gilliland and Olson (1998) outline how the citizens of nineteenth-century Montreal continually adapted to the environment (often annually through a rigid system of annual leases that expire May 1), seeking improved housing conditions through larger dwellings, less crowding, and lower population densities. Among Anglo-Canadians during this period, the rigid British social class structure still influenced daily life and the social customs of individuals, and arguably, with the exception of only dress, residential condition served as a primary sign of social status (Bradbury and Myers 2005, Choko and Harris 1990, Harris, Levine and Osborne 1981).

Despite these understandings, little work has been done to examine how an individual's residential conditions changed over time. A wealth of research exists on the changes in home ownership, and a notable literature has reviewed changes in the residence itself, but few have concerned themselves with the greater neighbourhood environment. Even less work has been done evaluating how residential mobility was associated with changes to the daily journey to work, despite the commute being recognized as an important factor in residential choice. This paper presents a historical GIS approach to uncovering changes in individuals' and families' residences and workplaces, and their corresponding effects on the daily journey to work over the decade from 1881-1891. By harnessing the built and social environment stages created during

the construction of the Imag(in)ing London HGIS (Lafreniere and Gilliland 2014), we follow the same individuals, over time, and evaluate the changes in both the quality of their dwelling, or residential environment, as well as their broader neighbourhood environment. We use the changes in the environment as a measure of social mobility and critique the impact these residential moves have on the daily journey to work. This unique geospatial view of the interplay between residential, workplace, and social mobility provides a new perspective on daily life in Canada's early industrializing cities.

The paper begins with the methods used to establish the longitudinal links needed to create the longitudinal study of the journey to work. It continues by evaluating the extent of residential, occupational, and workplace mobilities of the workers of London from 1881 to 1891. The succeeding section outlines an approach to capturing historic residential and neighbourhood environments as a proxy for social mobility. The paper concludes with a discussion of the relationship between the journey to work, residential moves, and social mobility.

5.3 ESTABLISHING LONGITUDINAL LINKS

To facilitate an analysis of the changing journey to work and residential and social mobility, we first need to establish longitudinal links across datasets to identify the same individuals over time. For several decades geographers, historians, and demographers have been laboring on projects that aim to link large samples of individuals from individual cities, regions or countries across decennial censuses and other nominal datasets such as annual city directories and tax registers. First the domain of the quantitative scholars of the 'new urban history' of the early 1970s, today historical

demographers push the level of sophistication and rigor in matching individuals across time. Some early examples include the parallel social history projects in Hamilton led by Katz (1975) and in Philadelphia led by Hershberg (1981). These early models used a combination of manual and automated record linkage procedures to link censuses over time and other enumerated sources, such as city directories, to the census. Steve Ruggles, the director of the Minnesota Population Center (MPC), one of the world's leading developers of linked demographic datasets, notes that these early studies generally lost between 60 and 80 percent of the population each decade due to linkage failures (Ruggles 2002). With the availability of national scale datasets in the last few decades and the capabilities of computer-aided linkages, significant progress has been made to improve techniques, though there are still many issues to overcome.

Important issues must be considered when attempting to record link the census. When working with national datasets, Ruggles (2002) outlines the need to control for migration, emigration, and immigration to achieve the best results and Hautaniemi, Anderton, and Swedlund (2000) argue that you must first determine deaths before controlling for various types of migrations. Steckel (1991) and later Dillon (2002) identify that infants, children, young adults, low-income individuals, manual labourers, black Americans, and single men are difficult to link. There are also issues of errors in enumeration (Curtis 2001, Dunae 1998, Hamilton and Inwood 2011), name changes (Dillon 2002), and transcription errors and bias (Antonie, et al. 2010). Early attempts at record linkage were done exclusively by hand, but as computing became mainstream, so did procedures to automate record linkages. All semi-automated or fully automated linking procedures attempt to use as many variables as possible to establish a true link

between data sets; combinations of name, age, birthplace, gender and occupation are common. However, with each variable included in the automation attempt, the processing time is increased. Antonie et al. (2010) observed in their attempts to link the 3.5 million records of the 1871 census to the over 4 million records in 1881 that it would take nearly two years to complete an automated analysis of all of the possible matches.

A number of models and procedures have been developed to overcome these issues while maintaining as high a match rate as possible. The first, addressing the issues identified by Antonie et al., is known as *blocking*. Blocking reduces the number of possible pairs by assigning an absolute clause to the match algorithm. For example, Antonie et al. used the first letter of the last name as well as birthplace. So thus, only someone with the same birthplace *and* first initial would be included in the subsequent analysis that looks for potential matches. There is no accepted standard for blocking, as the determination of good blocking is the careful balance between a high match rate and the accuracy of the matches, and this varies with the data sources being matched. For example, Ruggles (2002) used state of birth, race, and gender, while his colleagues from the Minnesota Population Center used only race and gender in their study (Goeken, et al. 2011). In this study we are record linking a sample of workers created in the previous chapter, derived from a combination of the 1881 census of Canada and local city directories, to their corresponding records in the 1891 census and directory. Since we are interested in the changing journey to work and residential environments of workers, we blocked first on geography, limiting our matched sample only to those who persisted in London over the decade.

The most researched procedure in historical census linking is related to *name matching*. It is recognized that names are not unique; however, they are the most unique of any individual characteristic in the census. Some researchers, such as Dillon (2002), have struggled with the linguistic differences found in Canada's early censuses by separating French and English surnames into two groups prior to attempting to link across censuses. To facilitate name matching researchers have adopted the use of a range of phonetic algorithms such as Soundex, NYSIIS, and Double Metaphone. Each one uses a different set of rules to convert names into an alpha-numeric code based on the phonetic composition of the name (see Elmagarmid, Ipeirotis and Verykios (2007) for a review). This indexing of names allows for quicker processing and potentially greater matches across datasets. Most early attempts at automated record linkage used one of these phonetic algorithms to help with issues related to misspellings and poor transcription, which are an unfortunate reality of working with historical censuses. Later projects, including those of the MPC and Antonie et al. (2010) at the University of Guelph, have begun using Jaro-Winkler distance algorithms to improve name and birthplace matching. Rather than convert a string into a pre-set alpha-numeric code as phonetic algorithms do, Jaro-Winkler measures the similarity between two strings (number of like characters) as well as measuring the distance between characters in each potential link set. Additionally, rather than having a binary result of 'yes' or 'no' to a potential name match, Jaro-Winkler creates a probability score ranging from 1, a direct match, to 0, or highly unlikely.

Similar to the probability metrics used in Jaro-Winkler, the most sophisticated researchers have started using probabilistic record linkage rather than the deterministic

methods used in the field's infancy. Unlike deterministic methods, where a set of rules are created to allow for a positive match, probabilistic methods use weights as well as support vector machines (algorithms that analyze data and recognize patterns) to teach the software what positive matches typically look like between the two datasets (Goeken, et al. 2011). This allows for the creation of 'fuzzy' matches that can then be interpreted by the knowledgeable scholar for validity. To our knowledge, no literature exists to support which algorithm (deterministic or probabilistic) is best suited to particular historical sources. For our case study of the journey to work in London, we employ a probabilistic record linkage approach and complete several passes across the dataset, adjusting weights each time after manually reviewing possible linked pairs.

5.3.1 Preparing Data for Record Linkage

To overcome some of the issues outlined above while maintaining as high a match rate as possible, it is necessary to first prepare data for use in a probabilistic record linkage software. Although it has not always been outlined in explicit detail in other studies, this procedure is critical when working with historical data, as it helps overcome both transcription error and short-hand notations that were widely used in non-digital census enumerations (Winchester 2002 is a notable exception). As our interest in this study is the relationship between the journey to work and environmental change, we need to first isolate only those individuals for whom we have positive links between home and work in both 1881 and 1891. The procedure of creating these links is outlined in Lafreniere and Gilliland (Forthcoming), known as chapter four in this dissertation. As previously reported for 1881, this resulted in a sample of 5081 workers; when the same

procedures were run for 1891, the result was a sample of 7956 individual workers. These two samples, when record linked will represent our *worker sample* used in this study.

As is necessary with most large projects, transcription and digitalization of data was performed by different groups of researchers. The worker sample was extracted from the 1881 100% count of the census provided by the 1881 Canadian Census Project, led by Lisa Dillon (U Montreal) with researchers from the Church of Jesus Christ of Latter-day Saints and the Institute of Canadian Studies at the University of Ottawa (Dillon 2000). The 1891 worker sample was extracted from a 100% sample compiled by the Historical Data Research Unit at the University of Guelph with assistance from the Minnesota Population Center. City directories for London were transcribed and coded primarily by student researchers in the Human Environments Analysis Lab in the Department of Geography at Western University, numbering several dozen over the course of nearly ten years. With such diversity comes the need to clean and standardize data for record linkage. Simple transformations, such as spelling, punctuation, and the treatment of initials, need to be considered but are relatively easy to standardize. Nicknames or short forms for first names are more problematic, as is age (revisit section 4.6.1 for details on overcoming issues with first names).

It is generally agreed that ages recorded in early censuses are unreliable with rounding to the nearest 0 or 5 common (Knights 1971, Mason and Cope 1987, Steckel 1991), yet there is no agreed-upon standard approach to dealing with the age variable. Hershberg, Burnstein and Dockhorn (1976) were the most generous in assigning weights, giving credit to links where individuals' reported age increased anywhere between 2 and 18 years between decennial censuses. Katz (1975) was similarly generous, with a

variance of ± 9 years still receiving consideration. Goeken et al. (2011) and Ruggles (2002) both accepted ± 7 years, while Antonie et al. (2010) and Olson and Thornton (2011) only accepted a tolerance of ± 2 years from the expected age. After several trial passes and observing how known matches were treated, we limited matches to ± 3 years, with significantly higher weights given to those within ± 1 year (Table 5.1).

Variable	Match Weights
Last Name	Jaro-Winkler Variable Exact Match: 7.5 Phonetic Match: 6
First Name	Exact Match: 5 Phonetic Match: 3 Nickname Match: 3
Gender	Exact Match: 1 Disagree: -1
Age	± 1: 8 ± 3: 5
Occupation	Exact Match: 2
Birthplace	Exact Match: 5

Table 5.1 – Match Weights Used to Record Link 1881 Worker Sample to 1891 Worker Sample

5.3.2 Record Linkage Results

To record link workers from 1881 to 1891, we employed a semi-automated approach to record linkage. A semi-automated approach allows the researcher, who has an intimate knowledge of the database, the population it represents, and its nuances, to review the matches and make necessary adjustments, all the while still benefitting from the techniques and algorithms provided by an automated approach. We began by harnessing the capabilities of a customized version of LinkageWiz, software that allows

for probabilistic record linkage of large datasets (LinkageWiz, 2011). Figure 5.1 outlines the workflow used to record link these two datasets. As our concern was not to record link the entire population, but only our sample of workers, we started with the linked city directory-census database outlined in chapter 4. This sample had already been blocked to only include those who lived in London or the surrounding suburbs. We further blocked using a Jaro-Winkler variable weight on the individuals' last names. Weights were then assigned for each variable as outlined in table 5.1. A minimum matched pairs retention threshold (MPRT) score of 10 (*s*-10) was needed for matches to be considered on a first pass. This first pass group only includes individuals with Jaro-Winkler scored similar last names and one additional variable other than gender (or two if occupation was matched). Accurate record linkage requires a reflexive approach, where researchers intimately familiar with not only the dataset, but the local geography, history, and economy, review each linkage run before discarding possible matches. After review, the dataset was run again with a minimum first name score of *s*-3 required, as this eliminated false matches that met the threshold of *s*-10 because of similarities in combinations such as last name and birthplace (*s*-12.5), last name and age (*s*-10.5-15.5), or last name, occupation, and gender (*s*-10.5). The second run MPRT was set at 7.9, with the last name weight not included and age reduced to 5 for a ± 1 year match and 2 for matches ± 3 years. This demanded that a minimum of two additional variables matched before the pair was considered for linking. The matched pairs were manually reviewed and the results joined in ArcGIS to each of their respective original 1881 or 1891 shapefiles.

The result is a geographically-referenced linked dataset of 1209 workers from 1881 to 1891, each with absolute links between home and workplace. Caution must be

taken when comparing match rates between studies, as each utilizes different source material and sampling strategies—or a 'different universe' (Dillon 2002, Ruggles 2002). There is a need to examine differing record linkage methods with like data samples—an aim outside of the scope of this research, but an area we hope to contribute to in the near future. For consideration, the match rate we captured is higher than that reported by Antonie et al. (2010), similar to that reported by Hershberg, Burnstein and Dockhorn (1976), but lower than the 39% rates captured by Darroch (2002). This is largely due to differing universes; ours is restricted by geography and work status, a rather restrictive universe, whereas Darroch was working with a sample across a much larger region. Although robust, our 24% link rate of the 1881 population does suffer from omissions. First, Ruggles (2002, 217) reminds us that forward-linked samples, such has our desire here, are more challenging than backwards-linked ones because of the effects of mortality and emigration. Our sample here suffers from these challenges, as well as losing individuals who left paid employment. We also miss young adults, who were under working age in 1881. For women, name changes due to marriage limit our ability to match across decades. Despite these omissions, this linked dataset will permit us to complete the first (to our knowledge) historical journey to work study that views the same population over time.

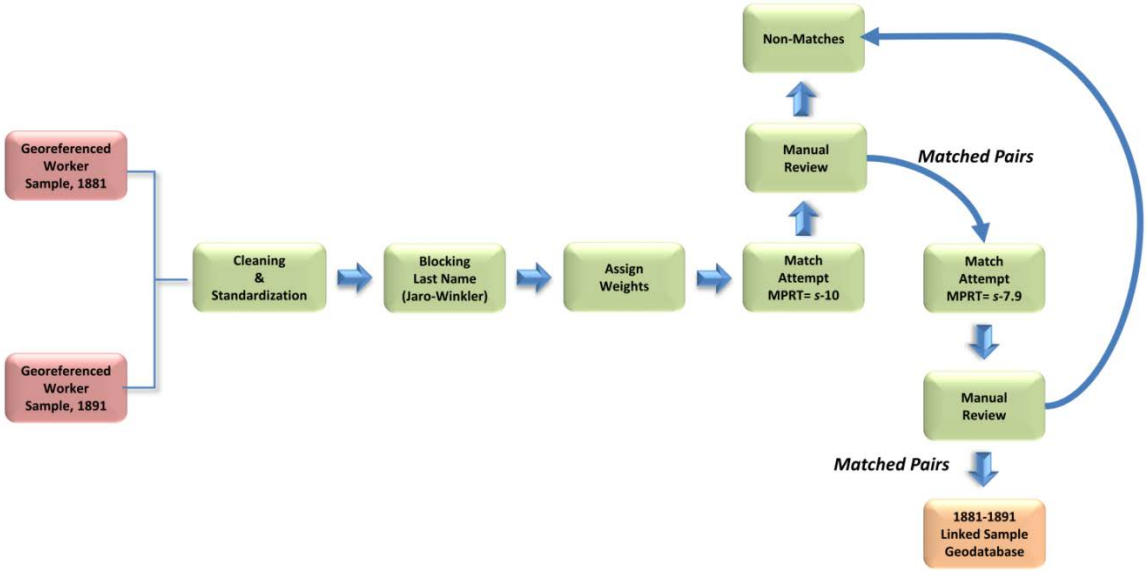


Figure 5.1 – Record Linkage Procedure

5.4 RESIDENTIAL, OCCUPATIONAL, AND WORKPLACE MOBILITIES

The study of the journey to work is fundamentally about the spatial relationship between home and work. We are reminded that residential mobility in the 19th century city was higher than it is today, with families and individuals constantly changing their residence due to changes in family composition, social status, or access to work (Gilliland 1998, Gilliland and Olson 1998, C. Pooley 1979). Studies of job or workplace mobility are dwarfed by the ubiquitous interest among social historians in the extent of occupational mobility. Led by the pioneering work of Curti (1959) and Thernstrom (1964), occupational mobility, or the ability to move to an occupation with a higher wage, has been the primary indicator used to measure an individual's upward social mobility. Meanwhile economic historians have not exhibited much interest in workplace

mobility, but instead have focused on the duration and drivers of individual job tenure, noting that industrial jobs during the late nineteenth-century were brief, citing that high labour mobility was an indicator of the 'tenuousness of the employment relationship and fluidity of the labour market' (Jacoby 1985, 36-37, Jacoby and Sharma 1992) These separate but complementary areas of scholarship all agree that individuals were mobile, constantly changing the relationship between home and work. Despite this agreement, the study of the changing relationship over time has received little attention, other than anecdotal cases about individuals (Pooley and Turnbull 1997, Ulrich 1990) or studies limited to employees from one workplace (Green 1988, Hoskins 1989).

5.4.1 Residential Mobility

To understand the changing relationship between home and work, we must first examine the rate and intensity of residential mobility. In London, we observe high residential mobility, similar to that reported for other Canadian cities during the same period. Of our sample, 74.4% (n=900) of workers were living in a different residence ten years later. The moves varied in intensity or spatial separation, from moves as close as across the street, to substantial moves of over four kilometres (Figure 5.2). Similar to the pattern found by Gilliland (1998) for Montreal, most moves were short, with a median Euclidean distance of 741m. The distances moved over the decade vary by the size of the household. We see a strong effect of the age of the household head on the distances of residential moves, with the distances decreasing as age increases (Figure 5.3). An increase in median distance moved is noted during the traditional years of retirement, likely indicating moves into residences of kin or to secure a residential environment more suitable to an individual with more limited personal mobility.

