Street Network Morphologies: On the Characterization and Quantification of Street Systems. A Case Study in Montréal.

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Abstract

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This study aims at understanding the spatial dynamics of the street system in residential sectors of Montréal. Different periods of development have produced street networks displaying a diversity of characteristics and configurations. Yet all these different pieces are spatially interconnected implying that they are part of a functional whole. In the course of the historical evolution of the city the new pieces of the network are connected to pre-existing rural roads from which they often stem. However, while responding to a set of internal functional rules and technical requirements, the street system does not deploy in autarchy. Rather, it is integrated within a broader spatial framework comprised of natural and human-made features such as the hydrographic system, the topography, the agricultural allotment system and in more recent times, of components of technical systems such as canals, railroads and high-capacity transportation infrastructure. By delving into the differing street networks geometries as well as into the barriers and boundaries that spatial discontinuities, the project sets about identifying the *"parts"* in order to understand their inner characteristics as well as the modalities of their articulation to the *"whole."* We hence define neighbourhoods as areas predominantly residential which exhibit some degree of internal homogeneity in regards to block geometry, street network configuration and refer to these areas as *"morphological neighbourhood areas,"* or simply, MNAs. A variety of quantitativea and qualitative methods are mobilized with the purpose of delimiting MNAs in the Island of Montréal. Subsequently, with MNAs as our unit of reference, a classification of urban neighbourhoods is proposed based on quantifiable spatial properties of the urban tissue, which include attributes pertaining local street network geometries, and part-to-whole topological relationships.

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Chapter 1

Introduction

1.1 On Neighbourhood Dynamics

Conceptualizing and defining what an urban neighbourhood is has been a recurrent issue in the urban planning literature, ever since the 19th century. Ranging from Clarence Perry's *Neighbourhood Unit* to *New Urbanism* and more recently to space syntax's *Virtual Community* the planning community has always sought to find a way to circumscribe the neighbourhood as a spatial and/or social entity. Some scholars, such as Lynch (1960), have given preponderance to physical aspects arguing that barriers allow for some sort of organization of the built environment. Rofe (2010), on the other hand, reduces the neighbourhood to the scale of the face-block, "*the two sides of one street between intersecting streets,*" in line with Caniggia & Maffei's (2001) *"contrada."* Hanson and Hillier (1986) brought the idea of neighbourhood defined by the topological properties of the street layout. They argue that the extent to which the space is accessible may create the conditions for the development of *"virtual communities"* which is the potential for encounters and interactions allowed by the configurational properties of the space alone.

This study aims at understanding the spatial dynamics of the street system in residential sectors of Montréal. Different periods of development have produced street networks displaying a diversity of characteristics and configurations. Yet all these different pieces are spatially interconnected implying that they are part of a functional whole. In the course of the historical evolution of the city, for instance, the new pieces of the network are connected to pre-existing rural roads from which they often stem. However, while responding to a set of internal functional rules and technical requirements, the street system does not deploy in autarchy. Rather, it is integrated within a broader spatial framework comprised of natural and human-made features such as the hydrographic system, the topography, the agricultural allotment system and in more recent times, of components of technical systems such as canals, railroads and high-capacity transportation infrastructure.

By devising a method to identify and map urban areas based on the geometrical and topological characteristics of their street networks, which distinguish the latter from the surrounding areas of which they are separated by barriers and other spatial discontinuities, this research tackles a significant issue in many studies of the urban form. When such studies use geographical areas of reference defined based on administrative criteria such as "census tracks," or "dissemination areas." – a highly common occurrence – the zones often encompass highly contrasted physical and spatial realities. Hence, the results of analyses focused on the built environment or on the relationship between the latter and social of environmental conditions, are inevitably suffering. The proposed framework allows for more accurate depiction and measurement of the built environment, while allowing for deeper analyses of the articulations between physical and spatial features and the broader social life that the built landscape supports and enables.

Among an handful of other authors, Jean-Claude Marsan (1974) has unveiled how previous agricultural subdivision practices in the Island of Montréal – a system known as the *"Côtes"* – informed the later development phases, and in particular the urbanization patterns. Montréal inner city neighbourhoods' orthogonal grid for instance is not the result of master planning, but stems rather from the agricultural allotment system, which has acted as a matrix (Marsan, 1974). This study is not morphogenetic in nature: it focuses on the current conditions. Historical circumstances, however, have left "traces" that are still perceptible in the inherited fabric. Some are readily recognizable, such as with the orthogonal street network and some are more elusive, as is the case when more subtle spatial discontinuities are the consequence of previous property subdivision. Chapter 4 of this thesis offers a case in point. A historical map illustrating the agricultural allotment is requisitioned to help mapping boundaries within the urban tissue system.

It is hence posited that a deep understanding of the spatial logics at play in the various residential sectors of Montréal requires that one consider both the local and the global realities of the street system. Such an approach would shed light on the varying local realities, while allowing for comparative analyses. It would also unveil how local portions of the system are articulated between each other and to the whole. The latter aspects will finally contribute to a better understanding of the said *"whole,"* i.e. of the properties, articulations, and configuration of the network in its entirety.

Although street systems are extensively studied by some urban planners, geographers and transportation engineers, studies that address simultaneously both the local and the global scales (i.e. a city as a whole) are relatively rare. It could be argued also that studies that look at the street system at both scales while considering as well the broader urban spatial framework are even less common.

Urban morphologists, for instance, are concerned with space and the material fabric of the city. They conceptualize the built environment as a complex, dynamic, spatial and physical system, which could be analyzed, or *"read"* at different scales and levels of spatial resolution. In that context the road and street system, though considered highly important, constitutes only one of many sub-systems that can only receive limited attention. Transportation engineers study roads networks extensively relying on quantitative methods and graph theory, for instance, while usually eschewing the broader urban physical and spatial context. Urban planners and geographers have spent enormous research efforts in studying the links between street systems, land-uses, the built environment, human activities and social practices in order to understand the particular the conditions that favor or deter active transportation in urban settings. When such studies investigate carefully the impacts of physical and spatial forms on transportation behavior, they tend to focus on a single area, such as a neighborhood, or on a limited sample of urban areas. When attempts are made to consider behavioral patterns or spatial conditions in the city as a whole, the latter is broken down in zones that are generally dictated by administrative subdivisions such as census tracts. Such a strategy can be considered as a limitation since these zones do not necessarily correspond to the morphological reality on the ground, i.e. to areas delineated according to some level of internal spatial homogeneity. Developments in geospatial technologies have facilitated the quantitative analysis of road networks as complex systems particularly allowing for the quantification of their topologies.

Each of the aforementioned approaches has obvious merits. But in spite of their richness and diversity, there remain gaps. Approaches that aim at characterizing and quantifying the street system at the global, or city-wide level, almost never consider the relationships between the said street system and other urban spatial systems that have an impact on its spatial deployment and development (e.g. the geo-morphological systems, or the technical infrastructure and other inherited anthropogenic settings). Moreover, most studies focusing on the street system do not analyze in a systematic way the relations of the local conditions to the citywide system or the relations of the local sectors between themselves. A case in point can be the issue of the urban barriers. Although numerous authors have discussed the impacts of urban barriers on city living, including in some of the most canonical texts in urban planning (Jacobs 1961, Lynch 1960, Mumford 1961, 1962), scientific research on the matter remained surprisingly scarce (Héran, 2011).

This study aims at filling some of these gaps by developing an analytical approach that borrows from urban morphology tradition, while mobilizing an array of quantitative methods to describe, measure and characterize neighbourhoods in regards to the street system within the broader urban physical and spatial system. It seeks to investigate, in particular, how and to what extent urban barriers affect the morphological structure of residential neighbourhoods. Our aim is to analyze the internal configuration of residential neighbourhoods by exploring and assessing the influence that barriers and connections, or lack thereof, have on properties of the street network such as connectivity and integration.

This is a case study set up in the Island of Montreal, although it also includes Île-Bizard and Île des Soeurs since they form part of the municipality of Montréal (Figure 1.1.1). It consists in analyzing the built environment at two levels of spatial resolution: citywide and neighbourhood scale. Drawing from urban morphological studies and space syntax, this project explores how intrinsic characteristics as well as topological and geometrical attributes of barriers impact on some qualities of the urban form. Urban morphology, i.e., the study of the urban form or *“the spatial pattern of large, inert permanent objects in the city”* (Lynch, 1981) provides the theoretical foundation for the understanding of the city as a complex system comprised of interrelated elements. Specifically, the discipline known as *“typomorphology”* or *“typomorphological studies,”* focuses on material objects and spatial configurations in the built environment as well as their evolution over time. Moudon (1994) argues that the study of the urban form is both typological and morphological because it subjects the analysis of urban objects to elaborated classifications of buildings and open spaces by type. Urban morphology conceives the human habitat as a dynamic system in which different objects come to play; this research looks specifically at three categories of such objects: the urban barriers, the *“neighbourhoods”*, and the road system.

Figure 1.1: Study Area, Island of Montréal.

The urban morphology approach here is primarily informed by the theories of urban form that originated in the Italian School of urban morphology and by Space Syntax. Saverio Muratori, founder of the Italian School, postulated that the urban form can only be understood through historical processes (Moudon 1994). Muratori's doctrine was further developed by Gianfranco Caniggia, who along with Gian Luigi Maffei, compiled and published the book *Composizione Architettonica e Tipologia Edilizia* (1979), later translated to English (Caniggia and Maffei, 2001).

Caniggia & Maffei provide a theoretical framework for the classification of the arterial system as part of their conceptualization of the *'urban tissue formation process'* and *'model of hierarchical structure'* whereas Bill Hillier, founder of the *space syntax* approach along with Julienne Hanson, contributes with both a theoretical ground for the conceptualization of urban neighbourhoods and a methodological approach that allows for the quantification of some properties of the urban form.

This research project develops an analytical approach based on urban morphology tradition while mobilizing an array of quantitative methods to describe, measure and characterize residential urban neighbourhoods.

1.2 Rationale and Research Objectives

The objective of this research project is to explore how and to what extent topological properties of the street network, geometrical characteristics of the urban fabric, and elements acting as barriers or boundaries affect the internal morphological structure of residential neighbourhoods keeping in mind how, by extension, the spatial distribution of human activities and patterns of movement are deeply informed by such morphological conditions.

The project consists in analysing the built environment at two levels of spatial resolution: global scale and local scale. At the global or citywide scale, we first create a morphological matrix of residential tissues. Borrowing from MacDougall's (2011), we propose a fragmentation geometry defined as residential tissues delineated by barriers. A fragmentation geometry is defined as *''the set of particular fragmenting elements of the environment that are appropriate for the investigation of the system affected''* (Jaeger, 2000).

At the local, or neighbourhood scale, we analyze the urban fabric not only in regards to physical barriers but also in relation to some topological properties revealed by space syntax, allotment system, and early subdivisions of land. While MacDougall's fragmentation geometry method is quite satisfying for defining patches of residential land use, urban neighbourhoods are not all made equal. Some residential patches may be very homogeneous in regards to their internal street pattern configuration. However, other patches may display a variety of street network conditions that point to the presence of different neighbourhoods. In consequence, we propose a second morphological matrix. The idea is to delineate areas that display common characteristics that distinguish them from surrounding areas. This matrix is based, on the one hand, on quantitative properties the urban tissue, such as intersection density and type; block orthogonality, compactness, and orientation; and indicators of connectivity and integration derived from space syntax. In addition, we use an 1890-map of Montréal (Figure 1.2.1) that shows ancient roads and old agricultural subdivisions of land in conjunction with Montréal's 2014 allotment system and space syntax to achieve a finer delineation of morphological units.