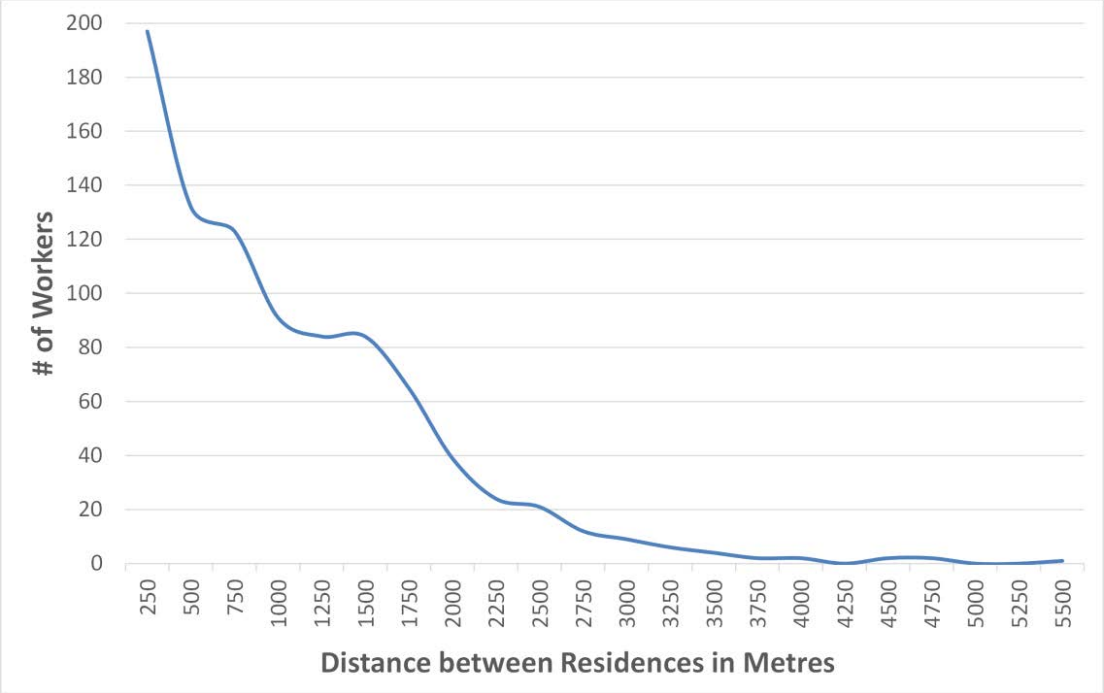


Figure 5.2 – Distance of residential moves from 1881 to 1891

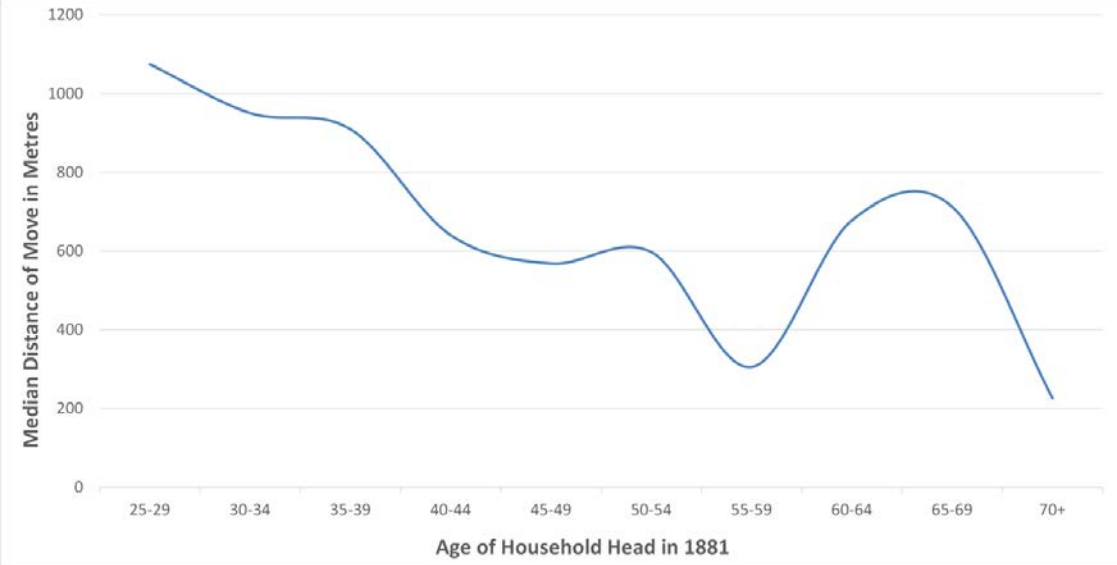


Figure 5.3 – Distance of residential moves from 1881 to 1891 by Age of Household Head

The effect of household size is less pronounced than the age-effect, but is still visible. The smallest and largest households moved greater distances as a response to socio-demographic changes (Figure 5.4). Small households were comprised primarily of young workers or widowed individuals who lived on their own. Over the course of a decade, both transitioned into midsized households, the younger adding children and the widows often taking residence with younger kin. These mid- to large-sized homes were located largely in the city's emerging neighbourhoods, further from the established neighbourhoods from which the families moved. Those in the largest households were generally young as well, living in boarding houses or residential hotels in the city's core. They were largely employed by the very hotels they lived in, as housekeepers, cooks, and barbers. The hotelkeepers themselves are found in this group, as well as individuals who worked at downtown factories such as Perrin's biscuit company or McClary's foundry. Ten years later, many of these individuals were living in small dwellings with families or had moved to smaller boarding houses in London East to take employment in one of the factories there. This pattern is consistent with that observed by Dunae et al. (2013) for a similar population of residential hotel dwellers in Victoria.

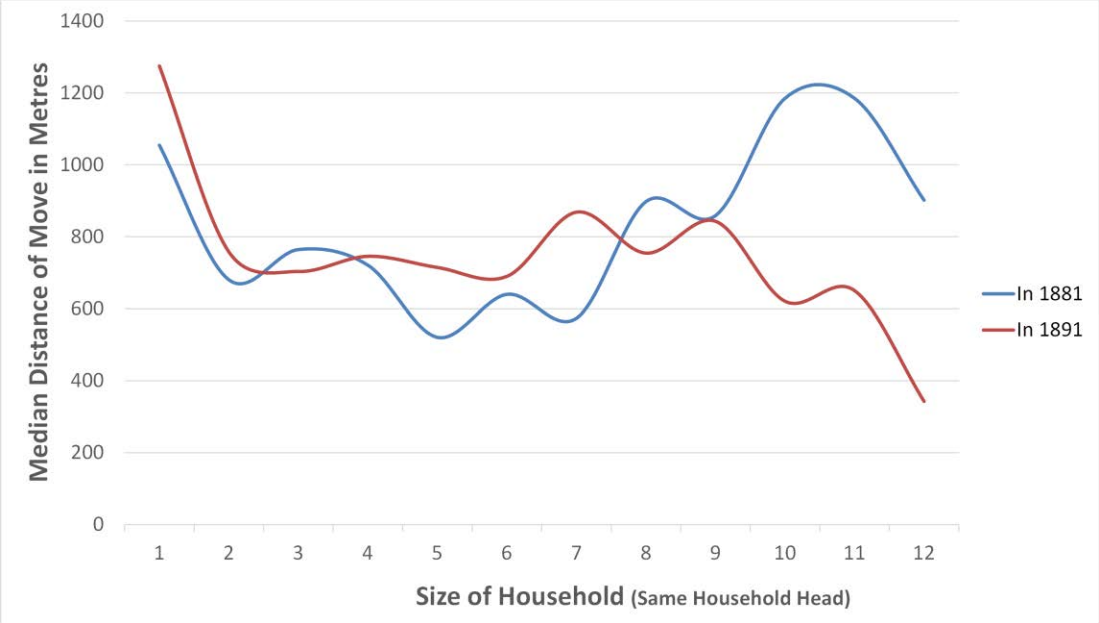


Figure 5.4 – Distance of residential moves from 1881 to 1891 by Household Size

Of particular interest to this larger study, we observe that moves vary based on occupational class. Significant differences are found between higher and lower class workers (Figure 5.5). Higher class occupations such as merchants, manufacturers, and professionals had the shortest distance moves on average (median). A sharp increase is noted for the middle classes. Labourers moved shorter distances than their middle-class counterparts, whereas servants had the longest moves, with a median distance of over 1100m.

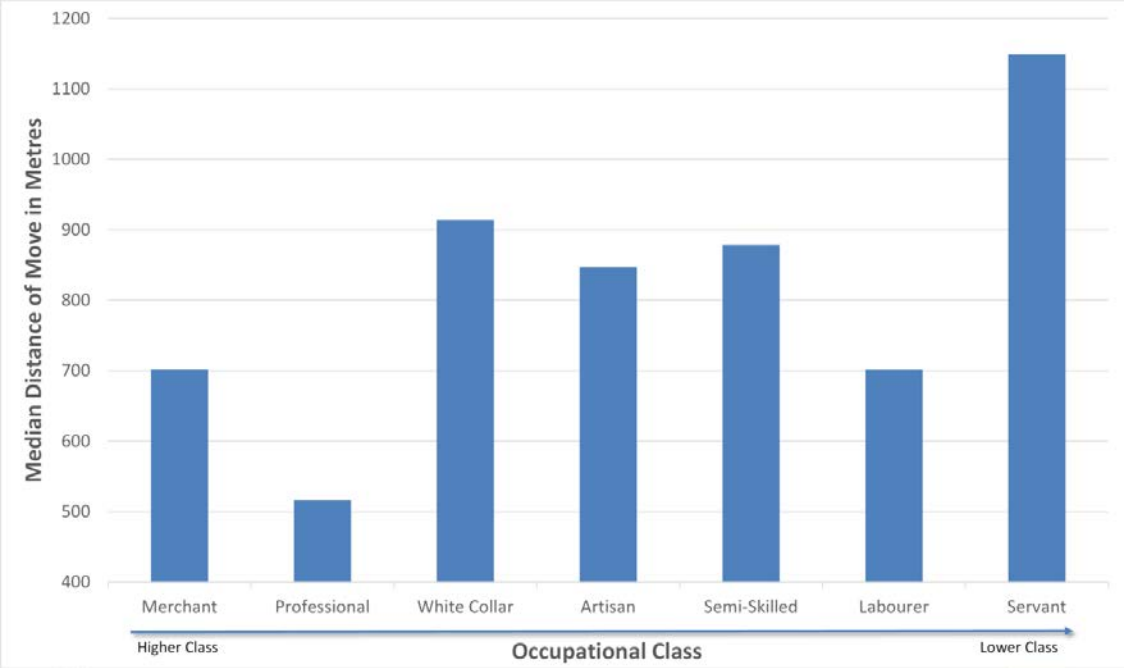


Figure 5.5 – Distance of Residential Moves from 1881 to 1891 by 1881 Occupational Class

The directionality of the moves presents a clearer picture. Figure 5.6 outlines the linear directional mean of the moves by occupational class. The linear directional mean is calculated by first obtaining the average distance of moves, by measuring the Euclidean distance between origin and destination for each individual. The directional mean of the lines is then calculated by statistical comparison of X and Y coordinates of the origin and destination points and the trend presented on a street map. The length of the line represents the mean distance between origin and destination. From inspection of the map, we discover that many of the upper-class workers (merchants and manufacturers, professionals, and white collar) moved into the wealthy near north neighbourhood of Woodfield. Woodfield sits north-east of downtown and abuts Victoria Park, at the time the city's largest public space. Today, Woodfield is designated as two

heritage conservation districts (West and East Woodfield) to help preserve the eclectic mix of Victorian architectures that adorn the neighbourhood (Figure 5.7). Many of the homes in what has been dubbed the 'Greatest Neighbourhood in Canada' were built by the individuals we are examining in this study (Canadian Institute of Planners 2012). We also see that servants, the lowest occupational class from Figure 5.6, followed their employers. They took residence in small, scattered cottages at the edge of the city's northern development, north of the present day CP Rail line on streets such as Pall Mall, Maitland, and Miles. The middle classes of artisans, semi-skilled, and labourers moved further eastward into the rapidly growing suburb of London East (which was amalgamated into the city in 1885). Carpenters, blacksmiths, painters, and rail-workers moved into the village to work at the oil refineries, rail yards, and car shops that were built in the southern portion of the community. They occupied modest, well-appointed homes, mostly Ontario cottages or homes built in the Queen Anne style, on streets north of Dundas, such as Dufferin, Lorne, and Princess. Known today as Old East Village, this thriving neighbourhood of past and present wage-workers has also been designated a heritage conservation district (Figure 5.8)

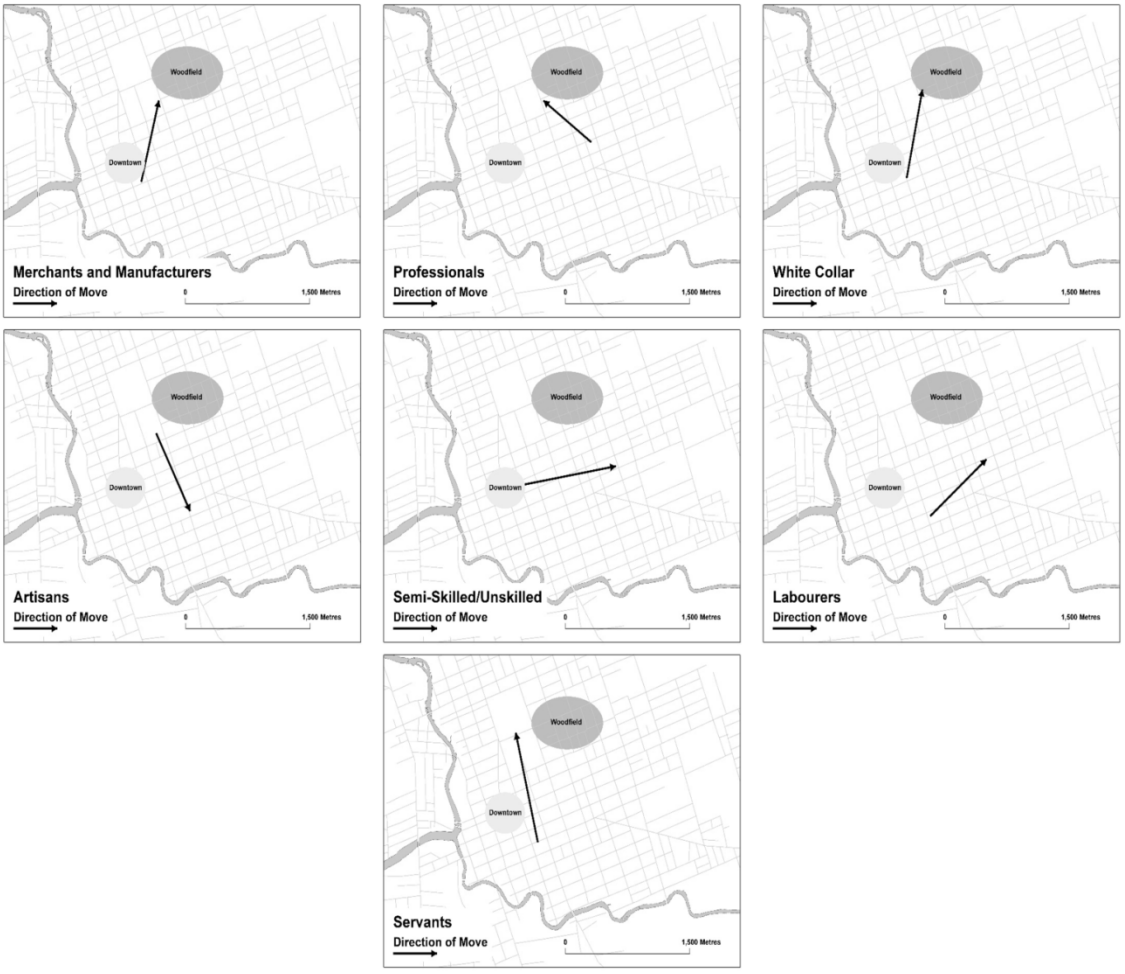


Figure 5.6 – Linear Mean Direction and Distance of Moves by 1881 Occupational Class

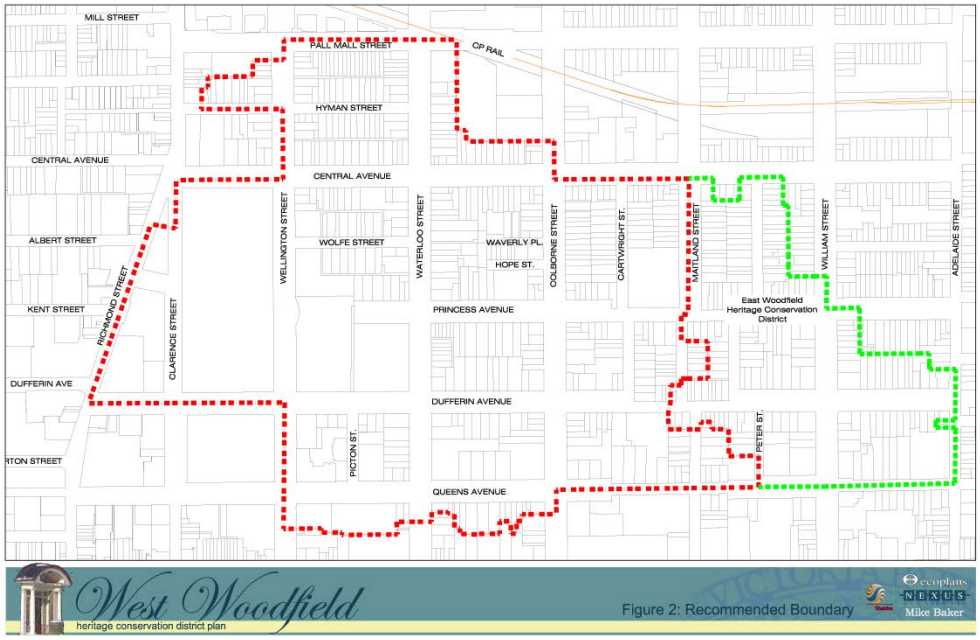


Figure 5.7 – Woodfield Heritage Conservation Districts 2008
(Source: *West Woodfield Heritage Conservation District Plan, 2008*. Stantec Consulting Ltd.for the City of London, Ontario)

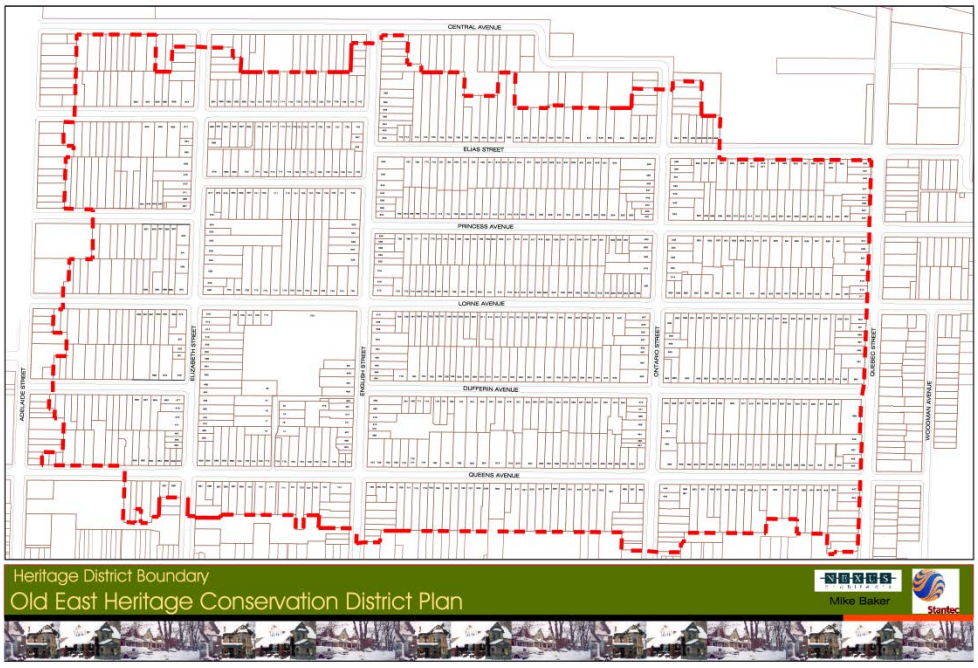


Figure 5.8 – Old East Village Heritage Conservation District 2008
(Source: *Old East Village Heritage Conservation District Plan, 2006*. Stantec Consulting Ltd. for the City of London, Ontario)

5.4.2 Occupational Mobility and Job Tenure

In studies of nineteenth century populations, occupational mobility has been widely used as a proxy for understanding social mobility. This is largely due to the gulf of primary sources available that provide actual wages for large numbers of individuals. This study is limited by the same lack of material and so we employ a method similar to most other studies. We apply the modified Darroch and Ornstein (1980) occupational class scheme (see Table 4.5) to our sample workers' 1881 and 1891 occupations. The result is a snapshot of social mobility across the decade. This view provides us a baseline understanding of the relationship between social mobility and the changing journey to work, an understanding we develop further in section 5.6.

Figures 5.9 and 5.10 illustrate the results of our brief look at occupational mobility for those in our population sample who did and did not change residence between 1881 and 1891. For those who changed residence, we observe that nearly three-quarters (74.6%) of the workers were not occupationally mobile, staying within the same occupational class. The remaining 25% of the workers were not exclusively upwardly mobile: 11.3% of the workers were downwardly mobile, moving down the occupational ranks over the course of the period. A slightly higher number were upwardly mobile (14.1%), moving into higher classes of occupations. Surprisingly, those individuals who were not residentially mobile (did not change homes over the decade) saw the same aggregate rate of occupational mobility as those who were residentially mobile. There was a slight trend (3%) towards being more upwardly mobile for those who stayed at the same residence, but this variance is minor.

Occupational Class	Upward Mobility	Not Mobile	Downward Mobility
Merchants & Manufacturers (1)	N/A	75.2%	24.8%
Professionals (2)	4.8%	80.2%	14.8%
White Collar (3)	22.4%	59.0%	18.7%
Artisan (4)	13.3%	81.4%	5.3%
Semi-Skilled/Unskilled (5)	30%	64.2%	5.7%
Labourer (7)	35%	50.0%	14.6%
Servant (8)	14%	86.5%	N/A

Figure 5.9 – Percentage of Occupational Mobility 1881-1891 by Direction and Occupational Class

Residential Mobility is Present

		1881						
Occupational Class		1	2	3	4	5	6	7
	1	11.1%	0.4%	2.4%	3.9%	0.3%	0.1%	0.0%
	2	0.8%	7.2%	0.9%	1.3%	0.1%	0.3%	0.2%
	3	0.8%	0.2%	8.8%	0.9%	0.4%	0.4%	0.2%
1891	4	2.1%	0.7%	1.7%	37.4%	0.9%	0.8%	0.1%
	5	0.0%	0.1%	0.4%	0.6%	3.8%	0.2%	0.0%
	6	0.0%	0.2%	0.2%	1.4%	0.1%	2.7%	0.0%
	7	0.0%	0.1%	0.4%	0.4%	0.2%	0.8%	3.6%

Downward Mobility	No Mobility	Upwards Mobility

Residential Mobility is <u>Not</u> Present

		1881						
Occupational Class		1	2	3	4	5	6	7
	1	15.8%	0.0%	3.6%	3.9%	0.3%	0.0%	0.0%
	2	1.0%	6.6%	1.0%	0.0%	0.0%	0.3%	0.0%
	3	0.0%	0.0%	11.5%	2.3%	0.7%	0.3%	0.0%
1891	4	2.3%	0.0%	1.3%	32.6%	1.3%	2.3%	0.3%
	5	0.0%	0.0%	0.0%	2.0%	2.3%	0.3%	0.3%
	6	0.7%	0.0%	0.3%	0.7%	0.3%	3.6%	0.3%
	7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.6%

Downward Mobility	No Mobility	Upwards Mobility

Figure 5.10 – Occupational Mobility by Occupational Class, 1881-1891, by Residential Mobility, Percentage of Individuals

When we observe mobility across the occupational classes we note that as a group, labourers were the most mobile, with 35% showing upward mobility and nearly 15% downward mobility into the servant class (Figure 5.9). The servant class was the least mobile, a pattern that is similar to that noted in the social mobility literature. The two upper classes were generally not mobile either, maintaining their position at the top

of the social hierarchy. It is interesting to note, however, that the amount of mobility between the merchant class and the artisan class is rather high, with 13.3% of artisans moving upwards into the top class and nearly a quarter of merchants and manufacturers moving downwards. Upon further examination, we see that most of the individuals who moved down the occupational class scheme were owners of small- to mid-sized businesses who later went to work for one of the larger industrial operations in the city. For example, John Fleming, owner of an axe factory in 1881, was found ten years later widowed and working as an engine man for the large Forest City Machine Works. Another, John Murphy, a grocer in 1881, became a box maker at Fleischmann's paper company. We see the reverse experience in the group of workers who were upwardly mobile into the merchant class. Workers left industrial employment to start small shops within the same industry in which they were previously working, often in partnership with other artisans. We must remind readers that observing occupational mobility through the use of coded occupational titles (such as the North American Population Project HISCO codes used in this study) does present challenges, as the ability to calculate changes relies on the proper coding of occupation titles into the appropriate groups. The meaning and nature of work associated with any given occupational title changes over time, and some of the mobility we uncover may be an effect of these changes.

Job tenure in London was remarkably high. We estimate that 34.8% of workers who were employed outside of the home were employed by the same firm ten years later. This is higher than the estimates of 26.9% reported by Carter and Savoca (1990) for San Francisco. Whether someone had changed employers is not a simple determination. As

the primary concern of this study is the changing relationship between home and work, we briefly examine job tenure along lines of residential and workplace mobility. We view job tenure as whether a worker is travelling to the same *worksite* in 1891 as they were 10 years earlier in 1881. We employ this approach to overcome the issues of changing employers' names, which was common during this period. Many companies changed from surname-based monikers to less personalized descriptions; for example, John Elliott & Son's Foundry became Phoenix Foundry and E. Leonard and Sons became London Engine and Boiler Works. We are uncertain if these name changes were in everyday use or if city directory enumerators began to formalize the titles of the firms they recorded. To determine if an individual was working at the same worksite, we compared the latitude and longitude in both time periods, providing a modest buffer of 50m for geocoding differences in the two datasets. For a study of job tenure, this is imperfect, as it does not account for individuals who stayed with the same employer but either the employer changed location or they took up a position at a different worksite operated by their employer. For a study of the changing journey to work, however, it is essential. Reviewing our sample of job tenure, we observe an expected pattern: the sample of workers who did not move had a higher percentage of decennial job tenure than did those who did move over the period (Table 5.2). What is of interest is that the differences were not great, 32.8% for those who were residentially mobile versus 40.8% for those who were not. Home-based job tenure was expectedly higher for the non-residentially mobile group versus the residentially mobile group.

Same Residence		n= 309
		n= Percentage
Same Workplace		
	Home-Based	42 13.6%
	Outside Home	126 40.8%
	Total	168 54.4%
Different Workplace		
	Outside Home	107 34.6%
	Home-Based to Outside Home	20 6.5%
	Outside Home to Home-Based	14 4.5%
	Total	141 45.6%

Different Residence		n= 900
		n= Percentage
Same Workplace		
	Home-Based	69 7.7%
	Outside Home	295 32.8%
	Total	364 40.4%
Different Workplace		
	Outside Home	394 43.8%
	Home-Based to Outside Home	90 10%
	Outside Home to Home-Based	52 5.8%
	Total	536 59.6%

Table 5.2 – Changing Home-Work Relationships

5.4.3 Changing Home-Work Relationships

We have established how workers in London were residentially and occupationally mobile and considered the lengths of their job tenure. What we have yet to review is the extent of workplace mobility that was present over the period. Workplace mobility is the critical missing link to completing our understanding of the changing relationship between home and residence and its corresponding effect on the daily journey to work, an area that, to our knowledge, has never been studied before using the same population over time. Table 5.2 outlines the changing relationship between work and home for our sample of 1209 workers in London. We observe that for those that were residentially mobile, nearly three out of five (60%) changed their workplace. More than two out of five (43.8%) worked outside of the home in both periods, where another 15% of workers had shifted their employment either into or out of their homes. For the remaining 40% of residentially mobile workers, the vast majority (82%) continued employment outside the home and a small cohort moved residences and maintained home-based employment. As we might expect, this cohort of home-based workers is smaller than the cohort of home-based workers who were not residentially mobile. We see a 14% difference in workplace persistence between the residentially mobile and non-mobile groups. These patterns reinforce our notion that relationships between home and work are complex and appear in various configurations.

In the aggregate, the average commute for all workers in the city in 1891 was 1305 metres (the median was 1216m). This is 22% longer than the average commute a decade before. The change can be largely attributed to the continued suburbanization of the city, especially to the north and east. The continued establishment of new factories in

London East drew workers to commute longer distances in order to secure jobs, many of whom either elected not to move or did not have the means to do so. The average for our sample of 1209 workers whom we have record linked across time is similar to, but slightly shorter than, the overall average (1206m vs. 1305m). When we view our sample across time, we see that journeys increase across every occupational class except for servants, which stayed the same (Table 5.3). Caution must be taken, however, when reporting the changing journey to work of aggregated groups over time because the groups themselves are not comparable. The professionals reported for 1881 in Table 5.3 are not all the same individuals in 1891 because of changes in occupational class. Only absolute demographic characteristics, such as gender and age can be accurately compared across time. As our larger concern in this paper is the relationship between changes in residential and neighbourhood environments and the journey to work, we will move to consider how these changed were experienced at the scale of the individual.

Occupational Class	Median 1881 (km)	Median 1891 (km)
Merchants/Agents/ Manufacturer	.86	1.16
Professional	1.04	1.32
White Collar	1.07	1.15
Artisan	.98	1.05
Semi-Skilled & Unskilled	.89	.98
Labourer	.98	1.14
Servant	.19	.18

Table 5.3 – Linked Worker Sample Journey to Work 1881-1891 by Occupational Class

As we outlined earlier, a near limitless combination of factors influences an individual's decision to change either their residential or workplace situation. To illustrate this complexity and its effects on the journey to work, we look closer at two individuals who represent the two largest groups in our sample.

Ira Collins, a 27-year-old harness maker, represents the largest group, those individuals who were residentially mobile and changed their workplace location over the course of the decade. In 1881, Ira lived on York Street, near Rectory Street, in the Village of London East with his wife Mary Jane and his three-year-old son Russell (Figure 5.12). He had a below-average commute of 858m to work each day at Globe Agricultural Works, where he was a saddle and harness maker. In 1891, at the age of 37, we find Ira and the rest of his family living across town on Clarence Street, near Horton Street. He is now employed as a yard man in the Grand Trunk Rail Grounds in London East making repairs on the wooden slats and doors on rail cars. His commute has increased 50% to nearly 1,700 metres. This would have been an increase of over ten minutes if we assume that individuals walk an average of 5 kilometres per hour, though it must have been much longer at times in the winter, when having to trudge through heavy snow. What caused this significant increase in Ira's daily commute?

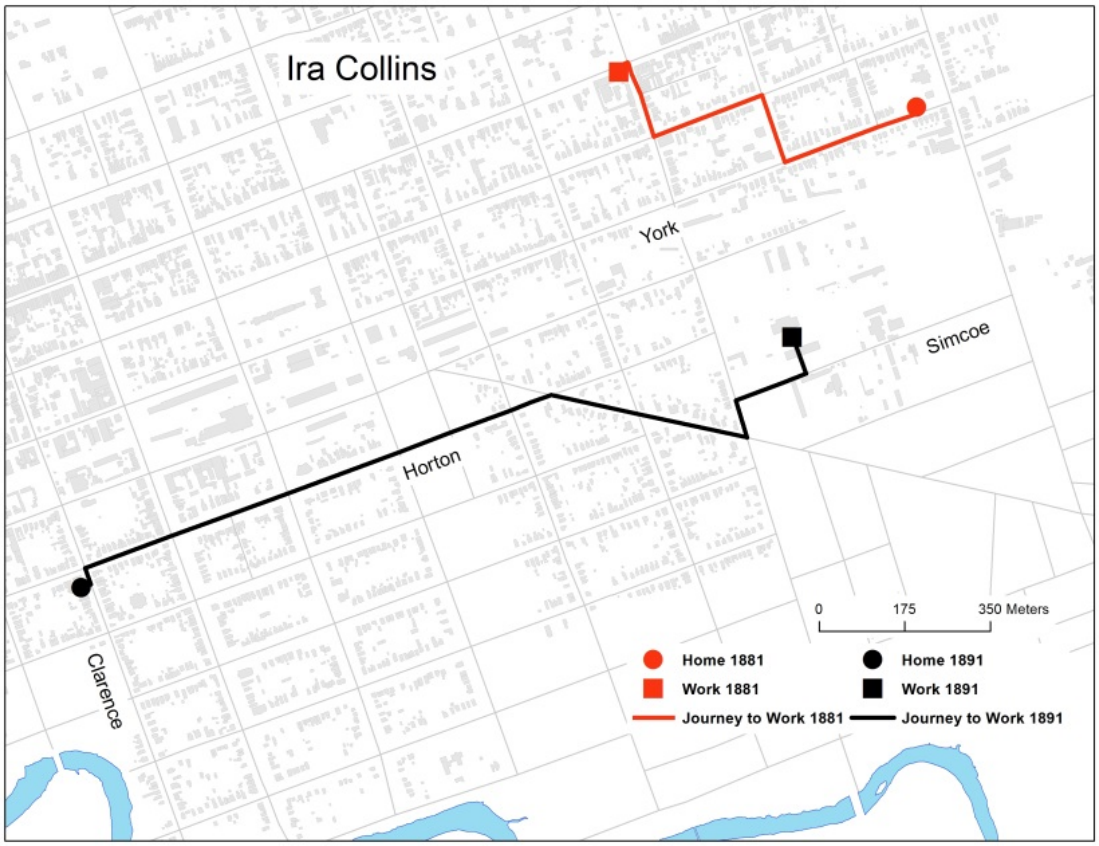


Figure 5.12 – The Changing Journey to Work and Residence- Ira Collins

Amelia Miller, a 24-year-old elementary school teacher, represents the second largest group, which includes those individuals who were residentially mobile but did not change workplace location over the course of the decade. Amelia was of Irish descent, but born in Ontario in 1857. In 1881, Amelia lived on Waterloo Street, at the eastern edge of downtown, renting a room in a house owned by the widowed Mary Dempster (Figure 5.13). Mrs. Dempster may have opened her home up to renters to help support herself after her husband Robert died. Also in the home with Amelia was her older sister Anna (26), and Isabella Quinn, a dressmaker. Amelia commuted just over 1600m each day to teach grade 7 at the Talbot Street School and had an income of $350 a year (we established her income from a database built for another project on the changing journey

to school [Board of Education for the City of London, 1891]). In 1891, at the age of 34, we find Amelia still teaching grade 7 at the same school. However, instead of a long commute, we find Amelia living 71% closer to work, residing in a boarding house on Kent Street only 463 metres from the school. Her income is now $450 a year, but she is living with seven other individuals rather than the four she did a decade before. The boarding house is run by Grace Heron, the oldest of the four Heron siblings who live together in the home. Her brothers George (41, a travelling salesman) and James (34, cabinetmaker), as well as her sister Maggie (35, no occupation listed—she likely helped run the house) share the living space with 26-year-old Mary Austin, a housekeeper at the Grigg House, young William Geary (22, an assistant druggist), and Amelia.

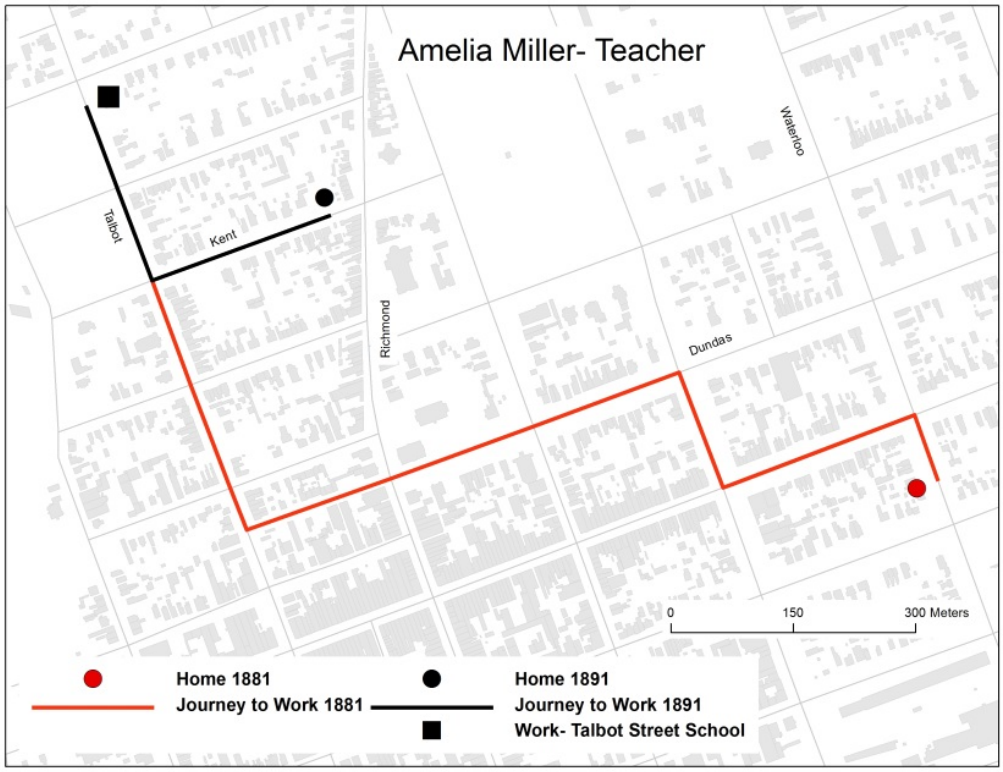


Figure 5.13 – The Changing Journey to Work and Residence- Amelia Miller

It appears that Amelia may have moved to shorten her long journey to work. However, it is also possible that she wished to secure accommodations with similarly-aged people, that the relationship with Mary Dempster went sour, or perhaps she sought a living situation that included both men and women. After moving, however, she shared a house with more people; was the consequence less living space, and greater crowding? What about the environment outside the front door? Was the Kent Street location a more appealing residential environment than Waterloo Street? Did it better represent her social status as a white collar worker? Did it suggest that she was of an even higher class? As for Ira, did he choose to move to a different neighbourhood? Or was he forced to leave his home in London East because of fire or financial difficulties? Did he lose his job at Globe Agricultural Works, or did he seek a new job with the G.T.R.? Was he seeking a better physical or social environment for his family? Some of these questions we cannot answer without detailed personal or business records. We can, however, harness the built environment stage in the HGIS to examine Ira and Amelia's residential and neighbourhood environments over time to glean a different perspective on why individuals may have changed their residential and workplace environments.