This research project, thus, mobilizes urban morphology theory, space syntax, and geometrical indicators for defining neighbourhood morphological areas (MNA). MNAs are

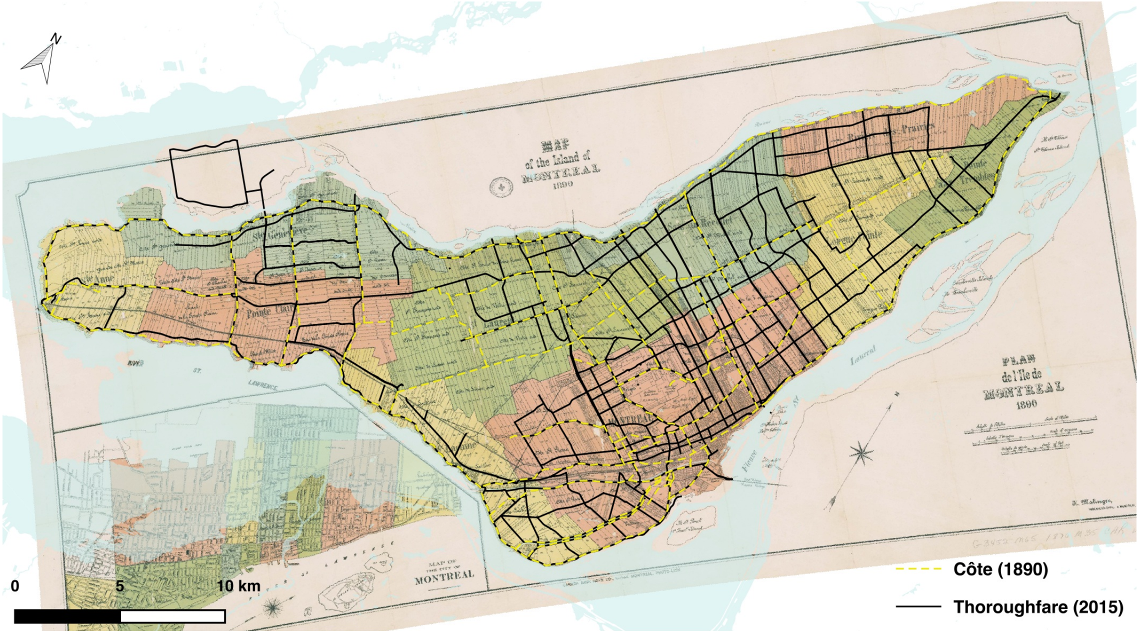


Figure 1.1: Agricultural subdivision of land and country side roads in 1890 and major roads in 2015.

subsequently subjected to a principal component analysis (PCA) and are classified using hierarchical clustering. The contribution of the thesis is two-fold. First, as transpires from the preceding paragraphs, it makes an original methodological contribution by devising an approach that allows for the characterisation, quantification, and from there, the delineation and classification of *morphological neighbourhood areas* based on street patterning. Secondly, in doing so, this research produces original knowledge on Montréal's island urban form. Such knowledge, we argue, could be of great interest for urban and transportation planners.

1.3 Thesis Structure and Organization

This thesis is organized in 6 chapters. Chapter 1 provides an introduction to the research topic, and presents rationale and objectives. Chapter 2 provides a review of some pertinent literature on urban morphology, space syntax, and landscape fragmentation. Following, chapter 3 introduces the general methodological approach while chapter 4 delves into the morphological analyses carried out to delineate MNAs. Chapter 5 presents a taxonomy of MNAs in Montréal as well as the detail of the methods developed to achieve such results. Chapter 6 provides a brief discussion of the results and conclusion.

Chapter 2

Literature Review

2.1 Introduction

The theoretical framework of this project is primarily informed by the urban morphological principles developed by Saverio Muratori, and continued later by Gianfranco Caniggia and Luigi Maffei from the Italian School of urban morphology. However, the British as well as the French schools contribute some important ideas to our study of the urban form and for that reason they are briefly reviewed in this section. Additionally, this chapter exposes the reader to space syntax theory, highlighting its main principles and methods applied in this project. Following, a section briefly introduces landscape fragmentation theory and the chapter closes with a comprehensive discussion on urban barriers.

2.2 Urban Morphology

Urban morphology refers to the study of the urban form. The Italian approach is usually referred to as *"typomorphological analysis,"* and more rarely as *"process typology."* Typomorphological analyses seek to unveil the system of the built environment by seizing the spatial and physical structure of cities using detailed typifications of buildings and open spaces to describe the urban form. Typomorphological analyses take into account all scales of the built landscape working at different levels of spatial resolution: from rooms within buildings to the urban region. Typomorpholgy considers the built environment as a dynamic process stemming from a dialectical relationship between producers and inhabitants that takes place over time (Moudon 1994). From a typomorphological perspective, the concept of *"type"* refers to the built landscape, i.e., buildings and open spaces and their relationship to the lot; to the subdivision of land; and to the study of the urban form in a morphogenetic manner, rather than morphological, since its proponents argue that the study of the city can only be understood historically (Moudon, 1994).

The study of the urban form has given place to the development of several schools of thought, among which are those that have emerged in England, Italy, and later on in France. The most prominent figures of the English and Italian schools were, respectively, M.R.G. Conzen, a German geographer who immigrated to the United Kingdom before WWII, and Saverio Muratori, an Italian architect and scholar. Gauthier & Gilliland (2006) point that, regardless their disciplinary and geographical situation, the different schools of urban morphology share a common ground in that they explore the spatial form of the city and the built environment as a dynamic, and relatively autonomous system.

The authors propose a classification scheme for understanding contributions from different theoretical approaches to the study of urban form, making a first distinction between cognitive and normative approaches. Cognitive stances, they posit, involve the production of knowledge or else the formulation of methods and techniques aimed at sustaining the production of such knowledge. Normative approaches, on the other hand, seek to develop or expose doctrines and rules acting as prescriptions for future practice. They further differentiate the urban morphology between what they deem internalist and externalist approaches. The former understands the built environment as a rather independent system, while the latter considers it as the result of a process essentially driven by historical, geographical, economic, political, anthropological, and perceptual agents. Researches in the British, Italian and French schools, particularly, seem resolved in their attempt to capture *"the empirical reality of the city,"* i.e. the form of the urban fabric, and in investigating the complex characteristics of these forms (Gauthier & Gilliland, 2005). Gauthier & Gilliland synthesize and graphically map the different contributions to the study of the urban form by means of a Cartesian grid (Figure 2.2.1), in which they expose how theoretical approaches seemingly different in their treatment of the urban form as an object of inquiry are equivalent from an epistemological perspective .

In the recent decades a new discipline termed Space Syntax has emerged in the urban morphology field. Bill Hillier and Julienne Hanson laid out the fundamentals of their new theory of space in the book *The Social Logic of Space* (1984). Bill Hillier further developed these ideas in *Space is the Machine* (1996). Space syntax establishes a series of principles and quantitative techniques based on interpretation of derived maps as a method for understanding social relations and urban form. Space syntax allows for the quantification of

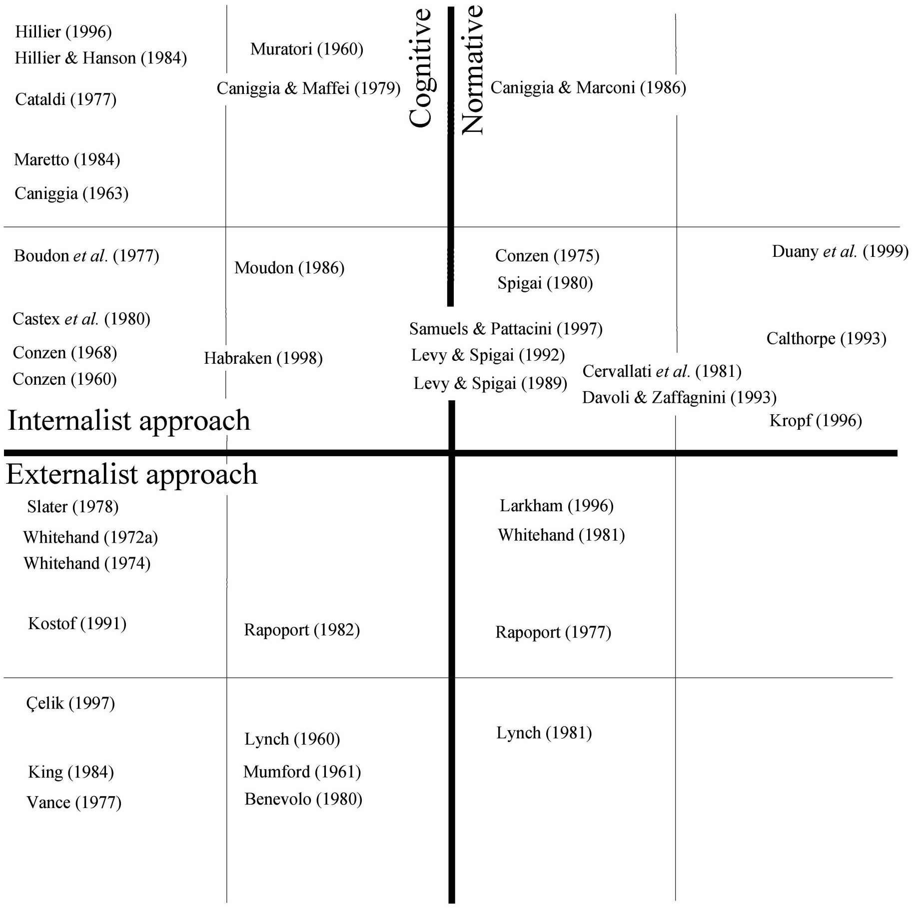


Figure 2.1: Contributions to the study of the urban form. A classification scheme. Gauthier & Gilliland (2005).

structural properties of the urban form using spatial analyses and statistical methods. It is an innovative concept that brings together a theoretical ground towards the study of space and a computer-based approach to investigate elements of the city that had been thus far examined only in qualitative or systemic terms (Sima & Zhang, 2009).

In accordance with Gauthier & Gilliland's (2005) classification scheme, the theoretical approaches of reference for this study, namely, from the so-called English, French, and Italian schools of urban morphology, as well as Space Syntax, fall within the cognitive/internalist category. In other words, the concepts and methods mobilized aim at explaining aspects of the built environment considered as a system of its own. The following sections discuss all three schools of urban morphology; however, a major emphasis is put on the Italian School, since its formulations, along with those from space syntax, inform the theoretical core of this research project.

The British School

The British school is primarily dominated by scholars interested in understanding morphogenetic processes. Its major figure was M.R.G. Conzen, a German geographer established in Great Britain who was highly concerned by the effects that modernist town planning was having on pre-modern urban landscapes. Such interest led him to develop a theoretical framework and methodology intended for research purposes, which consisted in describing and explaining how landscapes evolve through time (Moudon, 1994). His work primarily focused on the study of three elements of the city that he identified in the city landscape, which he termed, the *"townscape:"*

1. The town plan, a two-dimensional cartographic representation of the city consisting of a town's physical layout.
2. The building fabric, which is composed by the buildings and open spaces that make up the city.
3. Patterns of land and building utilization (Conzen, 1960, p. 4).