5.5 CAPTURING HISTORIC ENVIRONMENTS

When a family moves, a number of factors go into the decision of where to live. A family must tread a careful balance between finding a home that meets their space requirements, and is in a neighbourhood that is desirable to their lifestyle, all while keeping within their budget. When a life event requires a family or individual to move or change workplaces, it is also an opportunity to try to better their residential and/or

neighbourhood environment. If the family has had a stable residence for many years, a move opens an opportunity to update the environment to better reflect the needs of the family at its present stage in their lifecourse. Furthermore, moving into an environment of greater quality is a public reflection of upward social mobility.

To begin to understand how families and individuals in the nineteenth-century city attempted to improve their residential situations, we must look at two of the environments that closely influenced the quality of daily life for the individual: the residence and the neighbourhood. Figure 5.14 illustrates the environmental indicators used to determine the quality of residential and neighbourhood environments. The home or residential environment is determined by the characteristics within, and of, the residential dwelling. It is the finest scale of spatial resolution at which we can study the built environment of the city. It includes the socio-demographic environment within the home, which for families is generally homogeneous with the household head, but for individuals living in boarding houses, residential hotels, and institutions, we use the individuals' occupational class ranks. Living space per person provides us an indication of crowding in the home, which is generally seen as a negative environmental factor. High levels of crowding in nineteenth-century cities have been correlated with increases in conflagrations, disease, crime, and in extreme cases, higher mortality. Building material is typically used as a proxy for property condition or solidity. In London, most of the homes were made from either wood or brick, with brick being considered superior, especially during the late nineteenth century.

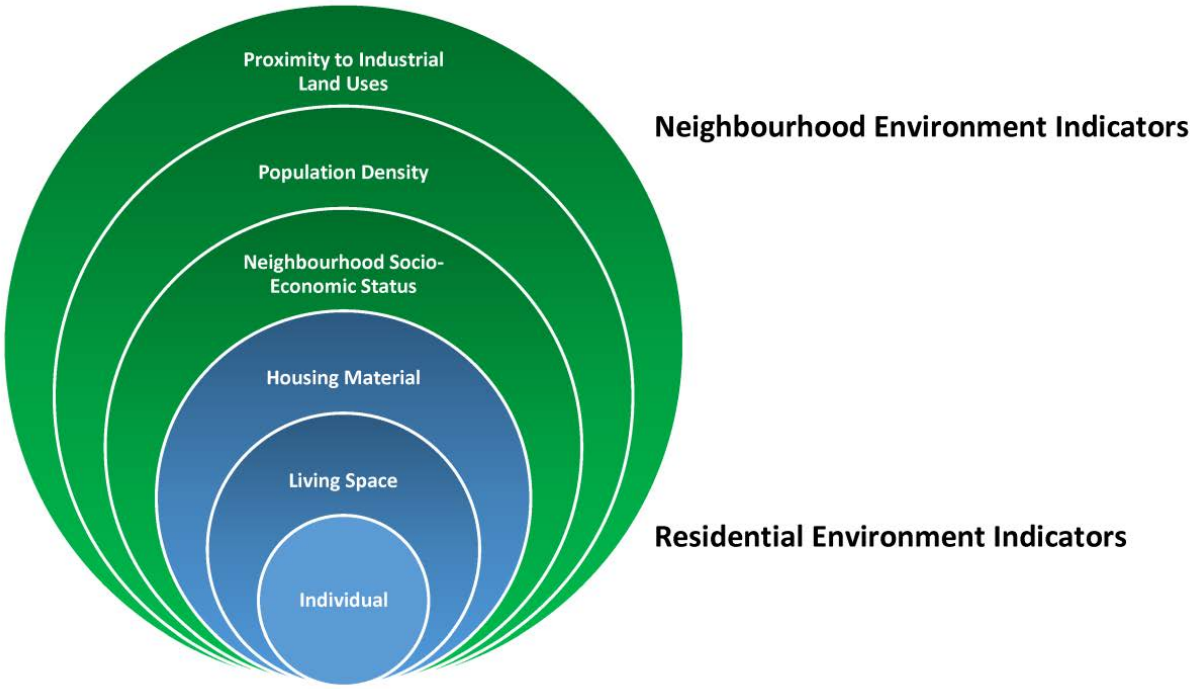


Figure 5.14 – Multi-Scaled Environmental Indicators Used to Determine Quality of Residential and Neighbourhood Environments

To examine the quality of the neighbourhood, we created three environment quality indicators. At the finest spatial scale is the socio-economic status (SES) of the neighbourhood. We use this indicator to gauge if an individual has moved up into a 'better' neighbourhood than they lived in a decade prior. The neighbourhood SES is calculated by determining the average SES of all individuals in the neighbourhood (methodological details are outlined in section 5.5.2). We then created a unique measure of population density, one that calculates the density of the population in the immediate vicinity of the subject residence, not a population density within an arbitrary areal unit such as a census tract or postal code. In the nineteenth century city, high population density was viewed negatively, as with increased density came increases in noise and waste and decreases in public and private open space. Our last environmental indicator is

proximity to industrial uses. We calculate how close each individual was to the foul smells, noise, and pollution that emanated from the smelters, factories, and coal-powered locomotives that dominated the urban landscape in the nineteenth century. The farther from these industrial environments a residence was located, the better the neighbourhood, in general. To create these environmental indicators we returned to the environmental variables embedded within the built and social environment stages of the Imag(in)ing London HGIS (as discussed in Chapter three). The result is a recreation of historic environments at a resolution, scale, and precision never seen before in urban historical geographical research.

5.5.1 Residential Environment Quality Indicators

We created three measures that allow us to measure the quality of the residential environment, household socio-economic status (SES), crowding, and change in dwelling construction. Household SES is covered extensively in section 5.2, where we outline the changes in occupational class ranking from 1881 to 1891. To establish our crowding measure, we needed to determine the number of individuals in each residence as well as the size of each dwelling. The number of individuals per building was captured by both the 1881 and 1891 census enumerators and provided to us as a variable by the 1881 Canadian Census Project and the Historical Data Unit, respectively. Thankfully, the enumerators were instructed in the same manner for both years, allowing for ease of comparison. Enumerators were to record all individuals per building rather than recording them by family unit. To establish the size of each dwelling, we turned to the building polygons embedded in the built environment stage. Each building polygon was created by digitizing the building footprints, as depicted on the fire insurance plans. Any

information about a building was recorded as attributes for analysis, such as the number of stories, the building material, and building usage. The footprints were then run through ArcGIS's geometry tool to calculate the gross square footage (GSF) of floor space (also known in property valuation as the Gross External Area). We did not deduct for the thickness of exterior or interior walls, or the presence of unusable living space such as chimneys and circulation areas (e.g., stairs, corridors, or entrance halls), as we were concerned with relative changes rather than absolute usable space, for which estimates would be less accurate. The square footage calculated was then multiplied by the number of stories, and the crowding measure calculated by dividing total square footage by the number of individuals in the building.

The final indicator of the residential environment is the building material of each residence. This information was recorded in the building polygons embedded in the built environment stage. Of the 3886 residential buildings in the city, 2443 were constructed from wood, 1399 were made with brick, 34 were brick veneer over wood, and 10 buildings were built out of concrete. For ease of comparison, we designated the brick veneer as brick and the ten concrete buildings as wood. This limits our comparison over time to four scenarios: brick-to-brick and wood-to-wood, denoting no change in building quality, wood-to-brick being considered an improvement, and brick-to-wood the opposite.

5.5.2 Neighborhood Environmental Quality Indicators

Moving outward from the fine spatial scale of the individual residence, we created three measures that allow for the measurement of the quality of the neighbourhood environment. First is neighbourhood socio-economic status (N-SES). We created the N-

SES in order to determine if an individual moved into a 'better' neighbourhood, or a community with a higher SES than they lived in a decade prior. We know that individuals seek neighbourhoods that reflect their desired residential community, with residents who share common socioeconomic characteristics and property values (Clapp and Wang 2006). Positive social interaction with neighbours is deemed one of the top neighbourhood features that lead to a high quality of life in contemporary cities (Sirgy and Cornwell 2002), and in the walking city, where kinship and neighbourly support was perhaps more valued and necessary (Olson and Thornton 2011), we expect that the same held true. Individuals who were upwardly mobile would have sought neighbours who would reflect their increased social status. To determine an upward move, we calculated the N-SES similarly to the individual-level SES, just computed for the entire neighbourhood rather than the head of household or the individual in a group living situation. However, how do we determine someone's neighbourhood?

There is little agreement in urban social geography about how to delimit a neighbourhood. Many scholars conceptualize 'community' interchangeably with the idea of 'neighbourhood'. George Hillery provided a cautionary reminder that 'community' is indeed an area of little agreement. In a broad review of the early literature on both rural and urban definitions of community, he found ninety-four different definitions, bounded within sixteen different concepts. His summary concluded that most scholars in the first half of the twentieth century agreed that community consisted of "persons in social interaction within a geographic area and having one or more additional common ties" (Hillery 1955, 111). To Porteous, an individual's neighbourhood is the 'geographic space in which one feels at home' (1977, 68). More contemporary ideas or proxies for

neighbourhood acknowledge that neighbourhoods exist at multiple scales. A child may perceive her neighbourhood as the area immediately adjacent to her home where she is permitted to play; older children may include the streets traversed during the walk to and from school (Loebach and Gilliland 2010). For adults, 'neighbourhood' may be used to describe a former settlement that has been amalgamated into a larger urban system. Neighbourhoods are also often considered to be delimited by administrative boundaries such as school attendance districts, residential subdivisions, heritage districts, or police precincts. Postal codes and census tracts have been commonly used as proxies for neighbourhoods in contemporary research, though it is acknowledged that these boundaries are arbitrary and are not available to students of the nineteenth-century city (Wood 2002). To Mayol, the neighbourhood is the domain 'in which the space-time relationship is the most favourable for a dweller who moves from place to place on foot, starting from his home." (1998, 11) However, other scholars have highlighted that neighbourhood is socially constructed by individuals within propinquity. Porteous (1977) reports that residents perceive their immediate social neighbourhood to be as few as nine to twelve houses. Borchert (1981) outlines the importance of frequent face-to-face interaction as critical to creating a sense of neighbourhood belonging and community.

We could delimit a walking-based conception of neighbourhood such as Mayol has suggested by creating radial or street network buffers using an arbitrary buffer distance as a proxy for 'walkable' distance. Instead, we combined Mayol's conception of neighbourhood with that of Porteous and Borchert and created a conception of neighbourhood centered on the individual. We delimited neighbourhood for each

individual in the city, which means no two people have same neighbourhood. This is in line with those who conceive of neighbourhood as being socially constructed. We start at the virtual 'front porch', and delimit neighbourhood by who an individual might see as they stepped out the front door and looked across and down their street. We coin this measure a 'viewshed buffer'. These are the 'Joneses', the individuals who make up the N-SES identity that may have influenced a worker to choose that house over another.

The viewshed buffer was created for each year (1881 and 1891) by completing an origin-destination cost matrix analysis in ArcGIS's model builder. Figure 5.15 outlines the workflow of the model. It began with the complete geocoded population file extracted from the social environment stage for each of the respective years. Road and pedestrian path networks were used and the location of each individual was referenced to the closest network node. Rail lines and water bodies were added as barriers. Each individual in the city is treated as an origin and the closest X number of individuals, based on network distances, to that individual is calculated. To determine X, several buffer thresholds in each year were tested to evaluate that the spatial extent was a reasonable distance to be considered a 'front porch viewshed'. Cost matrix buffers of 50, 75, 100, 200, and 400 individuals were tested for the entire city. Figure 5.16 illustrates the lowest three thresholds and how they vary, measured from the same residence in 1881 and 1891. The average distance between individuals was calculated for each buffer and the difference between the 1881 and 1891 averages was found. This was necessary to determine a threshold that would result in a similar viewshed in both decades. We also completed a visual analysis of the viewshed depicted in figure 5.16. With only a 3 meter difference between 1881 and 1891, we determined that 75 people was the most

appropriate threshold to create our population-based viewshed model for neighbourhood. The result is a unique view of the 3.4 million connections between neighbours, representing the complex web of social neighbourhoods in the nineteenth-century city (Figure 5.17). With our neighbourhoods determined, we extracted the occupational class for each of the 3.4 million neighbour links, calculated the average for each neighbourhood, and assigned the result to our worker sample. The difference between 1881 and 1891 is determined, which represents the change in N-SES for each of our residentially mobile workers.

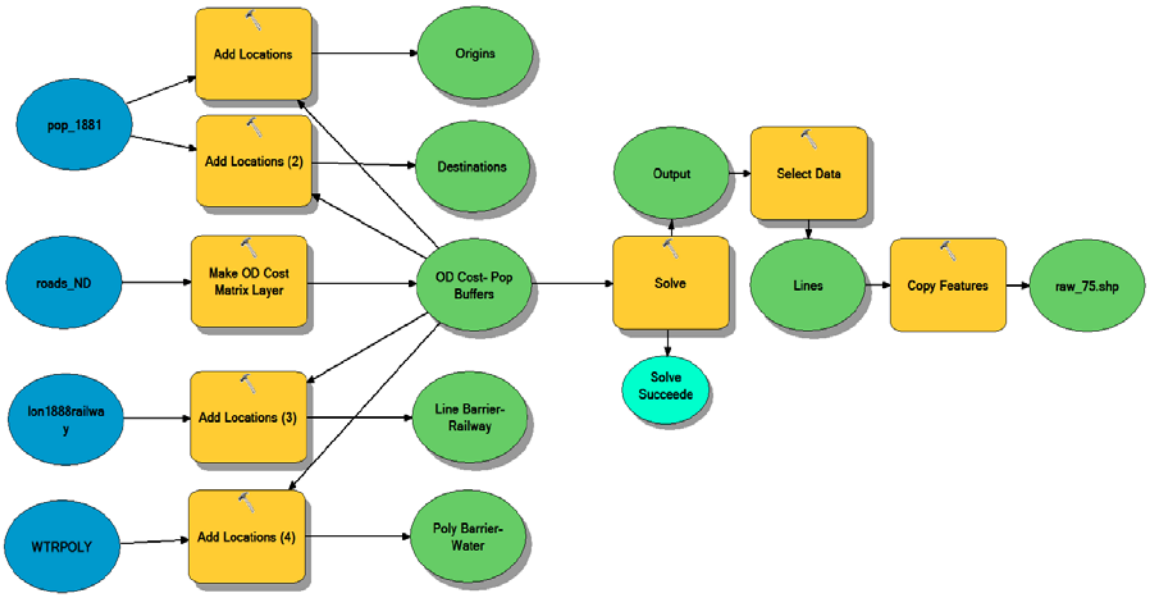
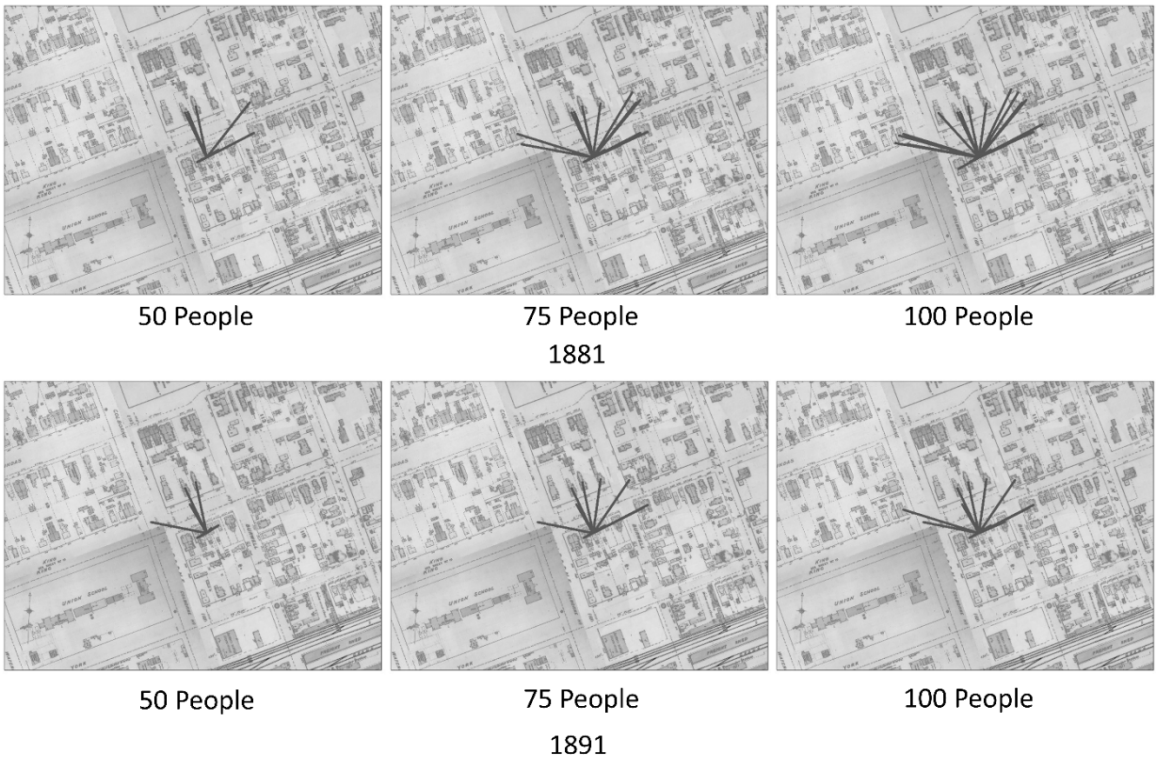


Figure 5.15 – Model for Population-Based Viewshed Buffer



* 1888 Goad Fire Insurance Plan of London used as base map for illustrative purposes