Conzen referred to this method as *"town-plan analysis."* It consisted in surveying how towns change over time through the analysis of cartographic representations of the built fabric (town plans) at different periods of development (Moudon, 1994). More specifically, his work focused on the analysis of streets, plots and buildings in medieval towns, with special emphasis put on the burgage (Figure 2.2.2), a type of plot of land that is deep and narrow. Conzen describes the town plan a compound of several plan units distinguishable from one another in terms of road configuration, allotment system, and built forms and volumes (Conzen, 1968). Scholars such as Moudon (1994) and Whitehand (2003) posit that the Conzenian methodology ignores individual buildings and focus, rather, in building fabrics.

Figure 2.2: Burgage blind-back housing, High Street, Huntingdon, England. Whitehand, J. W. R., et al (2014)

In 1980, historical geographers at the University of Birmingham formed the Urban Morphology Research group following the Conzenean approach. Among this group was T.R. Slater, who in line with M.R.G. Conzen, centred his research on the town-plan of medieval towns, and J.W.R. Whitehand, who focused his investigation on urban economics by exploring relationships and dynamics between the urban form and the industrial aspects of the city.

Moudon (1994) claims that his development of methods of analysis for the actual city allowed Conzen to produce *“the most thorough, detailed, and systematic typomorphological method of the three schools.”*

The French School

The French school emerged in Versailles in the late 1960s. Following the Muratorian tradition, French scholars believed that modernism had created an irreparable rupture with the past that needed to be amended by rediscovering the essence of architecture in past traditions. The Versailles School fostered a multi-disciplinary cooperative approach seeking to improve the understanding of the city, that brought together sociologists, historians, geographers, planners, and architects. In consequence, its typomorphological approach involved literary and social science stances rather than being exclusively dedicated to geography and design issues (Moudon, 1994).

The development of the French School is in part due to the influence that the ideas of sociologist and philosopher Henri Lefevre had on students, and particularly, on future architects and urbanists among them. Lefevre claimed that the focus of post-World War II house production was destroying French social practices. He argued that the ultimate goal of social life, appropriation, was being threatened by contemporary methods of house production, undermining the relationship between the society and the environment. The postulates of the French School promoted a more interdisciplinary approach and a reconciliation with the social sciences pushing for a more socially responsive and responsible architecture (Moudon, 1994).

Unlike the British and Italian schools, the French School took a more interdisciplinary stance in relation to the study of the urban environment by investigating the relationships between urban form and social phenomena. Yet the French and Italian schools concur in the need to consider different levels of spatial resolution. Though largely informed by the Italian theories and methods, French morphologists' work moved away from the Italian focus on the type. They assert that the study of the urban environment requires of a more flexible system of varying criteria chosen on a trial and error basis that will be dependent on the nature of the phenomena under investigation involving a critical assessment of design theory (Moudon, 1994).

The Italian School

The Italian School of urban morphology and building typology was founded and developed during the 1950s and 1960s by Italian architect and researcher Saverio Muratori while he was working at University of Venice and University of Rome. He believed that the architectural and planning crisis of the time was caused by Modernism, which had produced a rupture from traditional building and planning practices. Muratori observed that under modernist principles the study of the city was carried out by dismembering it and isolating its components from context (Pinho and Oliveira, 2009). Muratori conceptualized the city as a complex living organism which was under constant transformation, and that could only be understood by analyzing its urban and architectural elements from a historical perspective (Menghini, 2002).

The centerpiece of Muratori's approach is the study of the building type or *"process* *typology."* Muratori argued that type is linked to a specific time, a historical moment, and a place, that inform how the different objects that make up the urban fabric relate to each other. Muratori discovered that there was a spatial dynamic linking the urban fabric and the natural landscape. He identified this spatial dynamic in regards to the adjustments that buildings construction underwent in regards to topography; but this dynamic was also revealed by the existence of typical land forms, such as valleys or escarpments, accompanied by typical modes of human intervention (Menghini, 2002).

Muratori's work was further developed by Gianfranco Caniggia who turned it into the investigation of building type as the nucleus of the urban form (Moudon, 1997). Caniggia laid out his and Muratori's theories on typology and urban morphology in the book *Composizione architettonica e tipologia edilizia* (1982), written conjointly with architect and urbanist Gian Luigi Maffei. Caniggia focused his analysis on the built environment as a complex system in which there are four discernible levels of spatial resolution: the building, the urban tissue, the city, and the region (Larochelle and Gauthier, 2002). The built environment presents itself as an intricate system comprised of simple components and subsystems. Depending upon the scale of the analysis, an object such as a house, for instance, would be considered as a complex system (comprised of multiple components and subsystems) or as a simple component of the urban tissue (Caniggia & Maffei, 2001). One key argument by Caniggia and Maffei is that recognizable configurations denote the fact that the built environment is not a collection of discrete objects. Rather, in their spatial arrangement, objects conform to rules. Such rules are obeyed to unconsciously for the most part by the social agents. They enact cultural models, i.e. "types", similarly to the rules that govern language that are enacted in the act of speaking (Gauthier and Gilliland, 2005). Recognizable sets of characters and configurations allow the researcher to identify building types. Similarly, recognizable patterns in the urban fabric reveal typical tissues (i.e., urban tissue types) (Caniggia & Maffei, 2001).

Caniggia and Maffei (2001) argue that the urban tissue is a system comprised of objects that belong to three subsystems: the buildings (and the built fabric); the lots (and the allotment system); and the streets (as a part of the street system). Routes are not only structures aimed at providing connection between places but also at providing access to construction sites. Buildings, even if isolated, require routes to connect them to other buildings or places. Along a route, buildings' fronts reveal the *"conformation modularity of the aggregate,"* consisting of the built lot, which includes the built structure itself plus the *"pertinent area."* Pertinent area refers to the open space associated with each building on its lot and the term *"pertinent strip"* applies to the area facing and served by each route that contains the built lots (Caniggia & Maffei, 2001) (Figure 2.2.3).

Empirical analyses allowed morphologists in the Italian school to identify four categories of streets: the matrix route; the planned building route or settling route; the connecting route and the break-through route (Caniggia & Maffei, 2001). A matrix route is a route that pre-exists building development. It emerges as a route running in the countryside connecting two poles (two urban centers, for example) while minimizing the distance. However, topography or other obstacles may confer it a curvilinear shape. As a part of the initial stage of the urbanization process, building lots emerge on both sides of the road creating two parallel and continuous pertinent strips. Typically, the pertinent strips are symmetrical as long as the course of the matrix route is not interrupted by the natural elements, such as rivers or escarpments.

Planned building routes, in second place, are roads that develop perpendicularly to matrix routes usually following a rectilinear path in order to accommodate building lots developed orthogonally. Pertinent strips typically emerge at both sides of the road beginning at the limit of the matrix route's pertinent strip. Connecting routes emerge as joining planned building routes. The most important outcome of the connecting route for the urban form is that it allows for the delineation of the city block. Between intersections, pertinent strips on both sides of the road tend to be more cohesive and consistent since buildings are likely to go appear in synchrony and undergo similar changes throughout time. Caniggia & Maffei (2010) argue that this feature constitutes the basic unit of the urban tissue. To refer to this phenomenon the authors use the term *"contrada,"* which translates to *"face-block."* A *"contrada"* is formed by a street segment between intersections and its adjacent lots (Figure 2.2.3).

Finally, a break-through route is a route that overlaps the existing building tissue providing a more direct link between two poles within the urbanized area (Figure 2.2.4) (Caniggia & Maffei, 2001).

A classical example of a break-through route is the creation of an urban boulevard cutting through existing urban fabrics such as in Haussman's Paris. The concept of urban tissue is central to our work. Though this research focuses on one the tissue's sub-systems, the street network, it acknowledges that urban streets cannot be fully understood without considering the built lots that they support. In other words, the street network's geometry and configuration are in direct relationship with the tissue form. For instance, when delineating urban blocks, the street's geometry of the said blocks is determined by pertinent strips requirements, i.e., by built lots requirementes informed themselves by the architectural types requirements, etc..

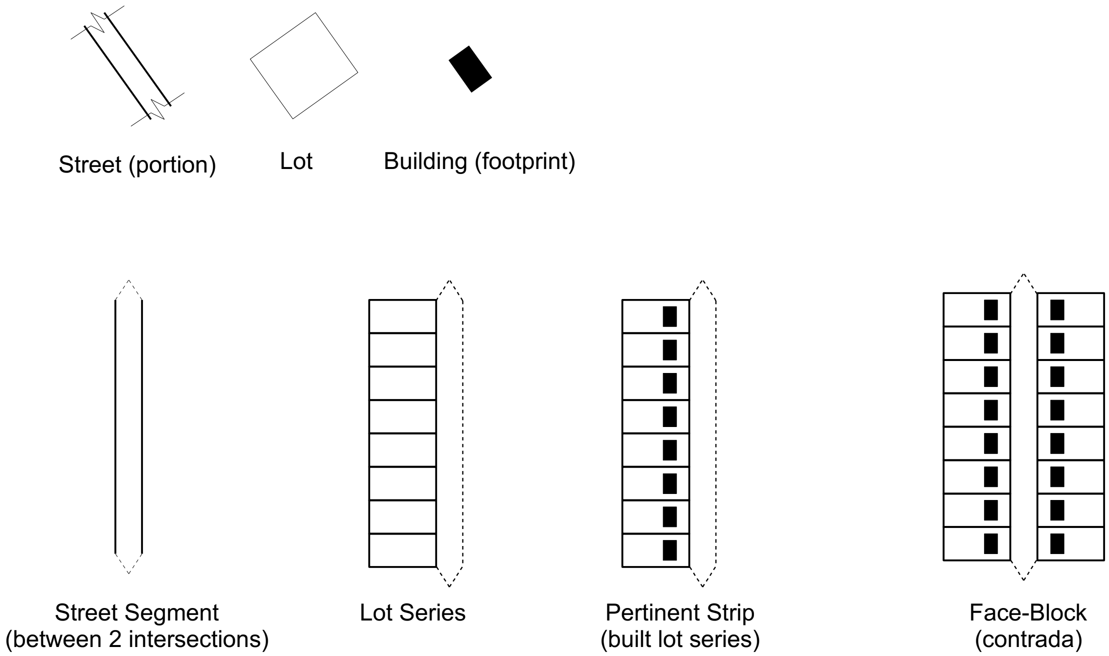


Figure 2.3: Components of the Urban Tissue. Gauthier (2016).

Caniggia and Maffei (2001) stress that though most routes are *“basic streets,”* i.e. regular residential streets, some do assume a specialized function. They argue that the specialization of a street’s function depend upon its relative position within the arterial system. They refer to this scheme as *“model of hierarchical structure.”* In this model, specialized urban roads fall in two broad categories: centralizing nodal axis, and anti-nodal dividing axis. The former represents a street segment which is centrally located and tends to specialize in commercial activities while the latter corresponds to a road specialized in traffic movement that may as well constitute a morphological boundary as we will further discuss later. The adjacent to specialized roads often assume a supportive function.

Accordingly, in Caniggia and Maffei’s model, change in function from the centralizing nodal axis to the anti-nodal dividing axis does respond to a form 4, 3, 2 ... 2, 3, 1, 3, 2 ... 2, 3, 4, where #4 represents an anti-nodal dividing axis and #1 a centralizing nodal

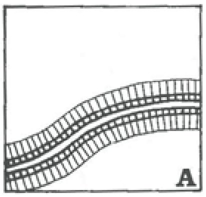
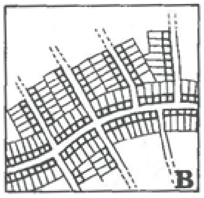
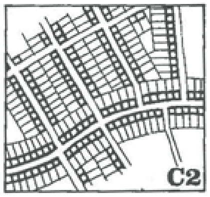
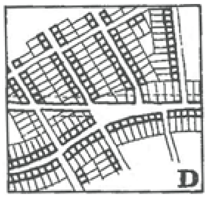
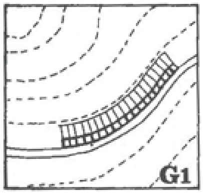
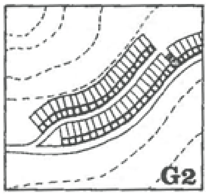
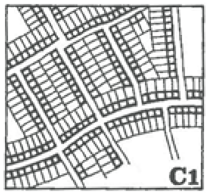
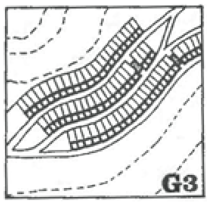
	Matrix Route	**Planned Building Route**	**Connecting Route**	**Break-Through Route**
Synchronic Variant 1				
	A – Building along matrix route	**B** – Building along planned building route.	**C2** – Formation of connecting route between planned building routes. No abutting property.	**D** – Break-through street formation.
Synchronic Variant 2				
	G1 – Matrix route in steep sloping area.	**G2** – Planned building route in steep sloping area.	**C1** – Abutting property on connecting route.	
Synchronic Variant 3				
		G3 – Planned building route in steep sloping area.		

Figure 2.4: Urban Tissue Formation Process (Simplified). Adapted from Caniggia & Maffei (2001).

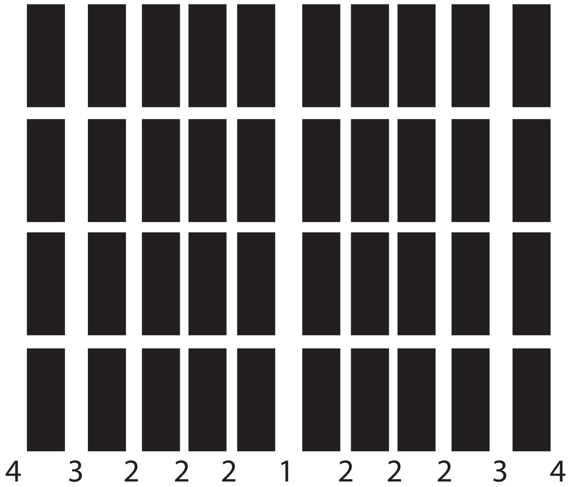


Figure 2.5: Model of street specialization. Adapted from Caniggia & Maffei (2001).

axis. Number 2 accommodates regular residential streets and #3 a supporting function to specialized streets #1 (commercial) and #4 (heavy traffic, parking).

Caniggia and Maffei's model of hierarchical structure displays similarities with the concept of centrality in Bill Hillier's theory of Space Syntax, which assumes that streets centrally located (and better connected to the road network) attract more movement than peripheral streets.

This section has introduced the concept of urban tissue and has discussed the generative process of which the said tissues are the results. Tissues do not exist in isolation obviously; when considered at another level of spatial resolution, for instance, city-wide scale, they are inscribed within a broader morphological matrix. At the city scale, the spatial deployment of basic tissues, i.e., predominantly residential tissues, as well as specialized tissues, that is, non-residential fabrics such as industrial parks or heavy commercial sectors, is informed by other structures either natural or anthropic. As such, the tissues are enmeshed in a nexus of barriers such as cliffs, rivers, railroads, etc.. The tissue formation and spatial layout is also informed by the pre-existing matrix that the agricultural allotment system constitutes. A following section will discuss at greater length the question of urban barriers.

Space Syntax

Space syntax is a theoretical and methodological approach that investigates the relationship between human behaviour and space. It was initially developed by Bill Hillier in the 1970s at the Bartlett School of Architecture of University College London. In 1984 Bill Hillier and Julienne Hanson formalise their theories in the book *The Social Logic of Space* in which they introduce space syntax as both a theory of space and as a set of quantitative methods for the analysis of the space.

Space syntax seeks to explain human behaviour and social activities by looking at the configuration of spatial structures (Jiang et al., 2000). The theory attempts to unveil the extent to which some social realities are conditioned by spatial patterns by analyzing the spatial configuration of the city. The theory adopts common measures of relationality in graphs, projects their potential as vectors for social ideas, and then using geometric representations of the space, transform them into measures of spatial structure (Hillier & Vaughan, 2007). Hillier & Vaughan argue that space syntax metrics basically are *"formal interpretations of the notion of spatial integration and segregation"* and they provide a quantification method that allows to explore the space statistically. The theory posits that trough the structural analysis of the city, architects and planners may derive a better understanding of the city and bring forth more sustainable urban layouts (Jiang & Claramunt, 2002).

According to Space Syntax theory, the spatial configuration of cities and street function are determined by patterns of movement and street connectivity (Hillier, 1996). Bill Hillier argues that street segments enjoying of higher levels of connectivity naturally attract movement regardless of the presence or absence of so-called *"attractors"*- i.e. amenities that accommodate well-attended activities. Connectivity is defined as the number of intersections, or one-step choices of a given road segment. The theory claims that it is not the location of activities that generates movement of people. Rather, it is the structural qualities of the network which determine the movement of people, and therefore, the spatial distribution of human activities and, therefore, movement of people. Bill Hillier (1996) defines this relationship between street layout and human behaviour as *"principle of natural movement"* and describes it as *"... the proportion of movement on each line [i.e., street segment] that is determined by the structure of the urban grid itself rather than by the presence of specific attractor or magnets."* Natural movement provides the conditions for the creation of *"virtual communities"* which is the field for potential encounters that are generated by the spatial layout alone. Virtual communities emerge from patterns of co-presence and co-awareness and from the effects of spatial design on movement and on the use of space (Hillier, 1996). Klarqvist (1997) argues that virtual communities are the result of a *"latent solidarity"* that depends upon to the extent to which urban barriers affect the urban fabric.

Space syntax provides a set of techniques for the representation, quantification, and interpretation of patterns of movement in space at both the urban scale and building scale. It is an objective approach for the assessment of the relationships between the morphological configuration of human-made environments and social structures (Hillier, 1996). The rationale behind space syntax lies on two fundamental ideas: First, the theory posits that space shall not be seen as the passive background for human activity; rather, the space must be

Figure 2.6: From left to right, people move in lines; interact in convex spaces; and experience changing visuals as they move around in the space. Hillier & Vaughan (2007).

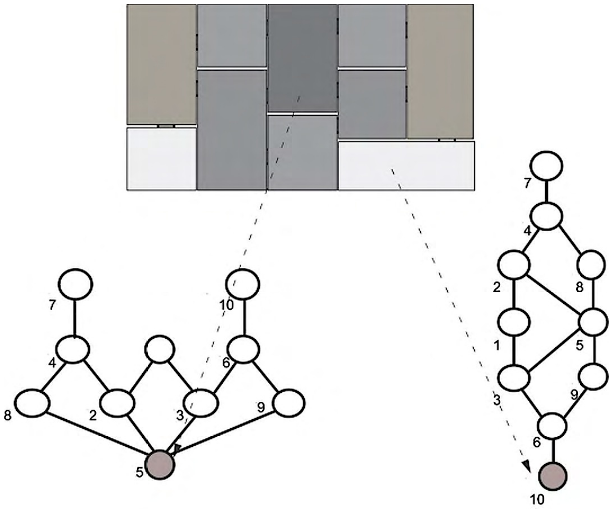


Figure 2.7: Same spatial layout looks and it is different when it is seen or perceived from different spaces within it. Hillier & Vaughan (2007).

taken as *"an intrinsic aspect of what humans do"* acknowledging that as people move in lines and interact in convex spaces, their perception of space varies from point to point as they move in space (Figure 2.2.6) (Hillier & Vaughan, 2007).

The second idea refers to the configuration of the space. Hillier and Vaughan refer to this as *"the interrelations between the many spaces that make up the spatial layout of a building or city."* They argue that the configuration of a given spatial layout not only looks different; it is also differing from different points of view (Figure 2.2.7) (Hillier & Vaughan, 2007).

As shown in figure 2.2.7, for instance, we see that each graph captures a different reality

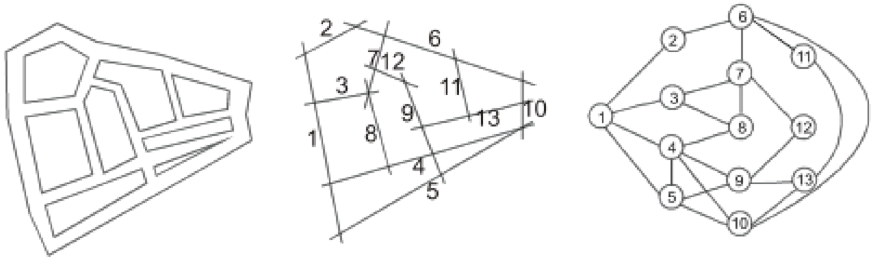


Figure 2.8: From left to right, fictitious urban layout; axial map ; and dual graph. Jiang et al., (2000).

expressing real properties of the same spatial configuration. This is a property of space that, from a graph theory approach, allows for quantification in terms of integration; that is, the cost of moving from one particular space to all other spaces. Integration will, thus, be in function to the shape of the graph. Shallow graphs (left) will be indicative of good integration while deep graphs (right) will reveal poor integration. Space syntax facilitates the indexation of the measures of integration and segregation of each individual space and estimates an average degree of integration for the whole spatial layout in relation to its parts.

In space syntax theory, street segments of uninterrupted view are referred to as *"axial lines."* Axiality, therefore, refers to the longest and fewest straight lines covering an entire urban system. A set of axial lines that mutually intersect and cover all free space in an area is called an *"axial map"* (Figure 2.2.8) (Jiang & Claramunt, 2002).

Yet the rationale behind space syntax studies is not the production of axial maps but rather the investigation of relationships between lines and spaces using dual graphs. The axial map is a graphical representation that describes the topological characteristics of a given urban space Hillier & Hanson (1984) define the axial map as *"the least set of lines which pass through each convex space and makes all axial links."*

Space syntax follows a dual approach for the representation of street networks. Here, the system is transformed into a dual graph, which, unlike in traditional network analysis, lines representing streets are transformed into nodes and intersections between each pair of lines are transformed into edges (Crucitti et al., 2006). This graph-theoretic model permits the computation of a series of indicators revealing hidden properties of the street network. Some scholars, such as Ratti (2004), have highly criticized space syntax methods for an apparent lack of objectivity. This author argues that the axial map is highly dependent upon the researcher interpretation of the axial line, which may result in different axial maps derived from a same street configuration.

In this research project we stumble upon this problem when attempting to automatically generate Montréal's axial map. The automated process we use for generating axial lines produced significant distortions to Montréal's street network; in consequence, we opted for an alternative approach based rather on *'natural roads.'* Under this method, axial lines are generated from street centerlines. Segments are joined following the Gestalt principle for a good continuation producing self-organized natural roads (Jiang, Zhao & Yin, 2008). Here, a road segment is joined to an adjacent segment only if a pre-set deflection angle falls within certain threshold; in our case, 45 degrees, which is the default value proposed by Axwoman 5.0, the ArcGIS extension for space syntax analysis. Axwoman computes 7 space syntax metrics. Such metrics, namely, connectivity, total depth, mean depth, local depth, global integration and local integration are defined by Hillier & Hanson (1984) as follows:

- *Connectivity* is the number of axial lines intersecting a given axial line. It is a measure of the status of an axial line.