Figure 5.16 – Examples of Population-Based Buffers at Different Population Thresholds for the Same Residence in 1881 and 1891*

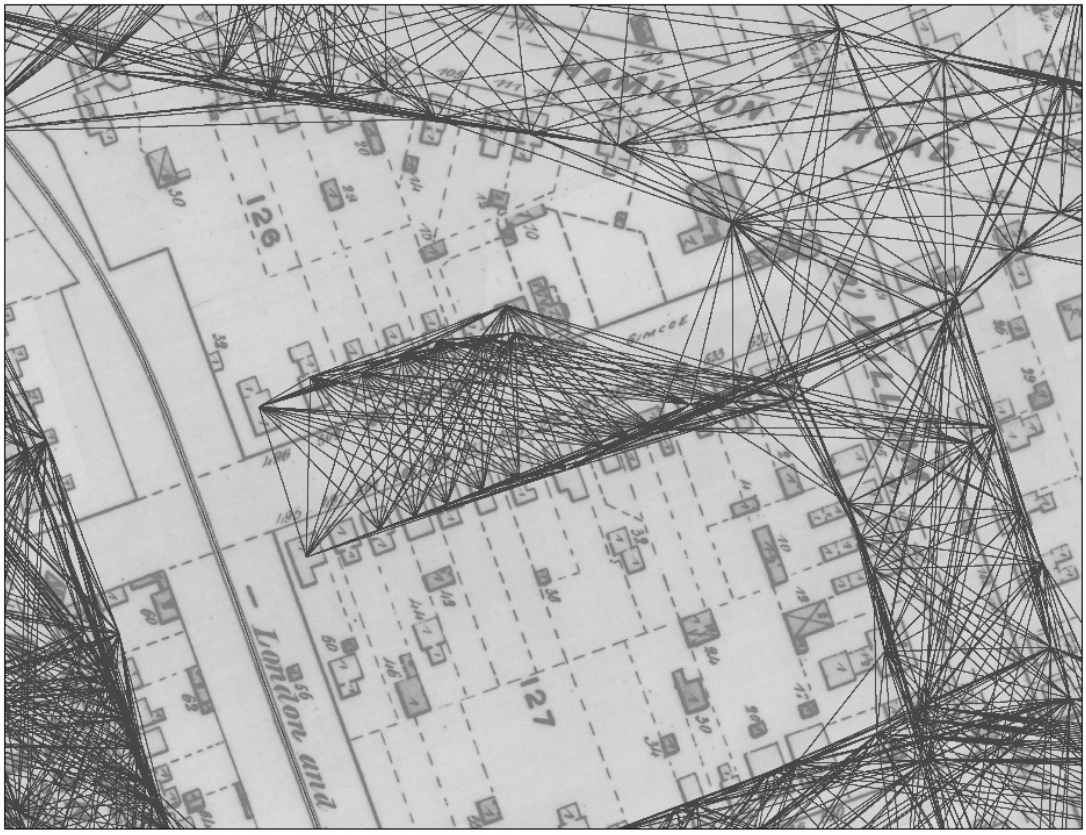


Figure 5.17 – The Complex Web of Social Neighbourhoods in London*

* 1888 Goad Fire Insurance Plan of London used as base map for illustrative purposes. Not all buildings have connections because they are either not residential buildings or are not inhabited

The second neighbourhood environment quality indicator is population density. Population density is typically reported as the total population divided by total land area; however, this technique does not work well when comparing small geographic areas. We instead harnessed the viewshed neighbourhood buffers to calculate the effective population density as experienced by each individual in the city. We captured the geographic distance between neighbours that was calculated during the origin-destination cost matrix analysis and determined the average distance between an individual and his neighbours. The lower the average distance, the higher the population density would

have appeared to the person of interest. We then compared an individual's experienced population density in 1881 and 1891 to determine if they moved to a more or less dense neighbourhood.

The final neighbourhood environment quality indicator is proximity to industrial uses. Industrial areas of the nineteenth century city were noxious environments. They were darker, smellier, and noisier than other areas of the city. Pollutants wafted from the smoke stacks, chemicals were piled in the yards, and waste was disposed of in any available open space or waterway. They were environments that most working people tried to avoid living in, but this was difficult during the late nineteenth century, when municipalities rarely limited land uses for fear of slowing industrial development. To determine the proximity of a worker's home to industrial uses, we first had to estimate the effect of industrial land uses on the adjacent residential parcels. We do not have information on the type of industrial activity in each factory, so estimating the amount of noise, smell, and pollution produced by each individual factory is not possible. Instead, we created a raster model of industrial impact by calculating a weighted interpolation of the square footage of each industrial building in the city (Figure 5.18). Railyards were also included, using a weight of 2 sq. feet for each rail line depicted on the fire insurance plans. The result is an estimate of how far the activities of factories may have influenced the neighbourhood environment of our sample of workers.

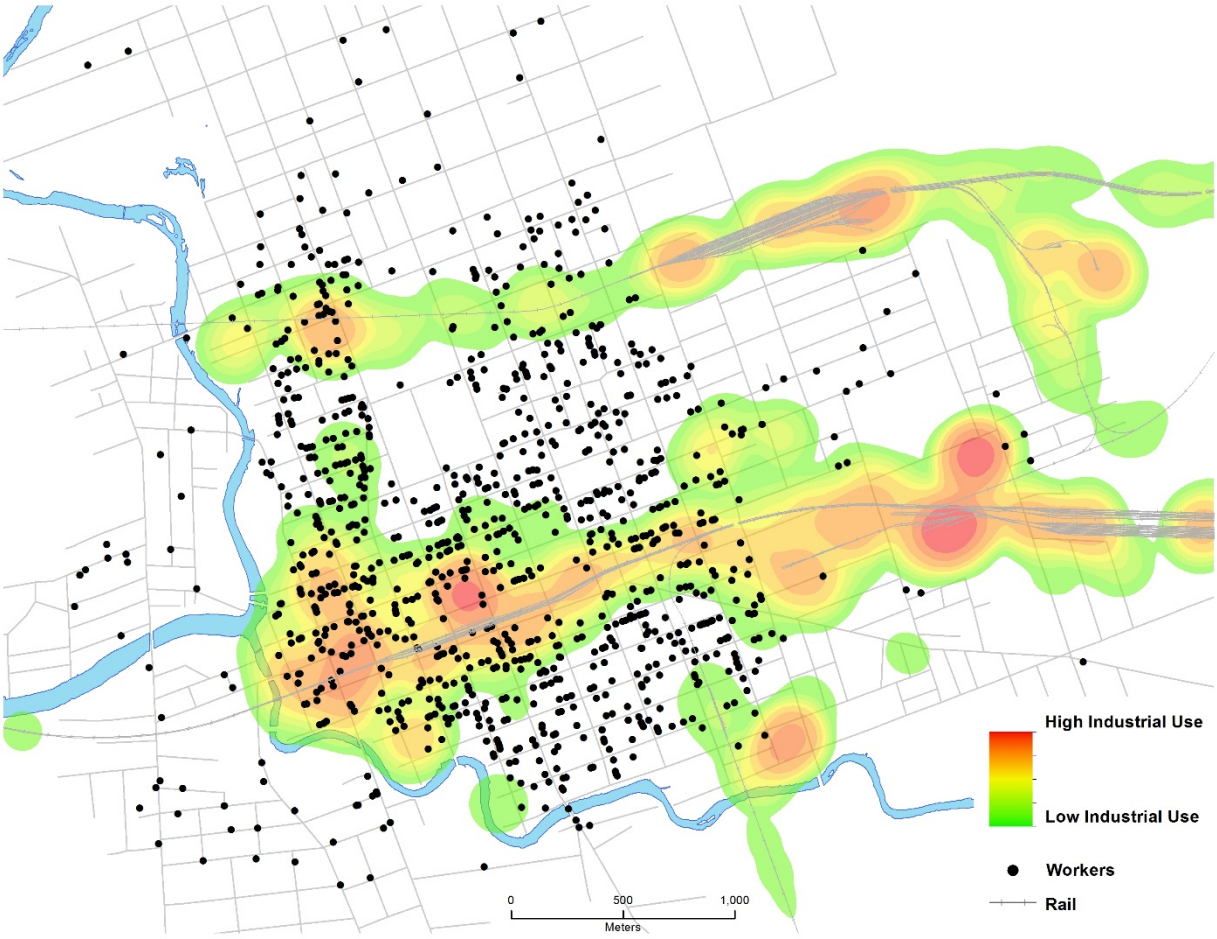


Figure 5.18 – Industrial Environment and Workers Residences, 1881

To calculate the proximity of each worker's residence to industrial uses, the weighted interpolated raster model had to be converted back to vector data to permit spatial queries. This was accomplished using the Raster to Point tool in ArcGIS. A spatial join retrieved the intensity value from the raster point and was assigned to each worker. The higher the value, the more industrialized their neighbourhood environment. For those who lived outside of an industrial area, the Near tool was used to calculate the Euclidean distance from their home to the closest industrial land use. Each set of values, industrial intensity and proximity to industrial uses, was normalized to a 10 point scale

for ease of analysis. The result is a scale of exposure with -10 being the furthest from an industrial area to +10 denoting living in an area with very high industrial exposure.

Residential Environment Indicators		
	Range of Values	**Derived From**
Individual SES	High: +5 = Upward Social Mobility Low: -5 = Downward Social Mobility	Difference in Occupational Class Rank
Crowding	High: +260 Sq. Ft / Person Low: -176 Sq. Ft / Person	Changes in Sq. Ft per Person
Residential Building Quality	Increase: Wood->Brick Stable: Wood->Wood, Brick->Brick Decrease: Brick->Wood	Changes in Building Material
Neighbourhood Environment Indicators		
	Range of Values	**Derived From**
Neighbourhood SES	High: +1.9 = Increase in Neighbourhood Quality Low: -3.9 = Decrease in Neighbourhood Quality	Difference in Average SES of Closest 75 Neighbours
Population Density	High: +309 = Higher Population Density Low: -496 = Lower Population Density	Changes in Average Distance to Closest 75 Neighbours
Proximity to Industrial Uses	High: +10 = Living in a Heavy Industrial Area Low: -10 = Furthest from an Industrial Area	Interpolation of Industrial Building Footprint

Table 5.4 – Residential and Neighbourhood Environment Indicators

We have created a multi-scalable, temporal geospatial model of a historical environment with spatial coverage and precision unique to studies of our urban past. We

began at a fine spatial resolution by uncovering the socio-economic status of the individual and how it changed over time. We moved outwards to the dwelling and viewed the extent of crowding and the quality of the residential unit. Then we continued onto the street to uncover an individualized perspective of the social and built environment that influenced daily life. The model was applied to each and every individual in the city, in two time periods, affording us a view of the city during the peak of industrialization. With this unique perspective on the city, we return to our interest in the changing journey to work and social mobility. Were the workers whom we can follow over socially mobile, as measured through improvements in their residential and neighbourhood environments? Did the desire to improve their environments result in a lengthened journey to work? Or were some able to secure a residential situation that both shortened their commute and improved the environments of their everyday lives?

5.6 THE COMPLEXITIES OF URBAN LIFE: ENVIRONMENT, SOCIAL MOBILITY, AND THE JOURNEY TO WORK

In this paper we have followed a sample of workers across the decade between 1881 and 1891. We have established that they experienced high levels of residential and workplace mobility. We expect that some of these mobility decisions were to acquire better wages, more stable work, or better working conditions, while some mobility was in response to changes in household composition such as needing to find larger accommodations for growing families or the need to move in with one's extended family in the later years of life. These moves provided individuals an opportunity to try to improve their quality of life, by increasing the quality or amount of living space in their

home, moving to a more well-to-do neighbourhood, or simply to an environment farther away from the pollution, noise, and smells of industrialization.

We begin our review of workers' residential environments in the aggregate, focusing on our sample of the 900 workers who were residentially mobile. At finest scale of the individual, we revisit our findings from section 5.4.2 and observe that 14.1% of workers were upwardly mobile and 11.3% went down the social mobility scale, leaving the vast majority (74.6%) as having no change in social status over time. For measures of crowding, we observe that a near equal number of workers increased their living space per person as decreased their living space per person (15% each). To our surprise, we see a large number of workers with no discernable change (less than 2 sq.ft/person) in their living space per household member. If we look closer at the family composition of this group, we see considerable changes in household size over the period, with 44% increasing the size of their household, 41% decreasing in size, and only 15% maintaining the same size. With near uniform consistency, those who increased their household size also increased the size of their dwelling, and similar decreases in dwelling size occurred for the group whose households decreased in members. In the aggregate, this pattern seems to suggest that many households were likely able to react to changes in household size with an astonishing degree of accuracy.

For our examination of the quality of the workers' residences, we see a more uniform distribution. Just over half (52.8%) of workers stayed in a similarly-constructed building over the decade: 58% of that group moved from a wood-framed house into another wood-framed house, while the remaining 42% moved from a brick home to another brick home. For those that did move to a dwelling with different construction

materials from their previous dwelling, a nearly equal number improved the quality of their home, moving from a wood-frame to a brick home as did those who appear to have decreased the quality, moving from a brick building to a wood one.

To review the three neighbourhood environment indicators in the aggregate, we start at the finest spatial scale of the change in neighbourhood SES. We observe that 90% of workers changed their neighbourhood quality over the decade, with 54% moving into a neighbourhood with a lower SES score than they were living in a decade previously, while the other 36% increased the quality of their neighbourhood. A small group of 90 (10%) saw no discernable change, which we determined to be any SES change of less than +/-.1 over the decade.

Moving further into the neighbourhood, the change in population density is relatively evenly distributed: 39% of workers moved to a neighbourhood with a lower population density, while 34% saw an increase in density. We determine that the remaining 27% had no change, with a change in population density indicator value of +/-10 metres, recalling that we measure population density by the average distance between the worker of interest and their closest 75 neighbours.

The last neighbourhood environment indicator is the proximity to industrial environments. As we expected, the vast majority of workers (82%) in 1881 were living in an environment we classified as industrial. By 1891, this number had dropped to 70%, but still represents the majority of workers. Further, 81 of the 164 workers (49%) who were not living in an industrial area in 1881 had moved into one by 1891, while 186 of the 736 workers (25%) who were living in an industrial area in 1881 were able to move out by 1891. Those who did not live in an industrial area, however, were still very close

by, as the non-industrial group had a median distance of only 89 metres to the closest industrial environment.

Discerning changes over time at the scale of aggregated groups of individuals is challenging. Can we devise a way to distill the patterns observed into a meaningful expression of environmental change? In other words, how best can we determine who moved into a better house and into a better neighbourhood? We have taken the following approach. For workers' residential environmental quality, we defined downward mobility as having any two or more of the following characteristics over time: a decrease in individual SES, higher crowding, or a decrease in quality of the residential unit. Upward mobility is defined as having any two or more of: increase in individual SES, lower crowding, or an increase in quality of the residential unit. No social mobility, or stability, is when two or more of the residential environment indicators show no change over time (Table 5.5).

Residential Environment Indicators		
Downward Mobility	***Stability***	***Upward Mobility***
2 or More		
Decrease in Individual SES	No Change in Individual SES	Increase in Individual SES
Increase in Crowding	No Change in Crowding	Decrease in Crowding
Decrease in Quality of Residential Unit	No Change in Quality of Residential Unit	Increase in Quality of Residential Unit

Table 5.5 – Determining Social Mobility by Residential Environmental Indicators

We apply a similar approach to determining whether a worker moved into a better neighbourhood over time. Movement into a better neighbourhood is used as a proxy for upward social mobility, and vice versa for decreases in neighbourhood quality. We see downward mobility as having two or more of the following characteristics over time: a decrease in neighbourhood SES, an increase in population density, or an increase in proximity to or intensity of industrial environments. Upward mobility is the opposite, having two or more positive characteristics: an increase in neighbourhood SES, a decrease in population density, or a decrease in industrial exposure. Like residential indicators, stability is when two or more of the indicators show no change over time (Table 5.6).

Neighbourhood Environment Indicators		
Downward Mobility	***Stability***	***Upward Mobility***
2 or More		
Decrease in Neighbourhood SES	No Change in Neighbourhood SES	Increase in Neighbourhood SES
Increase in Population Density	No Change in Population Density	Decrease in Population Density
Increase in Proximity to or Intensity of Industrial Environments	No Change in Proximity to or Intensity of Industrial Environments	Decrease in Proximity to or Intensity of Industrial Environments

Table 5.6 – Determining Social Mobility by Neighbourhood Environmental Indicators

5.6.1 Residential Environments, Social Mobility, and the Journey to Work

Did workers move to better their residential environments over the course of the 1880s? Our results, summarized in Table 5.7, indicate overwhelmingly that workers saw

stability in the quality of their residential environments: 74% of workers had stable environments, with 26.5% of all workers showing stability across all three residential environment indicators. We expected to see stability at the higher occupational classes, but the stability at the lower classes is surprising. This perhaps reflects a housing market that segregated lower class workers, restricting them to similar housing qualities and sizes, or perhaps was due to lack of housing choice because of low inventory or inflated costs.

Individual SES	Crowding	Quality of Residential Unit	Change in Residential Environment	n=	%
Down	Down	Down		2	0.2%
Down	Down	Stable		10	1.1%
Down	Down	Up	**Decrease**	1	0.1%
Down	Stable	Down	n=58	25	2.8%
Down	Up	Down	7.2% of all workers	3	0.3%
Stable	Down	Down		14	1.6%
Up	Down	Down		3	0.3%
Down	Stable	Stable		29	3.2%
Stable	Down	Stable		62	6.9%
Stable	Stable	Down	**Stable**	122	13.6%
Stable	Stable	Stable	n=668	239	26.6%
Stable	Stable	Up	74.2% of all workers	116	12.9%
Stable	Up	Stable		61	6.8%
Up	Stable	Stable		39	4.3%
Down	Up	Up		5	0.6%
Stable	Up	Up		15	1.7%
Up	Down	Up	**Increase**	3	0.3%
Up	Stable	Up	n=65	17	1.9%
Up	Up	Down	6.4% of all workers	5	0.6%
Up	Up	Stable		10	1.1%
Up	Up	Up		10	1.1%
Down	Stable	Up		18	2.0%
Down	Up	Stable	**Unclear**	10	1.1%
Stable	Down	Up	n=109	22	2.4%
Stable	Up	Down	12.1% of all workers	16	1.8%
Up	Down	Stable		16	1.8%
Up	Stable	Down		27	3.0%

Table 5.7 – Changes in Residential Environment, by Indicators

As we would expect, not all workers saw stability in the quality of their residential environment. We see that slightly more workers saw a decrease in their residential environment quality than saw an increase (7.2% vs. 6.4%). The key driver appears to be individual SES, as this correlates with an individual's social mobility as determined by the combination of their residential environmental factors. We have a

modest-sized cohort of workers for whom the direction of social mobility as related to changes in their residential environment is unclear. More than a third show an increase in individual SES, yet did not move to increase another attribute of their residential environment.