- *Control* is a local measure that estimates how significant an axial line is for all other axial lines linked to it.

- Depth is an estimation of the number of steps needed to move from one axial line to all other. There are three measures of depth:
    - *Total depth (TD)* is the aggregate of all depths in a given system; it indicates the distance to go from a given axial to all others lines in the system.
    - *Mean depth (MD)* is the average of all depths in a given system; it indicates the average distance to go from an axial to all others axial lines.
    - *Local depth (LD)* it is the average of all depths within a radius; in this study, radius = 3.

- *Global integration (GI)*: it is a normalised measure based on total depth developed to allow for comparisons between systems with differing numbers of axial lines.

- *Local integration (LI)*, as in the case of GI, is a normalised indicator based on local depth; in consequence, its computation is restricted to a given radius so as to reveal the local properties of a given system (Ratti, 2004).

- *Intelligibility* is a ratio between connectivity and global integration; it is a metric that provides a general understanding of the global structure of a system by looking at its local characteristics. This last metric is not included in Axwoman's output.

Space syntax provides an approach to the study of the urban form that differs from what other schools of urban morphology are proposing, as space syntax incorporates an analytical framework that focuses on the understanding of space from a cognitive point of view. Space syntax intends to provide an understanding of the city and of the way in which people use space by looking at its topological properties.

2.3 The Urban Landscape Mosaic

In his work on urban barriers in Montréal, MacDougall (2011) develops a method for analyzing the built environment, and in particular, the spatial distribution of predominantly residential areas otherwise delineated by barriers and boundaries . He proposes a taxonomy of urban barriers that is based on their degree of permeability, which leads him to identify two main types: barriers and boundaries. Barriers and boundaries, he argues, fragment the landscape while defining a mosaic of patches where human activity occurs. Drawing from landscape fragmentation theory, MacDougall develops a method that identifies two levels of fragmentation. Fragmentation geometry one, based strictly on urban barriers, and fragmentation geometry two, in which urban boundaries are taken into account. The following section covers the main aspects of landscape fragmentation theory and describe in detail the concepts of urban barriers and urban boundaries.

Landscape Fragmentation

Landscape fragmentation emerged as a theory centered on natural environments. However, though still a rare occurrence, principles are increasingly being applied to urban contexts Zipperer et al.'s (2000) work, *"The Application of Ecological Principles to Urban and Urbanizing Landscapes,"* which focuses on patch dynamics offers a case in point; and so does MacDougall's (2011) *"The Urban Landscape Mosaic, Assessing Barriers and Their Impact* *on the Quality of Urban Form: A Montréal Case Study.",* which integrates urban morphology methods with landscape fragmentation for investigating the effects of anthropogenic and geogenic fragmentation on the quality of the urban form. This study incorporates landscape fragmentation in an early stage of the research as it provides a solid foundation for analyzing the landscape in terms of non-fragmented patches, that is, areas in which movement is not restricted by any sort of barrier. In landscape fragmentation theory, non-fragmented areas of the landscape are called *"patchworks" or "patches."* In this study they are termed *"morphological neighbourhood areas (MNA)."*

Girvetz et al. (2008) argue that for quantifying the degree of fragmentation that some elements exert on the landscape, it is first necessary to establish a *"fragmentation geometry,"* that is, the set of particular fragmenting elements of the environment that are appropriate for the investigation of the system affected by such fragmentation. Commonly, fragmenting elements are transportation infrastructure, rivers and canals, topography, and intensive land uses. Jaeger (2000) makes distinction between anthropogenic and geogenic fragmentation to refer to either human-made or natural fragmenting elements respectively. Following Jaeger's and Girvetz formulations, MacDougall (2011) identified and grouped urban artifacts acting as barriers in two categories: first-order urban barriers and second-order urban boundaries. First order barriers are represented by topographic objects or areal tracts of land in the landscape that fragment the urban tissue. They are highly impermeable and their impacts can be appreciated at both regional and local scales. These barriers criss-cross and fragment the landscape creating a meshing that delineates zones or patches of land of different sizes and configurations in which human activity occur, such as dwelling, working or leisure. Second-order boundaries, on the other hand, are more permeable components of the built landscape, less physically intrusive, which in most instances constitute rather a boundary conceding varying degrees of permeability. As will be discussed below, boundaries may constitute a *"seam"* in some circumstances (Lynch, 1960) as they bring together parts of the city otherwise disconnected. Arterial boundaries, such as urban thoroughfares, act as such seams. The divisive character of the boundary is not, strictly speaking, the product of its physical properties or dimensions, for instance. But it relates rather on the level of difficulty of crossing it. As such, barriers and boundaries are spatial discontinuities interfering with the residential tissue of street networks.

Urban Barriers

Natural and human-made barriers constitute a morphological matrix, as they organize the space by delineating zones that can accommodate residential and other associated urban functions. Barriers, by definition, are obstacles that impede or restrain movement. Drawing from urban morphology theory MacDougall (2011) builds a taxonomy of urban barriers; that is, *"a classification of types that cannot be further reduced"* based on the morphological and functional characteristics of barriers.

Larochelle and Gauthier (2002) define urban barriers as *"extended zones of the built landscape that are affected by discontinuities produced by natural or human-made elements, where pedestrian crossing is tiresome, difficult, impossible, dangerous, or forbidden."* Urban barriers can be manifested in linear or areal forms. The extent to which they impede or restrain movement depends upon two sets of factors. The first set is determined by the nature of the barrier itself, as well as their associated physical and spatial properties, whether they are natural barriers, such as rivers or escarpments, or human-made, such as railroads or urban highways. The second set of factors refers to the presence and number of crossings as well as their relative position along the said barrier, which allows for interconnections between patches, i.e., barriers' crossings.

In *The Death and Life of Great American Cities* (1961), Jane Jacobs argues that streets that are in proximity to a border receive little or no use. In consequence, as they fail in facilitating circulation beyond, their character of dead ends is further reinforced. Under these circumstances, adjoining streets are as well affected, echoing in entire area next to the border. Jacobs (1961) claims that *"borders can thus tend to form vacuums of use adjoining them."* She refers to this phenomenon as *"border vacuum"* and points to components of the urban fabric, that are not necessarily linear nor usually not perceived as edges, that can represent a barrier under certain conditions. Such is the case of large monofunctional zones that accommodate activities other than residential. A large park or university campus could constitute such a barrier, for instance. The idea of border vacuums is somewhat explored as well by MacDougall (2011) and Gauthier (2014) when referring to *"relatively impassable barriers."* They argue that the barrier effect of some elements of the urban landscape will depend upon the level of spatial resolution to which the object is considered a barrier. For instance, a large mono-functional zones may not be considered barrier at a regional scale, although it may act as a barrier at a higher level of spatial resolution, as it happens with inner city airports, rail yards, or large urban parks.

Urban Boundaries

The notion that a certain element of the urban landscape constitutes a barrier is also evident in the work of Kevin Lynch. He coined the term *"edges."* In *The Image of the City* (1960), Lynch refers to as *"edges"* to those elements of the city that, while not constituting paths, act as boundaries between zones. His work, however, suggests that edges do not always translate into restriction of movement. Lynch argues that "if some visual or motion penetration is allowed" an edge may become a *"seam."* This is typical on fragmenting elements such as urban thoroughfares, i.e., routes specialized in transportation. These routes exert, to some degree, a barrier effect; however, as they are connected to the street network they may also act as *"seams"* that link two neighbourhoods together. Caniggia and Maffei's (2001) also allude to this barrier effect on their discussion on *"anti-nodal dividing axes"*, which in their work, are represented by peripheral routes specialized in transportation and that span through different zones in a city.

Inner-city boundaries are often made of roads specialized in transportation such as thoroughfares. Contrarily to controlled-access highways, thoroughfares are integrated into the street network. Unlike highways, thoroughfares possess at-grade regular intersections, and are at the top of the hierarchical structure of the arterial road network as busy streets. Their *'divisive'* character does not arise only from the difficulty in crossing and uneasiness induced in pedestrians, but also from their distinctive morphological properties such as arteriality, relative length, and relative position in the system (Gauthier, 2016). Arteriality implies that these roads are part of a hierarchical structure in which different networks manifest: a *'foreground'* network comprised by controlled-access highways and thoroughfares, and a

’background’ network constituted by residential and streets (Gauthier, 2016). In a road system one can identify different networks: local, city-wide, regional or national. According to Marshall (2004), these networks are characterized by a *“strategic contiguity”* that can be divided up in different contiguous tiers. Upper level tiers tend to form a contiguous network while lower tiers tend to form separate sub-networks (Figure 2.3.1) (Marshall, 2004).

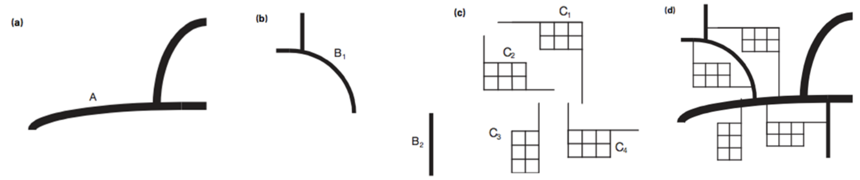


Figure 2.1: Nesting of arterial networks. a) Road network; b) and c) Road sub-networks possessing arteriality; d) Arterial network. Marshall (2005).

In his discussion about urban thoroughfares, Gauthier (2016), proposes an operational definition: *“a component of the street network such as boulevard or a functional expressway, which assumes the role of a thoroughfare and that: 1. is characterised by arteriality; 2. Spans over the length of several neighbourhood units that it serves; and 3. Tends to be located at the periphery of morphological units, where it acts as a dividing axis.”* When the latter condition is met, he terms such a thoroughfare an *“arterial boundary.”* Gauthier (2016) asserts that, unlike controlled-access highways, *“they* [thoroughfares] *are a manifestation of the cultural model of the street,”* by which he implies that thoroughfares serve lots and buildings that have an address on them. Contrarily to controlled-access highways, thoroughfares are part of the urban tissue. Caniggia and Maffei (2001) assert that urban thoroughfares generally constitute *“anti-nodal dividing axes*”, that is, streets located at the periphery of neighbourhoods whose purpose is to provide for accessibility through different areas of the city.

Together, urban barriers and urban boundaries form a morphological matrix that delineates of non-fragmented land. MacDougall proposes a method for identifying these areas in relation to first-order urban barriers and second-order urban boundaries, and develops a taxonomy of urban barriers. In MacDougall's work, fragmentation geometry one is produced based on first order barriers and fragmentation geometry two is produced by considering systematically thoroughfares as boundaries. In this project, we resort to MacDougall's methods for defining two fragmentation geometries as well. However, our approach is slightly different. More specifically, we develop further MacDougall's methods in assessing spatial discontinuities that constitute boundaries. Our fragmentation geometry two is then produced by a combination of methods aimed at identifying more subtle spatial discontinuities induced by differing street network patterning. According to this approach, not all thoroughfares constitute boundaries and some boundaries are not thoroughfares. Our main objective is then to delineate a morphological matrix that identifies residential zones depicting an cohesive internal structure. As a consequence, we denominate these zones morphological neighbourhood areas (MNAs). As mentioned, one of the outcomes of this refined method is to identify thoroughfares, or portions of thoroughfares that actually act as boundaries from those that do not assume such a role in the system, i.e., those that do not manifest the third characteristic of Gauthier's (2016) operational definition.

Chapter 3

Methodological Framework

3.1 Introduction

The methodological framework of this study consists in a series of spatial analyses carried out in GIS that aim at identifying and quantifying some properties of the urban tissue. It involves, first, the creation of a fragmentation geometry, for delineating predominantly residential sectors interspersed with spatial discontinuities caused by major natural and human-made barriers following MacDougall's *"fragmentation geometry one"* methodology. In this project we are proposing a second geometry for characterizing neighbourhood morphological areas (MNAs). MNAs are built upon the first fragmentation geometry; however, based on an array of spatial and historical data, a second fragmentation geometry is proposed by performing some intermediary analyses that include k-means clustering of city blocks, space syntax, and georeferencing and digitizing.

This chapter is organized as follows: first, we introduce the spatial datasets utilized to carry out the analysis and describe data preparation. Following, we describe the processes for the creation of both fragmentation geometries. And finally, we provide a concise description of the statistical methods mobilized for categorising urban blocks and MNAs.

3.2 Data Collection

Our methodology and analysis rely on several sources of secondary data on natural and built environments on the Island of Montréal. Among secondary sources, we make use of data from GeoGratis.ca (2015) which includes an ArcGIS-shapefile polygon layer for hydrography, and polyline layers for rail infrastructure and high power lines. Also, we incorporate data from OpenStreetMap (2015) for deriving road categories and performing the space syntax analysis. We employ as well CAD data from the City of Montréal (2008) for extracting city blocks and land use data from *Communauté Métropolitaine de Montréal* (2014). Lastly, we make use of cadastral data from *Ministère de l'Énergie et des Ressources naturelles du Québec* (2009) containing the allotment system for the Island of Montréal.

In terms of software applications, our main resources are Esri's ArcGIS v.10.0/10.2.1 as well as QGIS for spatial analyses and cartographic representations. We use Axwoman 9.2, which is an ArcGIS 10.0 extension for space syntax analysis. Statistical analyses, including clustering and principal component analysis are run on the RStudio platform.

Data Preparation

Considering that our case of study is constrained to the Island of Montréal, our first task consisted in clipping all spatial layers to the extent of our study area. Layers such as residential land use and controlled-access highways required simple SQL querying to derive them from the original data. The process required for extracting urban blocks from the Montréal CAD files implied multiple processes of querying, geoprocessing, conversions and manual editing. Similarly, the preparation of the street network layer for space syntax analysis was highly time-consuming as both datasets available to us DMTI (2008) and OSM (2015) had numerous topological errors that required intensive and prolonged manual fixing. In particular, the DMTI dataset presented some characteristics that proved problematic for operationalizing space syntax procedures, which are highly sensitive to topological relationships. More specifically, we found that the way in which two-way roads are represented in the DMTI dataset (two lines for a single road - representing one way each) affected significantly the measurement of connectivity, and by extension, the levels of integration of the street network. Finally, our analysis required the georeferencing of a 1890-map of Montréal followed by the digitizing of historical roads and agricultural allotment system.

Morphological neighbourhood areas are zones of residential land use exhibiting a certain level of homogeneity in regards to the street configuration. MNAs are delimited by discontinuities in the urban tissue caused by either barriers or boundaries. In the latter case, changes of orientation in the street layout or differing topological features denote the existence of a boundary. Gauthier (2015) defines MNAs as: *"geographical unit of reference for the analysis. They consist of internally cohesive (predominantly) residential areas delineated by a combination of first order spatial discontinuities induced by natural and artificial barriers and second order boundary discontinuities induced by differing street network geometrical and topological patterning."* Gauthier's definition implies that areas of predominantly residential land use are morphologically distinguishable based on coherent internal properties and that they can be delineated based on spatial discontinuities referred to as barriers or boundaries.

MacDougall (2011) has conducted an empirical work in Montréal in order to produce a taxonomy of urban barriers which includes natural elements such as rivers and steep slopes, and human-made works such as fortifications, canals, railroads, highways and high-tension power lines. He also identifies a category of areal barriers comprised of large non-residential mon-functional zones such as railyards, airports, or industrial or commercial clusters (a topic covered as well by Jane Jacobs (1961); she refers to *"border vacuums."*) Further, MacDougall proposes two fragmentation geometries, FG1 and FG2. FG1 is based on first-order urban barriers, generally impassable or quasi-impassable by foot in the absence of engineering works such as bridges or tunnels. FG2, on the other hand is built upon FG1 but incorporating more permeable second-order urban boundaries; i.e., urban thoroughfares.

Our intention, however, is not to replicate or put under scrutiny MacDougall's work but rather to produce our own analysis based on his methodology with the objective of producing two morphological matrices. Geometry one delineates areas of contiguous residential land uses that are fragmented by barriers, while geometry two that lays out neighbourhood morphological areas (MNAs). As illustrated in the following sections, MNAs are constructed in a two-pronged approach that builds upon geometry one with the addition of space syntax indicators, urban blocks metrics as well as analyses of the allotment system and historical cartographic data.

3.3 Producing Fragmentation Geometry One

Barriers and boundaries fragment the urban landscape, hence, unveiling morphological mosaics (MacDougall, 2011). In this project, these mosaics are areas of residential land use delineated by spatial discontinuities. Our first fragmentation geometry is based on physical barriers alone and it is denominated *"fragmentation geometry one"* (Figure 3.3.1) while the second morphological mosaic is referred to as *"fragmentation geometry two"* and is built upon *'geometry one'* while incorporating spatial discontinuities induced by differing street network patterning.

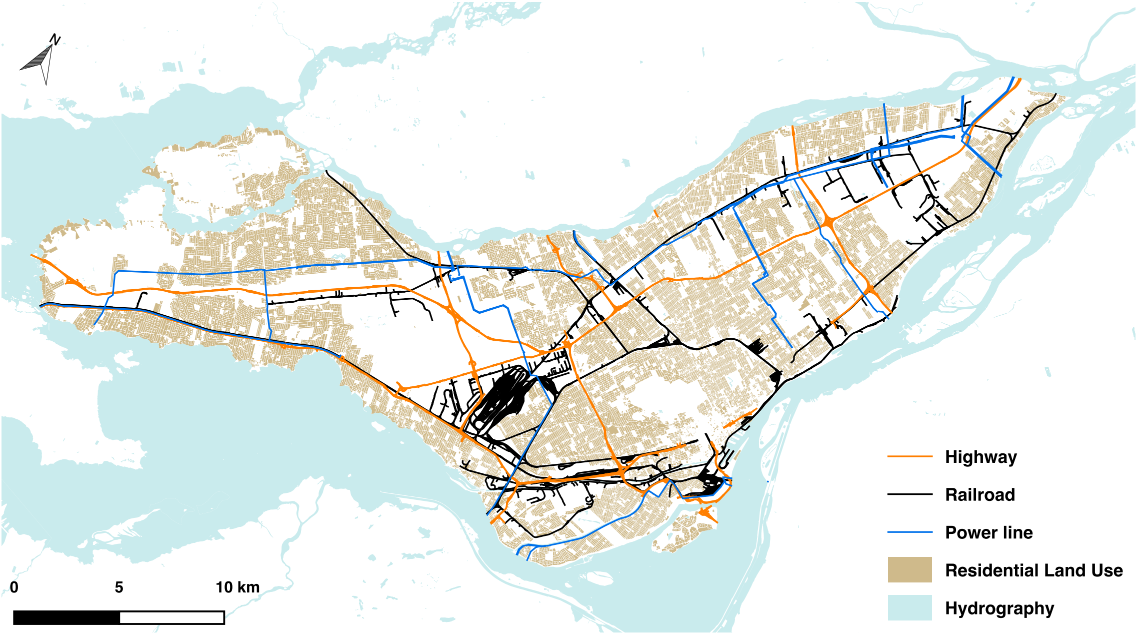


Figure 3.1: Residential tissues and first-order urban barriers.

In our analysis we first replicate MacDougall's *"fragmentation geometry one"* method for building our morphological matrix of urban barriers. Unlike MacDougall's work though, our analysis, is exclusively based on residential land uses and excludes topography, as we do not consider it as having a significant impact on the fragmentation of the landscape in the Island of Montréal. For building our first fragmentation geometry we use a set of spatial data in ArcGIS-shapefile format which includes hydrography, controlled-access highways above ground, railroad infrastructure above ground, high-tension power lines, and residential land use

The analytical sequence for producing geometry 1 is as follows:

1. Identification of all city blocks with a residential land use denomination data provided by *Communauté Métropolitaine de Montréal* from 2014.
2. Identification, classification and delineation of linear and areal discontinuities consisting of specialized tissues, infrastructure, and water bodies.
3. Filter contiguous residential aggregates larger than 2.5 hectares. Residential aggregates may include non-residential areas smaller than 2.5 hectares or mixed-used areas, e.g. lots occupied by residential buildings with retail on the ground floor.

3.4 Fragmentation Geometry Two

The production of geometry two aims at identifying and delineating neighbourhood morphological areas (MNAs). These are areas that display coherent street network configurations and are different from surrounding areas in terms of streets pattern and configuration. Here we identify residential zones that are internally coherent in regards to both first-order urban barriers and second-order urban boundaries; yet we define the latter in a method that differs from MacDougall's.

The said method unfolds as follows. First by running a cluster analysis on predominantly residential blocks as identified in the course of production of fragmentation geometry one. Here the urban blocks geometrical properties are used as a proxy for the geometrical properties of the street network. The urban fabric manifests a "meshing," where streets act as threads delineating urban block "meshes."

Conzen (1960, 5) defines an urban block, which he terms a *"street-block"* as *"the areas within the town plan unoccupied by streets and bounded wholly or in part by street-lines are street-blocks. Each street-block represents a group of contiguous land parcels or else a single land parcel."* In this research, we consider a block as an area bounded by street-lines or by a first-order urban barrier. It is the fact that blocks are delineated by streets (in the vast majority of cases) that justifies that blocks are used as a proxy for street networks.

The set of block metrics include morphometric characteristics (shape), metrological properties (dimensional) and compositional variables (topological); all deemed appropriate for capturing similarities or dissimilarities in the urban tissue. As we will discuss further in Chapter Four, the variables used to capture the geometrical properties of the blocks were: *area*, *perimeter*, *ratio area perimeter*, *compactness*, *orientation*, *orthogonality* and *number of neighbours*. Following, space syntax analysis helps to identify the status of certain streets in regards to their degree of integration in the system. By colour-coding block clusters and space syntax indicators we are able to identify and delineate internally cohesive zones constituting neighbourhood morphological areas. The process is validated and further refined using historical agricultural data and the current allotment system, in particular, when boundaries coincide with allotment parting lines (Gauthier, 2016). A workflow scheme describing the process for building geometries 1 and 2 is presented in figure 3.4.1 and the following section describes the process in detail.