Although we do not see a major change in most workers' residential environments over time, a necessary repercussion of residential mobility is a change in the journey to work. Did the desire to be socially mobile, as measured through our proxies of residential environment indicators, result in lengthened daily commutes? Did those who decreased the quality of their environment do so to overcome a long journey to work? Table 5.8 outlines the relationship between social mobility and the journey to work. We uncovered that a majority of those workers who were upwardly socially mobile also increased their journey to work over time. More noteworthy is the percentage of distance by which the journeys increased; this group of workers increased their daily commute, on average, 188% over their 1881 distances. Lengthening journeys to work also appear to have been a repercussion for many of the workers who remained socially stable. Considerably more of these workers had longer commutes in 1891 than they did in 1881, and the increase in the distance travelled was not modest, at nearly 50%. Consider that another 9% of workers shifted their employment from home-based to outside-the-home, resulting in an average journey of over 800 metres. The desire to maintain financial stability may have pushed these workers to look for wage employment.

Change in Residential Environment	Change in Journey to Work	% of Workers in Category	Median Distance Change (Metres)	Average % Change
Decrease	Shorter Journey	38%	(-645m)	46%
	Longer Journey	28%	579m	71%
	Outside Home to Home-Based	9%	(-589m)	
	Home-Based to Outside Home	19%	917m	
	Home-Based both Years	7%		
Stable	Shorter Journey	34%	(-375m)	29%
	Longer Journey	43%	443m	49%
	Outside Home to Home-Based	5%	(-548m)	
	Home-Based to Outside Home	9%	806m	
	Home-Based both Years	9%		
Increase	Shorter Journey	42%	(-295m)	33%
	Longer Journey	43%	572m	118%
	Outside Home to Home-Based	8%	(-1235)	
	Home-Based to Outside Home	6%	517m	
	Home-Based both Years	1%		
Unclear	Shorter Journey	29%	(-437m)	36%
	Longer Journey	43%	516m	55%
	Outside Home to Home-Based	9%	(-1486m)	
	Home-Based to Outside Home	12%	927m	
	Home-Based both Years	6%		

Table 5.8 – Relationship Between Changes in Residential Environments and the Daily

5.6.2 Neighbourhood Environments, Social Mobility, and the Journey to Work

Workers in late nineteenth-century London overwhelmingly maintained similar residential environments over the decade between 1881 and 1891. Although we see little change in their residences, did they manage to improve their neighbourhood environments? Our results, summarized in Table 5.9, indicate that workers had quite a variety of experiences. Rather than a large group that saw stability, we find nearly equal numbers of those who increased and decreased their neighbourhood environmental quality. For decreases in neighbourhood-experienced social mobility, it appears that population density is the key driver. This falls in line with literature that outlines how increases in density are generally associated with lower property values, leading to inhabitation by lower social classes and encouraging development by factory owners and small merchants. Interestingly, the largest contributors to the cohort of workers who experienced increases in neighbourhood quality are those workers who saw an improvement in population density and distance from industrial environments, yet a decrease in neighbourhood SES. A view of their spatial distribution (Figure 5.19) suggests that most moved from areas with an intensity of industrial use, mostly in the downtown core, out to suburban retreats. A large number of this group moved to the western suburb of Petersville, a neighbourhood of small homes occupied primarily by the working classes. Petersville (aka London West) suffered a devastating flood in 1883 which displaced approximately fifty households, especially from the southern portion of the community where we see many of this cohort moving to by 1891 (Novak & Gilliland, 2009). These workers made a choice to improve their environments, escaping the filth of

industry, even if at the cost of a decrease in the quality of the social environment on the street and the increased potential for flooding.

Neighbourhood SES	Population Density	Proximity to or Intensity of Industrial Environment	Change in Neighbourhood Environment	n=	%
Down	Down	Down		63	7.0%
Down	Down	Stable		47	5.2%
Down	Down	Up	**Decrease**	65	7.2%
Down	Stable	Down	n=313	29	3.2%
Down	Up	Down	34.8% of all workers	38	4.2%
Stable	Down	Down		11	1.2%
Up	Down	Down		60	6.7%
Down	Stable	Stable		51	5.7%
Stable	Down	Stable		8	0.9%
Stable	Stable	Down	**Stable**	10	1.1%
Stable	Stable	Stable	n=126	10	1.1%
Stable	Stable	Up	14% of all workers	5	0.6%
Stable	Up	Stable		7	0.8%
Up	Stable	Stable		35	3.9%
Down	Up	Up		100	11.1%
Stable	Up	Up		13	1.4%
Up	Down	Up	**Increase**	46	5.1%
Up	Stable	Up	n=284	36	4.0%
Up	Up	Down	31.6% of all workers	28	3.1%
Up	Up	Stable		27	3.0%
Up	Up	Up		34	3.8%
Down	Stable	Up		45	5.0%
Down	Up	Stable	**Unclear**	45	5.0%
Stable	Down	Up	n=177	16	1.8%
Stable	Up	Down	19.7% of all workers	10	1.1%
Up	Down	Stable		47	5.2%
Up	Stable	Down		14	1.6%

Table 5.9 – Changes in Neighbourhood Environment, by Indicators

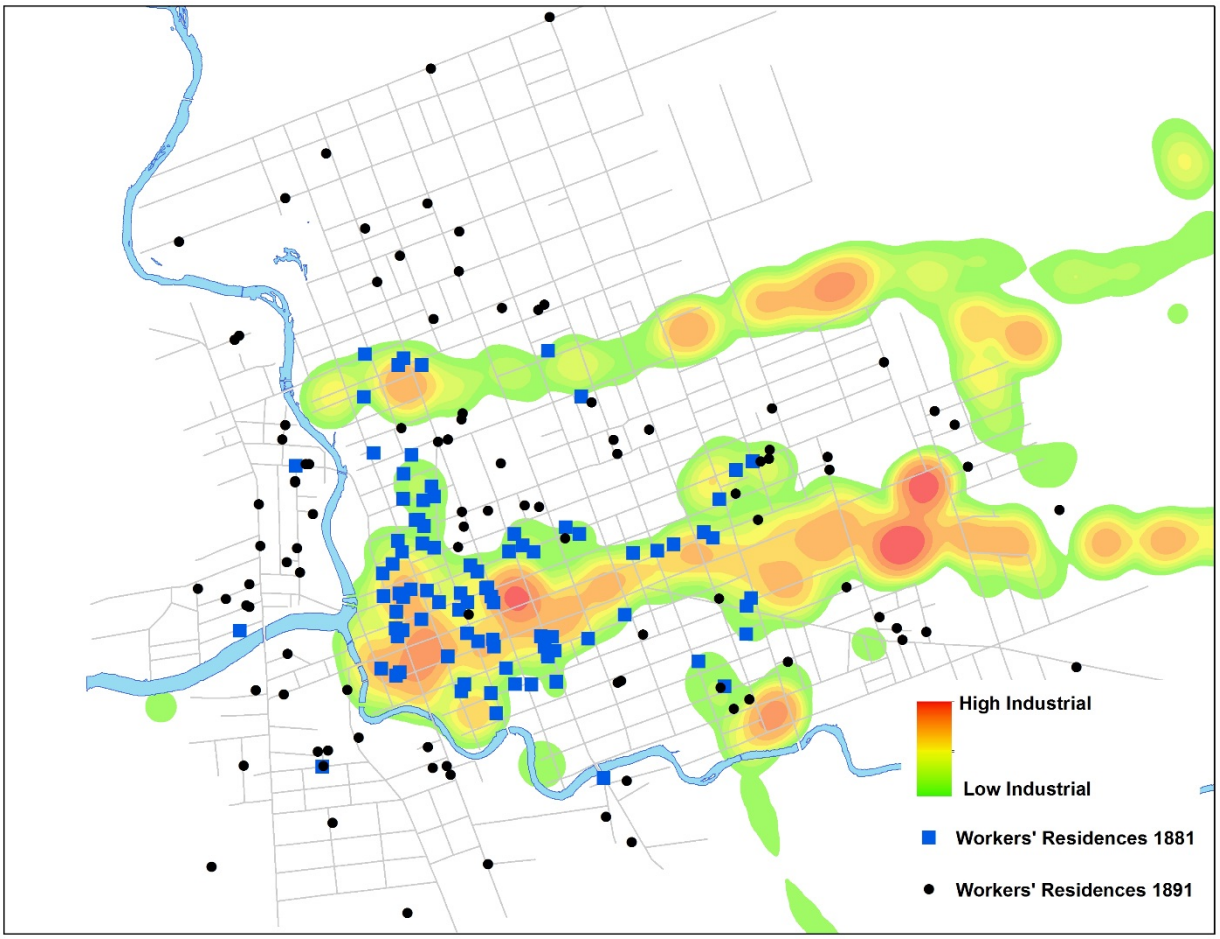


Figure 5.19 – Upwardly Mobile Workers Move Out of Industrial Environments into Suburban Neighbourhoods

The impact of residential mobility on the workers' journeys to work is striking. Over 80% of the cohort mapped in Figure 5.19 saw an increase in their journey to work, with a median increase of nearly a kilometre, representing a 111% increase over their 1881 commuting distances. If we look at all workers who were upwardly mobile, we see a similar pattern: 53% of them had a lengthened journey to work, with a median increase of 72% (Table 5.10). Another 14% of workers had shifted their work out of their homes, resulting in an above-average commute of 1006m. For those workers who were able to maintain stability, population density and proximity to industrial environments appear to

trump neighbourhood SES, and their journey to work response supports this pattern. We see very little change in the journey to work in this group, with equal distributions of workers having an increase and decrease in their commutes over time. The rate of change is low as well, with increases limited to 25% and decreases of only 12%. This suggests that there was a level of contentment with the neighbourhood environment by this group of workers.

Change in Neighbourhood Environment	Change in Journey to Work	% of Workers in Category	Median Distance Change (Metres)	Average % Change
Decrease	Shorter Journey	44%	(-480m)	41%
	Longer Journey	32%	326m	45%
	Outside Home to Home-Based	9%	(-734m)	
	Home-Based to Outside Home	8%	787m	
	Home-Based both Years	6%		
Stable	Shorter Journey	37%	(-88m)	12%
	Longer Journey	32%	221m	25%
	Outside Home to Home-Based	32%	(-832m)	
	Home-Based to Outside Home	6%	248m	
	Home-Based both Years	22%		
Increase	Shorter Journey	24%	(-354m)	26%
	Longer Journey	53%	604m	72%
	Outside Home to Home-Based	4%	(-731m)	
	Home-Based to Outside Home	14%	1006m	
	Home-Based both Years	5%		
Unclear	Shorter Journey	32%	(-390m)	26%
	Longer Journey	49%	493m	36%
	Outside Home to Home-Based	4%	(-1164m)	
	Home-Based to Outside Home	10%	557m	
	Home-Based both Years	6%		

Table 5.10 – Relationship between changes in Neighbourhood Environments and the Daily Journey to Work

Looking broadly at both the changes in residential and neighbourhood environments of our sample of workers, it is clear that individuals were increasing their daily journey to work in order to attempt to increase their social mobility. What about Ira Collins and Amelia Miller? Did they manage to improve their environments? We saw that Ira had a substantial increase in the distance of his journey to work of over 50%, moving from London East to a neighbourhood south-east of downtown which is today called SoHo (short for South of Horton). We see that he maintained stability in his residential environment, with stability in individual SES and measures of crowding. He did have a decrease in the quality of the construction of his home, moving from a brick home in London East to a similar-sized wood frame house on Clarence. Overall, we see a decrease in his neighbourhood environment, with a lower neighbourhood SES score and higher population densities than when he was living in London East. However, his proximity to industrial uses improved significantly considerably shifting 2.5 values in the normalized proximity to industry scale. Looking closer, Ira moved from being less than 300 metres from Canada Chemical Manufacturing and less than 200 from Bennett's large furniture factory to over 350m to the closest industrial use. Instead, across the street was one of the city's new elementary schools Was the proximity to the school for his young son Russell an impetus for his move? Were Ira and his wife Mary Jane seeking a healthier built environment overall for the family to live in? Or was the move initiated for other personal reasons, such as a job loss, eviction, or desire to live closer to relatives? We know that Ira changed jobs and occupations, moving from his work as a saddle maker at Globe Agricultural Works to a yard man with the Grand Trunk Railroad,

but without more information it is impossible to decipher the underlying motivation for Ira's moves.

Amelia Miller, the grade 7 teacher, did not change her workplace over the decade between 1881 and 1891, but she did make a substantial change in her residential situation. This change, however, did not impact her residential environment as much as we might expect. We see stability in her environmental indicators, with no change in individual SES (though we do know her wages increased over the period) or the quality of the residential building material. Where we do see an important decrease in is the crowding measure. Looking at her situation more closely, we see that although the number in the people in the household doubled from four to eight, the size of the dwelling increased substantially from a one-story 688 sq. foot bungalow to a very large 3200 sq. foot two-story house. The effective increase is a doubling of living space per person, which certainly would have improved her quality of life at home. Amelia's change in neighbourhood environment shows a significant increase in neighbourhood SES, confirming our earlier suggestion that she may have sought a neighbourhood that better represented her social class as a white-collar worker. We do see a decrease in the neighbourhood population density and proximity to industrial uses, as Amelia's new residence is located near John Carling's large brewing operations, she would have smelled the foul odors and heard the noise of horse carts that emanated from the brewery on a daily basis.

Ira's and Amelia's experiences highlight the complexities involved in balancing residential needs, neighbourhood environments, and the journey to work. Ira improved the quality of his neighbourhood built environment at the expense of a significant

increase in his daily journey to work. Amelia was able to improve the quality of her social neighbourhood and her personal living space while drastically decreasing her journey to work, but to do so she had to move to a more noxious industrial environment. Although complex, our re-creation of historical environments has allowed us to examine the extent of individuals' social mobility in a unique way, moving beyond just the abstract differences of changes in occupation. This environmental approach to social mobility provides a more nuanced understanding of how social mobility, reflected by one's environment, shaped the experience of daily life in the nineteenth-century city.

5.7 CONCLUSION

This paper has taken on an ambitious task, to complete a longitudinal study of a population, their workplaces, and environments. First, we extended the historical record linkage literature by developing a protocol that record-links geocoded samples of workers with high precision across time using public databases of decennial census records. These record linkages allowed us to follow the same workers as they changed residences and workplaces, permitting us to complete the first known study of the journey to work over an extended period of time with the same population. We established the extent of residential, occupational, and workplace mobilities for over 1200 workers with a high degree of spatial precision. We continued by creating a methodology for examining historical environments at multiple spatial scales, from the individual's home residential environment, to the larger social and built environment characteristics of their surrounding neighbourhood. This methodology moves beyond the arbitrary areal unit to include a personalized approach to conceptualizing neighbourhoods. Recognizing that

'neighbourhood' is unique to each individual, we devised a way to create a neighbourhood for each person in the city. Each person was placed as the centroid in his or her own neighborhood, which emanated out like the view they would have seen as they looked up and down the street from their front porch. Finally, we combined these approaches to create a new conception of social mobility in the nineteenth-century city, one based not only on changes in an individual's occupation, but also on the quality of the environments in which they spend their everyday lives.

It must be acknowledged that there are limitations to the methodologies and assumptions we present here. Baker reminds us that all inferences made in historical geography 'whether drawn directly from empirical evidence or indirectly from theory, are probabilistic statements', a warning that surely applies to the work we present here (1991, 226). Our study is fundamentally based on two time slices that follow the decennial census, 1881 and 1891. We know that many individuals would have changed their residence and/or workplace, and thus their environments, more than once during the course of this decade. With the methodologies and environmental stages in place, we hope to revisit this study in the future to see it is possible to follow individuals every calendar year. This would provide a more fine-grained understanding of life histories and the frequency of change. For our treatment of environmental reflections of social mobility, we were limited by the source material for determining the quality of the residential environment. Ideally, information on the cost or rents of residential units would have provided an additional factor to contribute to a more comprehensive view of changes in residential quality.

Regardless of these opportunities for further development, what we have shown in this study is that the relationship between home and work is complex. Individuals were frequently changing their residential situations, trying to improve their residential and neighbourhood environments while reducing or limiting the increase of their daily commute. In 1880s London, Ontario, we find that many individuals did significantly improve their residential and neighbourhood environments, but did so at the expense of a longer commute each day. It was a fine balancing act, not different from that which many of us face today. Although we often think of the past as a simpler time, we know that life was not so simple, at least for the decisions on where our ancestors lived and worked.

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CHAPTER SIX

Conclusion

6.1 SUMMARY

Lowenthal (1985) reminds us that 'the past is a foreign country'. This dissertation has set forth to serve as the introductory chapter preamble for its travel guide. When I started down the long path of research that is a doctoral dissertation, I was inspired by several writers and thinkers of the early discipline of historical GIS. Among them, Anne Kelly Knowles asserted that 'people love new tools that enable them to do what they have dreamed of doing" (Knowles 2000, 451). What was lacking, however, was a guidebook by which the student of this emerging discipline could use to learn these new tools and apply them broadly to interests in our urban past. Thus emerged the broad aim of this dissertation: to establish a comprehensive geospatial research framework for the study of past populations and their environments. The framework and its complementary techniques were used to fulfill this dissertation's empirical aim: to advance our understanding of the social spaces in both the diurnal and nocturnal nineteenth-century city by reconstructing the daily movements of individuals to and from work or school. These two aims merge and are addressed in this integrated format dissertation as three independent studies.

The first study, presented here as chapter three, outlined the creation of the foundational layers of the historical GIS and presented a methodological framework for the study of the daily-space time patterns of individuals in our past cities. This study also outlined an approach to integrating qualitative sources into a GIS, an area of research that has only recently begun to find its way into historical studies. The foundational layers,

referred to as environmental stages, provide not only the means to rapidly place seemingly aspatial historical sources in a geospatial environment, but they also provide the important contextual information about the world in which the people represented in the sources were living. To illustrate, this study uses the attendance records of three elementary schools to recreate the likely journey to school for 699 students in 1881. The integration of the attendance registers with the built and social environment stages permitted an interrogation of relationship between social class and industrial exposure during the daily walk to school. The integration and contextualization of qualitative sources, such as the personal diary of Richard Matthews used in this study, highlights how this stage-based approach to historical GIS allows scholars to do more than place historical data on a map, but to move toward the creation of complex spatial stories of everyday life. The culmination is the 3D representation of Matthews' daily journey to work, highlighting the varied social and built environments he would have experienced and interacted with on a daily basis. This study will be of particular interest to historically-minded scholars who are just beginning to integrate GIS into their research programs and to humanities scholars who are looking to interrogate the spatial qualities of their qualitative sources.