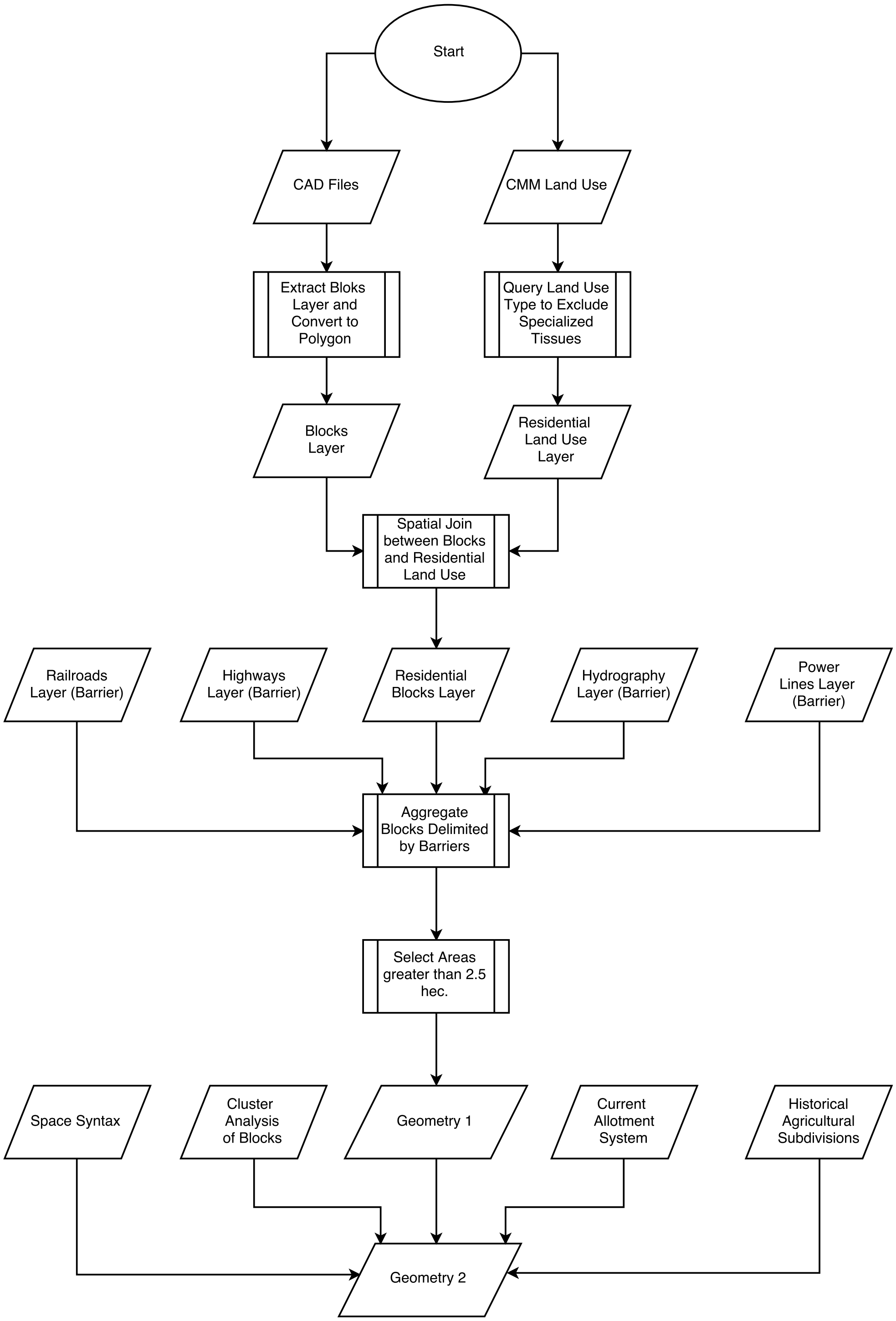


Figure 3.1: Flowchart for the creation of the fragmentation geometry of urban barriers and boundaries.

3.5 Clustering and Principal Component Analysis

This research makes use of clustering procedures in two instances. Firstly, clustering is used to to analyze variables aimed at capturing geometrical properties of urban blocks as part of the effort to identify and delineate MNAs. Here, establishing categories of blocks, or clusters, allows for mapping their spatial distribution. Such mapping then allows to identify aggregates of blocks either characterized by their homogeneity (i.e., comprised of blocks from the same clusters), or by some level of heterogeneity, yet displaying a *'recognizable mix'* of block types that distinguishes such aggregates from surrounding areas. The detailed procedure is discussed and performed in Chapter Four.

Secondly, clustering is performed again in Chapter Five. This time, to group MNAs according to their internal morphological characteristics (i.e., specific street network patterning) as well as the ways in which these MNA's street networks relate to surrounding street networks and to the street system of the island as a whole (i.e., assessing part-to-whole topological relationships). The details of the latter procedure are discussed in Chapter Five, as are its results.

Cluster analysis is a very effective method for handling multivariate data. The clustering procedure allows to classify and group objects by identifying patterns in the data. Clustering methods and algorithms can be broadly classified in non-hierarchical (k-means) and hierarchical. In non-hierarchical clustering the number of groups desired must be specified prior to the analysis while hierarchical methods allow for a more exploratory approach where groups can be identified by analyzing a dendrogram plot. Principal component analysis, on the other hand, is a statistical method aimed at reducing the dimensionality of multivariate data. PCA transforms the data into a new subspace in which only principal components retaining most of the variability in the data are retained. We use PCA in combination with hierarchical clustering in order to identify the most significant variables in our data.

Cluster Analysis

Classification mechanisms are an effective way of organizing data and detecting patterns. Classes provide a better understanding of the data structure and allow for extracting information more effectively. A categorization facilitates the description of patterns of similarity and dissimilarity in datasets thence reduced to a smaller number of groups of individuals (Everitt et al. et al., 2001).

Cluster analysis is a statistical method that consists in partitioning group of observations in a multivariate dataset into different subsets. Given a set of variables of interest, observations in a particular cluster are very similar to each other and share many attributes while being very different to observations in other clusters (Legendre & Legendre, 2012).

Carrying out a cluster analysis requires making three important choices in advance. First, deciding on the set of variables suitable for detecting differences in the data is crucial for determining the number of partitions and the cluster membership of every individual in the dataset. In second place, it is necessary to select a clustering algorithm. Some of the most common clustering approaches include k-means partitioning, hierarchical clustering, and two-step clustering (Mooi & Sarstedt, 2010). Last, a decision must be made in regards to the number of partitions sought in the data. In k-means clustering, for instance, the number of partitions has to be determined prior to the analysis. Such number may be already known by the researchers based on their understanding or familiarity with the data. Alternatively, some techniques exist for finding the optimal number of partitions in a dataset include: *Rule of Thumb*, *Information Criterion Approach*, *Information Theoretic Approach*, *Silhouette*, *Cross-validation*, and the *Elbow Method* (Kodinariya & Makwana, 2013).

Below, we expand on k-means partitioning and hierarchical clustering since these are the methods selected for our analysis. However, it is worth mentioning that the literature on cluster analysis includes a vast collection of varying procedures and algorithms that go beyond the scope of this study.

K-means clustering is the method of our choice for the classification of city blocks. This method is a non-hierarchical unsupervised algorithm that minimizes the total error sum of squares (SSE). It is unsupervised because there is no pre-existing class value attached to the data. Legendre & Legendre (2012) describe this method as *"the sum, over the k groups, of the sums of the squared distances among the objects in the groups, each divided by the number of objects in the group."* However, as mentioned previously, this method requires deciding on a number of partitions prior to the analysis. This method consists in plotting the sum of squares errors starting at k = 2 and subsequently incrementing the number of partitions by 1 in each iteration. The optimal number of clusters is identified at the point where the curve bends implying that k has reached a plateau and that there is no marginal gain in the sum of square error, therefore, no gain in adding a new cluster (Kodinariya & Makwana, 2013).

Similar to k-means clustering, hierarchical clustering (HC) also seeks to detect partitions of similar observations in multidimensional spaces. This method does not require a precise number of clusters. HC consists in starting with each observation in the dataset in a separate cluster and then progressively combine them into larger clusters (Everitt et al., 2001). This method produces a dendrogram, a tree-like chart (Figure 3.5.1) that permits to explore the data visually by showing how observations cluster from the bottom up and distribute among the branches of the tree (Mooi & Sarstedt, 2010).

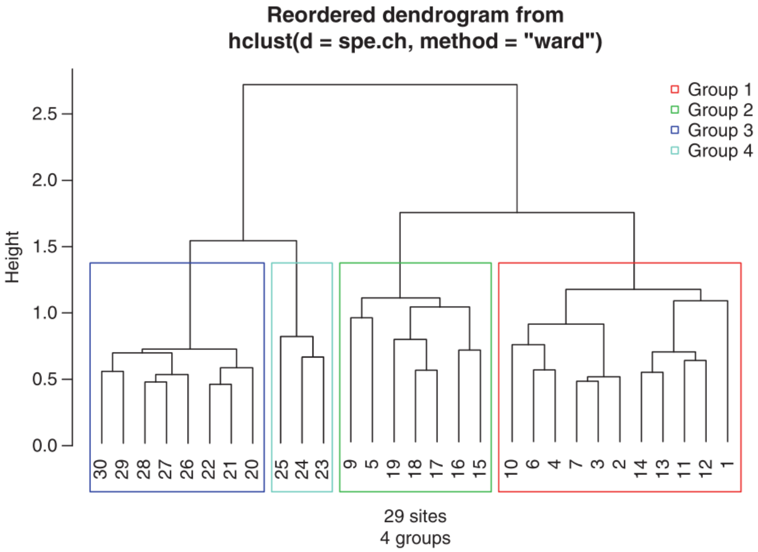


Figure 3.1: Dendrogram. Source: Legendre & Legendre (2012)

In this study, we find k-means simplicity and responsiveness appropriate for conducting the cluster analysis of city blocks, a rather large dataset comprised of 10576 observations and 7 variables. On the other hand, we resort to hierarchical clustering (HC) for the partitioning of our dataset of morphological neighbourhood areas (MNAs), consisting of 341 MNAs and 32 variables or dimensions. Hierarchical clustering, here, is used in combination with principal component analysis (PCA). PCA is a multivariate data mining technique that is most often used to reduce the number of variables in a dataset to a fewer number of *'principal components'* while retaining most of the information in the data (Husson, Josse & Pages, 2010). We elaborate on this procedure on the following section.

Analytical sequence for clustering city blocks:

1. Identify variables and compute capturing properties that allow for categorization;
2. Select clustering method and decide on the number of groups to retrieve from the data;
3. Subject the dataset to k-means clustering analysis;
4. Identified groups of blocks to be used for delineating MNAs.

Principal Component Analysis

Principal component analysis is a mathematical algorithm commonly used for reducing the number of variables, or dimensions, in a dataset. The method reorganizes the data identifying new, and fewer, variables called principal components. Principal components are linear combinations of the original variables that seek to capture most of the variability in the dataset. The first axis (PC1) captures most of the variability (Figure 3.5.2) while each of the following components (PC2, PC3, etc.), which are orthogonal to each other, account for the rest of the variability (Legendre & Legendre, 2012).

Principal component analysis is used to reveal patterns in the data, emphasizing variation. For identifying patterns in our dataset of morphological neighbourhood areas we use a combination of principal component analysis and hierarchical clustering. PCA is used to reduce the dimensionality of our data, which consists of 32 variables, to a smaller number of components that capture most of the information. Subsequently, we carry out a hierarchical clustering analysis on the main principal components for identifying groups observations sharing similar attributes.