The second study, presented here as chapter four, outlined a new methodological framework for recreating the historical spatial relationships between work and home. This methodology was applied to a sample of over 5000 individuals to empirically review their daily journey to work. This study revisited the existing scholarship on the nineteenth-century journey to work and outlined how the stage-based geospatial research framework discussed in chapter three can be used to overcome a number of the

methodological challenges that plagued previous studies. These challenges include a reliance on small, atypical samples of workers, approximations of the spatial relationship between home and work, and unrealistic interpretations of journeys travelled by employing only Euclidean paths. Probabilistic record matching techniques were outlined to illustrate how to create larger, more demographically and spatially representative samples of the working age population, as well as to establish absolute spatial links between their homes and their workplaces. A network-derived journey to work model was developed that recreated more realistic journeys that consider the many natural and built environment barriers that influenced the paths and distances travelled. Case studies of brewery and cigar factory workers illustrate the improvements the models offer to previous journey to work methodologies. The study concludes by presenting empirical results of the journey to work in London in 1881 along lines of occupational class, coincident home-work location, and gender. The results indicate that the highest occupational classes lived closer to their workplaces than any other group and labourers lived the furthest, which departs from the findings in other studies. Coincident home-work locations of workers in London were compared to studies in Philadelphia and Milwaukee, with results highlighting that differences in the size and location of industries influenced which occupations were performed from home and which were carried out as wage labour. Finally, women's experience of work was reviewed and the dominance of domestic labour that fills the pages of other studies also held true in London. A cohort of dressmakers who worked outside of the home remind us of the importance of women's wages to the total household income.

The third study, presented here as chapter five, combines the methodologies and results from the previous two chapters to present an approach to studying the relationship between residence, workplace, and environment. The study begins by outlining and applying a methodology for record linking populations longitudinally across decennial censuses and city directories and is used to create a sample of workers that we can follow across time. The result is the first journey to work study that evaluates the same population over an extended period of time. This worker sample is followed across the decade to evaluate the changes in the quality of both their residential and neighbourhood environments. The change in environments is used as a measure of social mobility and is compared to their change in journey to work. To facilitate analysis, six environmental indicators were created to evaluate changes in the characteristics of workers' residential and neighbourhood environments. Empirical results highlight that the relationship between residential needs, neighbourhood environments, and the journey to work is complex. What is clear is that individuals who were able to be upwardly socially mobile and improve their overall environment did so at the expense of substantial increases in their journey to work.

The approaches and case studies found within these three studies represent a melding of four distinct disciplines from across the social sciences (Figure 6.1). At the surface, this work would be identified as scholarship in the discipline of historical geography, though it is far from representative of recent or traditional historical geographical scholarship. This dissertation instead treats the study of historical populations and environments through a truly interdisciplinary lens. Methodological, theoretical, and empirical contributions are made to urban and time-space geographies,

such as the treatment and consideration of built environments and their influence on pedestrian paths and the influence of industrial landscapes on residential mobility. Contributions are made to social history by presenting, arguably for the first time, the whole of a past population in their individual residences and neighbourhoods, allowing us to see patterns and processes in a new way. Some social historians will appreciate the methods and case studies for utilizing archival sources already familiar to them, such as diaries and school records, to reveal social interactions between large numbers of individuals. Historical demography and the emerging discipline of spatial demography benefit from advances in record linkage techniques, especially utilizing the spatial characteristics that have been difficult to fully appreciate until now. Demographers will also benefit from methodologies that outline how to spatialize the Canadian census, providing opportunities to revisit their classic interests in household structure, fertility, mortality, marriage, and kinship through a spatial lens. Finally, but most significantly, is the contribution these studies have made to the field of GIS, specifically historical GIS. Contributions are made to qualitative GIS, highlighting not only a technique for geocoding, but how to integrate and contextualize qualitative sources with traditional quantitative ones. Various methods and models are contributed to historical GIS, such as 3D GIS modelling of historical landscapes and a person-based viewshed buffer for modelling historic conceptions of neighbourhood. Finally, these studies have illustrated that historical GIS can move beyond the 'point on the map' or visualization of history that is still so common in historical GIS studies. Instead, they encourage scholars to more fully utilize the analytical capabilities that make GIS such a promising tool. I hope

this dissertation can be an inspiration for new way to approach the study of our urban past and provide other scholars the frameworks they need to turn their ideas into reality.

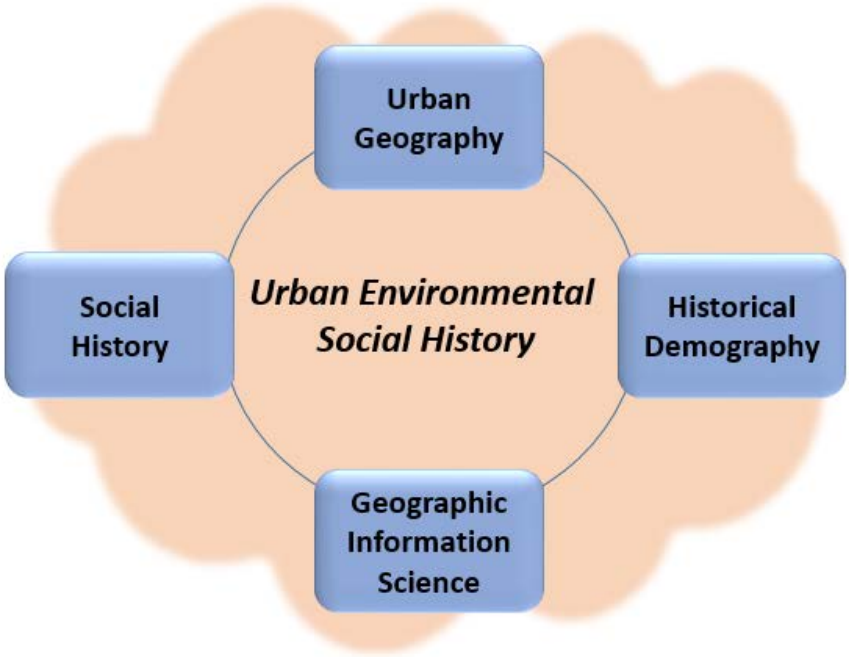

Figure 6.1 – Melding of Disciplines Represented in this Dissertation

6.2 FUTURE DIRECTIONS

In the same way the built and social environment stage built in this study provided a base for exploration into the journey to work and social mobility, this dissertation provides the humble beginnings of a platform for other researchers to build upon for future interdisciplinary historical GIS research. There are multiple pathways forward and one is to expand the framework presented here beyond the boundaries of a single city. A consideration should be given to expanding this framework to a national spatial infrastructure, in much the same way as has been done for forestry through the Canadian

National Forest Information System or water management with RésEau, the Canadian Water Information Network. This may start by digitizing and geo-enabling the comprehensive Historical Atlas of Canada, or partnering with the Canadian Century Research Infrastructure by georeferencing the 100% sample of the census for 1871 and 1881. An expanded framework would allow researchers not only to study the cities of their research domain, but to study geographic, social, demographic, economic and political patterns across cities and across time.

Additionally, there are opportunities to advance and automate techniques for integrating qualitative sources. Establishing techniques for non-textual sources such as photographs, art, or oral histories would benefit researchers as well as provide an outlet for collaborations with public partners in heritage preservation, genealogy, libraries, and museums. Similar collaborations could arise from expanding the humble attempts at 3D historical landscape modelling outlined here to more immersive presentations, such as virtual or augmented reality platforms.

For studies of the journey to work, further directions include comparing the aggregated patterns reported here with those of similar mid-sized Canadian cities such as Windsor, Kingston, and Quebec City. Following individuals at a finer temporal scale, such as every year, or, if appropriate records can be located, across every change in workplace, would provide further insight into the relationship between home and work. Additionally, we know very little about those individuals who have transient worksites, such as travelling salesmen, letter carriers, and livery drivers. Furthermore, much more can be done to understand how the urban and physical environments, such as the impact

of snow storms, muddy streets, major construction, and rail traffic, influenced the time-space patterns of individuals, including the journey to work.

For studies of social mobility as reflected through one's environment, we have opportunities to dig deeper into residences and consider the age and cost of the dwelling, or to determine changes made to a structure over time that may increase its value. A consideration for neighbourhood amenities such as schools, churches, recreation halls, and parks would provide further insight into the quality of the neighbourhood. So would consideration of the amount of crime, fires, and accidents.

This dissertation advocated for the re-creation of the 'real world' within a geospatial environment, a lofty goal that has not been fully realized. We have been told that the past "can never be recovered as a solid whole, as history is always fragmented" (Black 2010, 478). This may be true, but we can continue to strive to make the past a little less foreign.

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Appendices

Appendix A: Modified Darroch and Ornstein Occupational Class Scheme

*NAPP HISCO Code (North American Population Project modified Historical International Standard Classification of Occupations)

Occupation Title	Occupational Class	NAPP HISCO Code
Accountants	2	11010
Accountants nec	2	11090
Actors and related workers	2	17300
Advertising salesmen	1	44200
Agents nfs	1	43010
Agronomists and related scientists	2	5300
Alkali and soda makers	4	74430
Ambiguous responses	9	99500
Animal stuffers, taxidermists and shell workers	4	94920
Appraisers	1	44330
Architects	2	2100
Artificial flower makers	4	79940
Artistic Painters	2	16130
Artists nfs and art teachers	4	16110
Assistants nfs	5	99420
Athletes, sportsmen and related workers	9	18000
Auctioneers	1	44320
Auditors	2	11020
Authors	2	15100
Baker and confectioner	4	77610
Bakers	4	77620
Bank clerks	3	33140
Bank tellers (US)	3	33142
Barbers	5	57030
Barristers	2	12120
Bartender	5	53230
Basket makers	4	94220
Bath attendants	5	57040
Bicycle makers	4	84300
Biologists, botanists, zoologists and related scientists	2	5100
Blacksmiths	4	83120
Bleachers, dyer or textile product finisher	4	75600
Block, mast and tackle makers	4	87550
Boarding and lodging house keepers and managers	1	51040
Boatmen and canalmen	5	98130

Occupation Title	Occupational Class	NAPP HISCO Code
Boilermaker	4	87350
Bookbinders and related workers	4	92600
Bookkeepers and bookkeeping clerks	3	33120
Bookkeepers nfs	3	33110
Bookkeeping, account and cash handling workers nec	3	33190
Bookmakers (sport)	5	59920
Boot and shoe makers and repairers	4	80100
Bottlers	4	77880
Box makers nec	4	81790
Box makers nfs	4	81710
Braziers	4	87230
Brewers	4	77820
Brick and tile makers	4	89300
Bricklayers	4	95120
Bristle and straw workers nec	4	94290
Brokers	1	43040
Broom makers	4	94240
Brush makers	4	94230
Builders	1	21230
Bus, tram or streetcar conductors	3	36040
Butchers	4	77310
Butlers	7	52050
Butter, cheese and dairy product makers	4	77500
Buyers	1	42000
Cabinet makers	4	81120
Candy makers	4	77640
Cannery workers and other food preservers	5	77400
Canvassers	1	49050
Capitalists	1	21330
Caretakers and janitors	5	55100
Carpenter and joiner	4	95410
Carpenters	4	95420
Carpet planners	5	95930
Carter (agricultural)	5	98562
Cartoonists	2	16140
Cash desk cashier	3	33160
Cashiers, bank or office	3	33130
Cattle workers, except specified dairy	6	62420
Caulker	4	87560
Cement makers	4	89620
Cement masons and finishers	4	95200
Chain makers	4	83840

Occupation Title	Occupational Class	NAPP HISCO Code
Chair makers	4	81130
Chambermaids and room attendants	7	54060
Charcoal burners	4	74320
Charworkers	5	55200
Chemical engineering technicals	2	3250
Chemical engineers	2	2500
Chemical workers, product nfs	4	74000
Chemists	2	1100
Chimney sweeps	5	55240
Chiropractors	2	7930
Chocolate makers	4	77650
Cigar makers	4	78200
Cigarette makers	4	78300
Civil engineering technicians	2	3220
Civil engineers	2	2200
Civil servants, title unknown	3	31010
Clay-based products makers	4	89700
Clerk, nfs	3	39000
Clerks in shops and stores	3	45130
Clerks of court and other court clerks	3	31060
Clog makers	4	81600
Coach, carriage and wagon makers	4	81300
Coal gas makers	4	74330
Collector (cash or account)	3	33180
Commercial travellers	1	43020
Common labourers or general labourers	6	99130
Companions	7	54050
Compositors	4	92120
Conductors, nfs	3	36010
Confectioners and pastry makers	4	77630
Construction contractors	1	21220
Construction workers nec	4	95910
Contractors nfs	1	21210
Cook (Domestic) [UK only]	7	53101
Cook (Not domestic) [UK only]	4	53102
Cooks	4	53100
Coopers, hoop makers and benders	4	81500
Coppersmith or copperware maker	4	87330
Correspondence clerks	3	39320
Cottar and Fisherman	8	61330
Crane and hoist operators	5	97300
Croupiers	5	59930

Occupation Title	Occupational Class	NAPP HISCO Code
Customs officers	3	31040
Cutler (knives, forks, spoon)	4	83550
Cutlers and cutting instrument makers	4	83540
Dairy farmers	8	61270
Dancers and dancing teachers	2	17200
Day labourers (e.g journalier)	6	99140
Dealer, merchant etc. (Wholesale and retail trade)	1	41010
Dealers and salesworkers nec	1	49090
Decorators	4	93200
Delivery men and drivers of goods	5	98550
Demolition workers	5	95950
Dentists	2	6200
Designers	2	16200
Distillers	4	77860
Draughtsmen	3	3100
Dressmakers	4	79130
Drivers (general haulage)	5	98560
Drivers (personal, for hire)	5	98530
Drivers (private)	5	98520
Drivers (public)	5	98540
Drivers, nec	5	98510
Drug workers	4	74100
Dye makers	4	74630
Economists	2	9000
Editors	2	15220
Electrical engineering technicians	2	3230
Electrical engineers	2	2300
Electrical fitters and electrical equipment assemblers	4	85100
Electrical products inspector or tester	2	85920
Electricians and wiremen	4	85500
Electricity generators	4	96100
Embroiderers	4	79540
Engine and locomotive builders	4	84140
Engineering technicians nec	2	3290
Engineers (US) nfs	4	96220
Engravers	4	16400
Engravers and etchers (artistic)	2	16150
Errand boys and errand girls	5	59950
Executive officer finance company	1	21182
Executive officer of other transport and communications	1	21162
Executive officer of public utilities	1	21172

Occupation Title	Occupational Class	NAPP HISCO Code
Executive officers of extractive industry	1	21142
Executive officers of manufacturing concerns nfs	1	21122
Executive officers of railway concerns	1	21152
Executive officers of specified manufacturing concerns	1	21132
Factory labourers (unspecified)	6	99200
Farm labourers: orchard and fruit farm workers	6	62300
Farm machinery operators	5	62800
Farm managers, formen and supervisors nfs	8	61400
Farm workers (dairy)	6	62500
Farm workers (field crop and vegetables)	6	62200
Farm workers (poultry)	6	62600
Farm workers, specialisation unknown	6	62110
Farmer and Fisherman	8	61320
Farmer's sons and other male relatives	8	62113
Farriers or horseshoers	4	83150
Fashion models	3	45140
Fellmongers	4	76120
Fertilizer and manure makers	4	74920
Fibre preparers	4	75100
Field crop farmers	8	61220
Firefighters	4	58100
Fish butchers	4	77360
Fish farm workers	5	64920
Fishermen	5	64100
Foregemen	4	83140
Foremen and supervisors nfs	2	23110
Foremen and supervisors, commerce	2	23180
Foremen and supervisors, construction, except railway construction	2	23170
Foremen and supervisors, manufacturing	2	23120
Foremen and supervisors, mining	2	23130
Foremen and supervisors, nec	2	23190
Foremen and supervisors, other transport and communications	2	23150
Foremen and supervisors, public utilities	2	23160
Foremen and supervisors, railways	2	23140
Forest fire-fighters	5	63250
Foresters and wood wardens	5	63220
Forestry workers	5	63230
Fur and pelt dressers	4	76200
Fur-bearing animal workers	6	62450
Furriers and fur workers	4	79200

Occupation Title	Occupational Class	NAPP HISCO Code
Gardener (Domestic)	7	62711
Gardener (Not domestic)	5	62713
Gardeners nfs	5	62710
Gate keepers	5	98730
General farmers and farmers nfs	8	61110
Gilders	4	93400
Glass bottle makers	4	89130
Glass engravers, etchers and finishers	4	89400
Glass makers	4	89120
Glaziers	4	95700
Glove makers and related workers	4	79400
Glue, size and gelatin[e] makers	4	74740
Goldsmith	4	88030
Governesses	3	13920
Government administrators	2	20200
Government functionaries, nec	3	31090
Grooms and horse keepers (Domestic)	7	62461
Grooms and horse keepers (Not domestic)	6	62463
Groundskeepers, etc.	6	62940
Guides	5	59100
Gunpowder and explosive makers	4	74200
Gunsmiths	4	83600
Habitant	8	61119
Hairdressers	5	57020
Hammersmiths	4	83130
Hat makers	4	79330
Healers and therapists nec	2	7600
Heating, ventilation and refrigeration engineers	2	2460
Helpers nfs	5	99430
Helpers of relative or helping at home	5	99440
Hirers out	1	41020
Horse breaker	1	62470
Horse workers	6	62460
Hotel clerk or other receptionist	3	39400
Hotel keepers and managers	1	51020
House servants nfs and maids	7	54020
Housekeeper	7	52020
Husbandmen or cottars	8	61115
Hydrographic surveyors	2	3040
Industrial engineers	2	2800
Industrial machinery or tools engineers	2	2420
Ink, blacking, colouring, etc., makers	4	74640

Occupation Title	Occupational Class	NAPP HISCO Code
Inspectors [of manufactories, companies], etc.	2	24100
Insurance clerks	3	39350
Insurance salesmen and agents	1	44120
Insurance, real estate and securities salesmen nec	1	44190
Insurance, real state or securities salesmen, nfs	1	44110
Interpreters, translators and philologists	2	19500
Investors nec	1	21390
Japanners	4	93330
Jewellers	4	88020
Joiners	4	95430
Journalists, reporters and correspondents	3	15230
Judge	2	12200
Jurists (except Lawyer, Judge or Solicitor)	2	12900
Knitters	4	75500
Labourers nfs	6	99120
Lacquerers and enamellers	4	93320
Land surveyors	2	3020
Landscape gardeners	5	62740
Lawyers	2	12100
Leather curriers and finishers	4	76140
Legal clerks	3	39340
Legislative officials and heads of government	2	20100
Librarians, archivists and curators	3	19100
Library and filing clerks	3	39500
Life sciences technicians	2	5400
Lime burners	4	89630
Linesmen: telephone, telegraph and electric	4	85700
Linoleum makers and floor cloth makers	4	94930
Lithographers	4	92400
Lithographic printers	4	92200
Livestock farmers	8	61260
Livestock workers, general or nfs	6	62410
Livestock workers, nec	6	62490
Lock and gate keepers	5	98700
Lock keepers	5	98720
Locksmiths	4	83700
Lumbermen, loggers and kindred workers	5	63120
Machine makers, builders and fitters	4	84130
Machinists	4	83400
Mail carriers [aka Postmen (UK)]	3	37030
Mail sorters	3	37050
Makers of soft drinks	4	77870

Occupation Title	Occupational Class	NAPP HISCO Code
Maltsters	4	77830
Manufacturer's and sales agents	1	43030
Manufacturers nfs	1	21120
Manufacturers or proprietors of specified manufacturing concerns	1	21130
Marble mason	4	95160
Marblers	4	95960
Marine engineers	2	2440
Marine superintendents (deck)	2	4270
Market garden labourers	6	62720
Market gardeners	8	61240
Mason nfs or combined	4	95110
Material handling equipment operators nec	5	97900
Mathematicians and actuaries, etc.	2	8000
Matrons	7	52040
Mattress makers	4	79640
Meat cannery workers and other meat preservers (not sausages)	5	77380
Mechanical engineer (motors and engines, except marine)	2	2430
Mechanical engineering technicians	2	3240
Mechanical engineers, general or nfs	2	2410
Mechanics	4	84110
Medical and related assistants	2	6500
Medical doctors and physicians (UK: Medical doctors only)	2	6110
Medical doctors, nec	2	6190
Medical nurses, untrained or level of training unknown	2	7220
Medical scientists	2	5200
Members of religious orders	2	14140
Merchants, specified large-scale wholesaleing	1	41015
Messengers	3	37040
Metal annealers, temperers and hardeners	4	72600
Metal casters and workers in metal casting plants	4	72400
Metal drawers and workers in metal drawing	4	72700
Metal grinders and sharpeners	4	83530
Metal melters and reheaters, and workers in metal melting mills	4	72300
Metal moulders and coremakers	4	72500
Metal platers and coaters	4	72800
Metal polishers and finishers	4	83520
Metal rollers	4	72200
Metal smelter and furnacemen	4	72100

Occupation Title	Occupational Class	NAPP HISCO Code
Metal Turners	4	83320
Metal workers, specialisation unknown	4	72000
Metallurgical technicians	2	3260
Metallurgists and assayers	4	2600
Metalworking machine operators	4	83310
Midwives	2	7320
Military officers	2	58420
Military, rank unknown	5	58410
Millers and related workers	5	77100
Milliners	4	79320
Millwrights	4	84120
Mine surveyors	2	3030
Mineral or stone treaters	5	71200
Miners	5	71120
Mining engineers	2	2700
Mining technicians	2	3270
Ministers of religion	2	14120
Missionaries	2	14130
Money collector	3	33150
Monthly nurses	2	7330
Music teachers	2	17130
Musical instrument maker nfs	4	94110
Musical performers and musicians nfs	2	17110
Nailer and nail makers	4	83850
Navvy, excavator and diggers, nfs	6	97410
Net maker	4	75920
Newsvendors	1	49040
Non-metallic mineral product makers	4	94300
Notary	2	12300
Nursemaids	7	54040
Nursery labourers	6	62730
Nurserymen and florists	8	61250
Nurses nfs	2	7200
Nursing aids and attendents	2	59940
Occupational title unclassifiable	9	99300
Oculist	2	6170
Office clerks, specialisation unknown	3	39310
Office machine operators	4	34000
Oil mill workers	4	74500
Oil Producer	1	21141
Optical instrument makers and workers (not opticians)	4	84230
Opticians and optometrists	2	7500

Occupation Title	Occupational Class	NAPP HISCO Code
Orchardists and fruit farmers	8	61230
Organ builder	4	94140
Osteopaths	2	7920
Other (specialised) metal workers	4	72900
Other animal workers [e.g., dogs, elephants]	6	62920
Other baked goods makers	4	77690
Other barbers, hairdressers and related workers	5	57090
Other blacksmiths, hammermen and forgeing-press operators	4	83190
Other charworkers, cleaners and related workers	5	55290
Other cloth and related product manufacturing workers	4	79990
Other coal product makers [e.g., coke]	4	74390
Other compositors and typesetters	4	92190
Other correspondence and reporting clerks	3	39390
Other crew of boats, ships, etc.	5	98190
Other drinks makers and workers	4	77890
Other electrical fitters and related electrical workers	4	85990
Other fishermen, hunters and related workers	5	64990
Other food and beverage processors	4	77990
Other food and drink service workers	5	53290
Other forestry workers	5	63290
Other freight handlers	5	97190
Other furniture makers	4	81190
Other garment makers	4	79190
Other hat makers	4	79390
Other hospitality and entertainment keepers and managers	1	51090
Other housekeeping service supervisors	7	52090
Other jewellery and precious metal workers	4	88090
Other law enforcement officers	2	58290
Other leather goods makers	4	80390
Other machinery fitters and machine assemblers	4	84190
Other makers of wooden products	4	81990
Other mechanical engineers	2	2490
Other Medical, Dental, Veterinary and Related Workers	2	7990
Other members of the armed forces	5	58430
Other metal grinders, polishers and tool sharpeners nec	4	83590
Other metal workers nec	4	83890
Other metal working machine operators	4	83390
Other ministers of religion	2	14190

Occupation Title	Occupational Class	NAPP HISCO Code
Other musical instrument makers and tuner	4	94190
Other nursery workers and gardeners	5	62790
Other owners of large scale productive enterprises	1	21190
Other paper product makers	4	91090
Other plant workers [e.g., gathers of herbs etc.]	6	62930
Other printers and related workers	4	92900
Other production or related worker, specialisation unknown	4	94910
Other professional, technical and related workers nec	2	19990
Other protective service workers	5	58900
Other road, railway and related construction labourers	6	97490
Other roofers	4	95390
Other sales personnel men, shop assistants and demonstrators	1	45190
Other Service Workers nec	5	59990
Other sheet metal workers	4	87390
Other ship builders	4	87590
Other ships' deck officers and pilots	2	4290
Other specialised farmers	8	61290
Other specialised painters nec	4	93190
Other specialised textile workers nec	4	75990
Other specialized agents	1	43090
Other specialized instrument makers (not musical instrument makers)	4	84290
Other specific glass makers	4	89190
Other specified clerks	3	39900
Other specified contractors	1	21290
Other specified creative artists	2	16190
Other specified leather curers	4	76190
Other specified servants	7	54090
Other stationary engine and related equipment operators	4	96900
Other street traders [for coffee and food?]	1	45290
Other structural metal preparers and erectors	4	87490
Other surveyors	2	3090
Other teaching personnel	2	13990
Other telephone/telegraph operators	3	38090
Other tobacco product makers	4	78400
Other tool makers and metal markers	4	83290
Other transport equipment operators	5	98900
Other welders, braziers, solderers	4	87290
Other wooden construction workers	4	95490
Other woodworking machine operators	4	81290

Occupation Title	Occupational Class	NAPP HISCO Code
Other workers in meat preparation	5	77390
Others drivers	5	98690
Others hand sewers	4	79590
Others in agricultural or husbandry	6	62990
Others in building construction	4	95990
Others in construction	4	95190
Others in logging and wood cutting	5	63190
Others in machinery	4	84900
Others in music	2	17190
Others skilled railway workers	5	98490
Others working in mines and quarries	5	71190
Others working in upholstery jobs	4	79690
Others writers	3	15900
Oyster farm workers	5	64930
Packers	5	97150
Paint and varnish makers	4	74620
Painters, construction	4	93120
Painters, nfs	4	93110
Painters, ship	4	93130
Paper and paperboard products makers, except boxes	4	91020
Paper box makers	4	81730
Paperhangers	5	95920
Papermill machine operators and paper makers	4	73300
Patent Agents	1	19920
Pattern makers nfs and nec	4	83230
Paviours	4	95150
Pawnbrokers	1	49020
Performing artists nec	2	17900
Personal servants and valets	7	54030
Pharmacists	2	6400
Photo-engravers	4	92500
Photographers	3	16300
Physical science assistants and technicians	2	1400
Physical scientists nec	2	1300
Physicians (UK only)	2	6120
Physicists	2	1200
Piano maker	4	94120
Piano tuner	4	94130
Pig workers	6	62440
Pipe coverers and Insulators	4	95600
Pipe fitters	4	87130
Plasterers	4	95140

Occupation Title	Occupational Class	NAPP HISCO Code
Plumbers	4	87120
Policemen and detectives, employer unknown	2	58210
Policemen and detectives, private service	2	58230
Policemen and detectives, public service	2	58220
Pork butchers	4	77320
Porters	5	97140
Post office, mail, and message workers nec	3	37090
Postal, mail and telegraph clerks	3	37010
Postmasters or postmistresses	3	31050
Postmen	3	37020
Pottery and porcelain makers and workers	4	89200
Pottery and porcelain painters	4	89500
Poultry farmers	8	61280
Printers nec	4	92000
Printers nfs	4	92110
Prison keepers and guards	5	58500
Producers, performing arts	2	17400
Production and related workers nec	4	94990
Professional engineers nec	2	2900
Professional engineers, specialisation unknown	2	2000
Proprietor nfs	1	21110
Proprietor, finance	1	21180
Proprietor, mining, quarrying, oil and natural gas extraction	1	21140
Proprietor, other transport and communications	1	21160
Proprietor, public utilities (i.e., water, gas, etc.)	1	21170
Proprietor, railway company	1	21150
Prostitutes	5	59300
Pub, saloon, tavern and coffee house keepers	1	51050
Public health physicians	2	6160
Publisher	1	21192
Quarrymen	5	71130
Railroad, railway clerk	3	39600
Railway breakmen	4	98420
Railway builders, workers and labourers	6	97430
Railway clerk (UK) or railway agent (CAN/US)	3	33200
Railway freight handlers	5	97130
Railway guards (UK) and Railroad Conductors (US/CAN)	3	36020
Railway signallers	5	98430
Railway switchmen and shunters	5	98440
Railway/railroad engineers and enginemen	4	98320
Railway/railroad firemen and stokers	4	98330

Occupation Title	Occupational Class	NAPP HISCO Code
Real estate agents	1	44130
Refuse collectors and removers	5	55250
Restaurant keepers and managers	1	51030
Riggers nec or nfs	5	97210
River drivers	5	63130
Rivetters nec	4	87430
Road builders, workers and labourers	6	97420
Roofer, specialisation unknown	4	95310
Rope makers	4	75700
Rubber product makers	4	90100
Saddlers and harness makers	4	80320
Sail, tent and awning makers	4	79920
Salespeople, wholesale or retail trade	1	45120
Salt makers	4	74420
Sanitarians	2	7940
Sausage makers	4	77350
Saw makers	4	83820
Saw, spade, shovel and half wood/half metal agricultural instrument type things	4	83830
Sawyers and other titled wood/sawmill operatives	4	73200
Sawyers, woodworking	4	81220
Scaffolders	4	95440
School administrators and principals	2	13300
Scrap and junk dealers, scavengers	1	49030
Sculptors	2	16120
Seal hunters	5	64960
Seamen	5	98120
Seamstresses	4	79520
Servants nfs	7	54010
Sewers and sewing machine operators	4	79530
Sewing machine makers and builders	4	84150
Sheep workers	6	62430
Sheet metal worker, general	4	87320
Sheriffs and their deputies	2	58240
Ship and boat builders	4	87520
Ship and boat pilots	4	4260
Ship boat loaders and dock workers	5	97120
Ship construction engineers	2	2450
Ship riggers	5	97220
Ship’s carpenters	4	87540
Ship's cooks [UK only]	4	53103
Ship's engine men	5	98200

Occupation Title	Occupational Class	NAPP HISCO Code
Ships' engineers	2	4300
Ship's masters and captains (inland waterways)	2	4240
Ship's masters and captains (sea or inland waterways)	2	4230
Ship's masters and captains (sea)	2	4220
Ship's navigating officers and ship's mates	2	4250
Ships' officers nfs	2	4210
Ship's pursers	2	51060
Shipwrights and ship joiners	4	87530
Silversmith	4	88040
Ski makers	4	81930
Slate and tile roofers	4	95320
Slaughterer, meat cutters or meat packer	4	77340
Sleeping- or pullman-car attendants	3	36030
Soap and perfume makers	4	74730
Social scientists and historians	2	19200
Social workers	3	19300
Solicitors	2	12130
Specialised makers of forged metal products	4	83160
Specialised occupations in the boot and shoe making industry	4	80200
Specialised physicians	2	6140
Specialised surgeons	2	6150
Specified chemical workers nec	4	74990
Speculators	1	21340
Spinners, doublers, twisters and winders	4	75200
Starch makers	4	74930
Stationary engineers and engine men	4	96230
Stationary firemen and firemen nfs	4	96240
Stereotypers and electrotypers	4	92300
Stewards	7	52030
Stock, weight and shipping clerks	3	39100
Stockbrokers	1	44140
Stone carvers or cutters and stone yard workers	4	82000
Stone masons	4	95130
Straw hat makers	4	79340
Street traders	1	45220
Structural metal workers	4	87420
Sugar refiners	4	77200
Superintendents and managers nfs	2	22110
Superintendents and managers, commerce	2	22180
Superintendents and managers, construction, except railway construction	2	22170

Occupation Title	Occupational Class	NAPP HISCO Code
Superintendents and managers, manufacturing	2	22120
Superintendents and managers, mining, quarrying, etc.	2	22130
Superintendents and managers, nec	2	22190
Superintendents and managers, other transport and communications	2	22150
Superintendents and managers, public utilities	2	22160
Superintendents and managers, railways	2	22140
Surgeons	2	6130
Surveyors, general and nfs	2	3010
Tailors and tailoresses	4	79120
Tallow chandlers, candle makers and grease makers	4	74720
Tanners	4	76130
Tanners or fellmongers, specialisation unknown	4	76110
Tar makers	4	74340
Tax assessors	3	31030
Tax collectors	3	31020
Tea, coffee and cocoa preparers	4	77700
Teachers (of the disabled)	2	13250
Teachers (pre-primary)	2	13240
Teachers (primary)	2	13230
Teachers (secondary)	2	13220
Teachers (unspecified)	2	13210
Teachers in higher education	2	13100
Teamsters (inc. mine driver, etc.)	5	98670
Technicians	2	3210
Tel. operator	3	38010
Telegraph operator	3	38030
Telephone and telegraph installers	4	85600
Telephone operator	3	38020
Textile printers	4	92800
Textile workers, specialisation unknown	5	75000
Thatchers	4	95330
Timber cruisers	5	63240
Timekeepers, factory	3	39730
Timekeepers, railway	3	39720
Timekeepers, undefined and nec	3	39790
Tinsmith, tinner or tinker	4	87340
Tire makers and vulcanisers	4	90200
Tobacco preparers and tobacco factory workers	4	78100
Toll collectors	3	33170
Tool and die makers	4	83220
Tool makers nfs	4	83210

Occupation Title	Occupational Class	NAPP HISCO Code
Toy and doll makers	4	94940
Trained nurses	2	7110
Transport conductors, nec	3	36090
Trappers or hunters	5	64970
Trunk or bag maker	4	80330
Turpentine makers	4	74940
Typists, stenographers and secretaries	3	32000
Umbrella makers	4	79930
Undertakers and embalmers	1	59200
Underwriters	1	19930
Upholsterers (except vehicle)	4	79620
Vehicle trimmers and upholsterers	4	79630
Veterinarians	2	6300
Vinegar makers and workers	4	77850
Waiter or waitress	5	53220
Washing and laundry services	5	56000
Watch and clock makers	4	84220
Watchmen and guards	5	58300
Waterway and harbour builders, workers and labourers	6	97440
Wax and polish makers	4	74750
Weavers	4	75400
Weaving and knitting-machine setters and pattern-card preparers	4	75300
Welders	4	87220
Well drillers, borers and related workers	5	71300
Whale hunters	5	64940
Whale or seal hunters	5	64950
Wheelwrights [and cartwrights]	4	81400
Whitewashers	5	95940
Wicker furniture makers	4	81140
Window cleaners	5	55230
Wine workers	4	77840
Wire makers	4	83860
Wood carvers	4	81250
Wood cutters and choppers	5	63140
Wood planers	4	81240
Wood treaters	4	73100
Wood turners and handle makers	4	81230
Wooden box makers	4	81720
Wooden tool makers	4	81920
Woodsmen and workers in the woods, nfs	5	63110

Occupation Title	Occupational Class	NAPP HISCO Code
Woodworkers	4	81210
Worker nfs	6	99150
Workers in religion nec	2	14900
Working with gems and stones	4	88050

Curriculum Vitae

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Post-secondary Education and Degrees:

Eastern Michigan University
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2006-2009 B.Sc., Geography w/highest honours
B.Sc., History

The University of Western Ontario
London, Ontario, Canada
2009-2014, Ph.D., Geography

Select Honours and Awards:

Vanier Canada Graduate Scholar – 2011-2014
Fellowship, National Endowment for the Humanities – 2012
Pass with Distinction, PhD Comprehensive Examination – 2012
Carville Earle Award, AAG – 2011
ESRI Canada Ltd. Graduate Student Award – 2011
Ontario Graduate Scholarship – 2010
Best Paper Award, *Journal of Maps* – 2009
SSHRC Canada Graduate Scholarship- Master's – 2009

Select Publications:

Lafreniere, D., and Gilliland, J. 2014. All the World's a Stage: A GIS Framework for Recreating Personal Time-Space from Qualitative and Quantitative Sources. *Transactions in GIS*. doi: 10.1111/tgis.12089

Dunae, P., **Lafreniere, D.**, Gilliland, J., and Lutz, J. 2013 Dwelling Places, Social Spaces: Revealing the Environments of Urban Workers in Victoria using Historical GIS. *Labour/Le Travail* 72, 37-73.

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