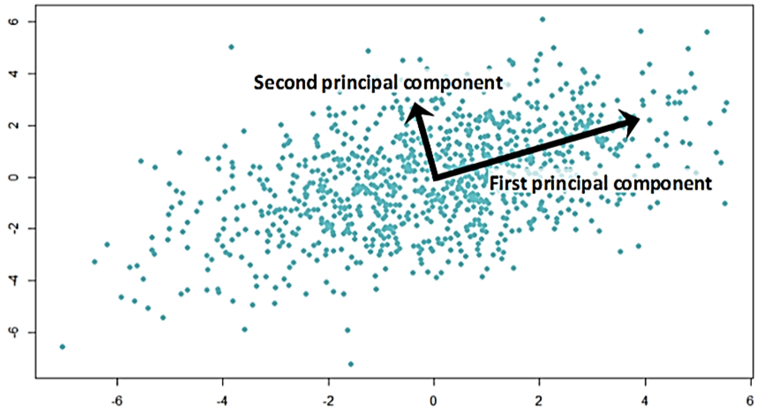


Figure 3.2: Principal component analysis. Source: Ringnér (2008).

Analytical Sequence for clustering MNAs:

1. Identify variables capturing properties that allow for categorization;
2. Remove highly correlated variables;
3. Identify and remove outliers;
4. Perform principal component analysis;
5. Identify most significant indicators;
6. Perform PCA on most significant variables;
7. Carry out hierarchical clustering on PCA results;
8. Test PCA results using multinomial logistic regression.

This chapter has broadly described our approach to defining and categorising morphological neighbourhood areas using a set of spatial and statistical methods. Additional details regarding these processes and results are presented in the following chapter.

Chapter 4

Identifying and Delineating MNAs

4.1 Introduction

As previously mentioned, one of the key objectives and by extension, a key contribution of this research is to devise a method to delineate and map morphological neighbourhood areas (MNAs), defined as predominantly residential environments displaying internally cohesive street network - and urban blocks geometries. An MNA is, hence, defined by its internal characteristics, which can distinguish it from surrounding areas, but also by *"spatial discontinuities"* that are either produced by physical or spatial barriers or by differing street patterning (in the latter case, we talk of boundaries) (Gauthier, 2016).

As per the methods briefly introduced in chapter 3, the identification and mapping of physical barriers allows determining first-tier spatial discontinuities in order to produce what MacDougall termed *"fragmentation geometry one"* (FG1). The identification of second-tier spatial discontinuities, i.e. boundaries leads to the production of a fragmentation geometry two when the latter are mapped in addition to FG1. The predominantly residential tissues, hence, delineated are what we term MNAs.

This chapter details at greater length the methods developed to delineate MNAs and presents the results of the said analyses. The first section centers on fragmentation geometry one, while the following sections concern fragmentation geometry two.

4.2 FG1: Urban Barriers, a Morphological Matrix

The first fragmentation geometry is comprised of threads; i.e., first order barriers and of meshes, which are the space delineated by the former, and that is occupied by contiguous predominantly residential tissues. The process of creating geometry one is carried out in ArcGIS using the *'Aggregate polygons'* tool and involves the following steps:

1. Filter urban blocks layer from CAD files from the City of Montréal.
2. Convert blocks to polygons;
3. Using land use data from *CMM* (2014), filter residential land use and intersect with block polygons;
4. Aggregate residential city blocks delimited by barriers:
    a) Controlled-access highways;
    b) Railroads;
    c) Hydrography
    d) High-tension power lines;
    e) Specialized tissue aggregates greater than 2.5 hectares;

5. Include in residential tissues non-residential land use lots smaller than one hectare such as schools, small parks, or commercial strips that, due to their small scale, do not constitute a barrier or generate boundary effects;

6. Remove patches smaller than 2.5 hectares.

The delineation of residential aggregates produces a map depicting fragmentation geometry one (Figure 4.2.1).

Figure 4.1: Fragmentation geometry (FG1) of residential patchworks.

The resulting layer contains 132 patches of varying size ranging from 2.7 to 2424 hectares (Figure 4.2.1). As shown in the inset map in the figure, these zones display contrasting internal realities, evident in the street pattern configuration and block orientation, that depend on factors other than first-order urban barriers (Figure 4.2.2). In consequence, for building geometry two we need to bring into the analysis indicators that allow for a finer delineation of differing street networks. Here, we resort primarily on properties of the urban blocks and on space syntax.

Figure 4.2: FG1. Patches delimited by first-order urban barriers as per natural break-down of surface area.

4.3 Building FG2

This chapter outlines the process for identifying morphological neighbourhood areas (MNAs). The process involves a semi-automated phase that includes a classification of urban blocks using cluster analysis so as to clearly identify discontinuities in the urban tussie. Following, we perform a detailled analysis that involves parameters of space syntax, allotment system, and historical information. Our goal here is to expose latent patterns in the urban tissue that allow for outlining morphological zones. Finally, we refine our morphological neighbourhood areas by eliminating noise in fringe areas and by pairing their perimeter to the allotment system.

Assessing Street Network Geometries

The following sections illustrate the method devised to produce fragmentation geometry two (FG2), which constitutes the second step necessary to delineate and map the morphological neighbourhood areas (MNAs). FG2 builds upon FG1, as first order barriers are integral part of the second mosaic. The method for creating FG2 can be described as an iterative process. Through the various steps of the process, second-tier spatial discontinuities (i.e. boundaries) are gradually revealed, validated and precisely traced. The MNAs hence correspond to the *"meshes"* delineated by barriers and boundaries that act as threads. An important aspect to consider is that the identification and mapping of each MNA is based both on their *'internal'* coherence, i.e. their recognizable street network geometry, and on spatial discontinuities that mark their contour. As a consequence, the analysis is focused both on identifying differing street patterning, and on spatial disconnects in the street network (see in particular Gauthier, 2016).

Building upon FG1, the analytical sequence for producing fragmentation geometry two unfolds as follows:

1. Using the urban blocks as a proxy for street network geometry, a cluster analysis of the blocks is conducted based on morphometric (shape), metrological (dimensional) and compositional (topological) variables in order to produce a representation of the spatial distribution of blocks belonging to the different clusters.
2. Using a Space Syntax metrics, a quantitative analysis of street integration is conducted and represented spatially.

3. Spatial representations of blocks (colour-coded by cluster), and of streets (colour-coded according to level of integration) allow for triangulation, in order to distinguish and delineate the contours of internally coherent residential aggregates.

4. The precise mapping of local discontinuities is validated and further refined by taking into consideration the thoroughfares, the historical agricultural plotting, and current allotment system (in particular when boundaries coincide with allotment parting lines).

An urban block is typically a piece of land accommodating some sort of activity and delineated by roads. In the context of this study, we define the urban block as the aggregate of primarily residential lots delimited either by first order barriers including specialized tissues greater than 2.5 hectares. By specialized tissue, we are referring to land uses other than residential. Here, the urban blocks are used as a proxy a for revealing properties of the street network since blocks are delineated by streets, the blocks' shape and size, for instance, reflect some of the geometric properties of the street network in which they are enmeshed (Figure 4.3.1) .

Figure 4.1: Sample of Residential Aggregates from FG1.

Type of Indicator	**Variable**
Metrological	Area
	Perimeter
	Ratio Area-Perimeter
Morphometric	Compactness
	Orientation
	Orthogonality
Compositional	Number of Neighbours

Table 4.1: Block geometry variables.

Clustering of City Blocks

Urban Blocks Geometry

We quantify urban blocks based on morphometric characteristics, metrological features, and compositional patterns. Our goal is to group the city blocks using k-means clustering so as to expose patterns or spatial discontinuities which may contribute to the delineation of neighbourhood morphological areas. We have identified seven variables pertinent to this objective (Table 4.1):

Metrological variables are easily computed in GIS and do not require any preparation. The computation of the rest of the indicators, on the other hand, demands some additional geoprocessing operations. *Orientation* and *Orthogonality,* for instance, both pertaining to the morphometric variables, are based on properties of the minimum bounding rectangle (MBR), which is the smallest bounding rectangle that envelops a shape. The process of generating the MBR is carried out in ArcGIS. Its output produces an additional polygon layer with values for main orientation, length, width, and area, all attached to its attribute table. The data on this layer is re-introduced into the original block layer and appended to its attribute table for performing the estimations.

The indicator *orhogonality* is a ratio between the area of the block and the area of the MBR with values ranging from 0 to 1; higher values reveal more regular, rectangular blocks. Following, *orientation* is based on the *main orientation* of the minimum bounding rectangle. Therefore, in that latter case, values computed do not belong to the block polygon per se but rather to the MBR; however, in orthogonal blocks, these coincide. *Orientation* values range from 90 degrees at geographical north to -90 degrees at the geographical south. Figure 4.3.2 presents MBR, orthogonality and orientation values for a select group of blocks in the west of Montréal.

Figure 4.2: Minimum bounding rectangles, Orthogonality and Orientation of blocks.

Our third morphometric indicator, the *Compactness Index,* requires several geoprocessing steps that include buffering, querying, spatial joins, and intermediate calculations. *The compactness index* is a measure for differentiating between elongated and circular geometries. We based our method on the *"exchange index"*, an indicator developed by Angel, Parent, & Civco (2010) for detecting gerrymandering in U.S. congressional districts. This metric computes the proportion of the total area of a shape, i.e., a city block, that falls inside a circle of the same area; both aligned to their centroids. Figure 4.3.3 shows three different shapes of the same area displaying varying degrees of compactness. *Compactness* values range from 0 to 1 with values closer to 1 being indicative of more compact, rounded, shapes.

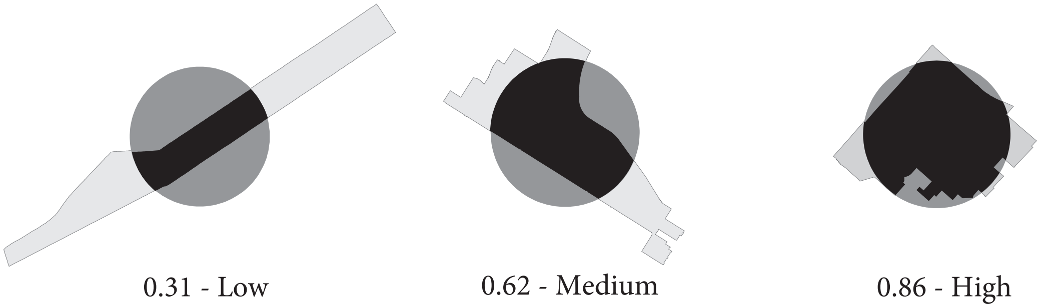


Figure 4.3: Compactness index measured on three shapes of the same area but differing spatial configurations.

Finally, the computation of our single compositional indicator, *number of neighbours*, is a rather simple process carried out in ArcGIS using the tool polygon neighbors, which computes the number of neighbouring features of a given polygon, blocks in this case. This variable provides a good understanding of the topological properties of an area by estimating how blocks are laid out. In a typical grid configuration, blocks are usually surrounded by 8 neighbouring blocks while in areas showing irregular layouts the number of neighbours varies greatly .

Blocks Statistics	Area	Perimeter	Ratio Area Perimeter	Orthogonality	Angularity	Number of Neighbours	Compactness
Min. :	901.20	112.10	3.54	0.12	-90.00	0.00	0.14
1st Qu.:	9384.20	421.40	21.66	0.79	-25.00	4.00	0.53
Median :	14296.70	566.30	25.17	0.95	26.00	5.00	0.62
Mean :	18400.80	656.40	25.44	0.86	13.30	5.21	0.63
3rd Qu.:	20694.40	731.10	28.78	0.99	41.00	7.00	0.73
Max. :	497386.70	12861.20	78.90	1.00	90.00	27.00	1.00

Table 4.2: Statistics of city blocks metrics.

In Table 4.2 below we present some basic statistics for the set of metrics just described. From there we can make some inferences about Montréal's block configuration. For the purpose of the illustration, we can argue that a hypothetical, average Montréal block is around 1.6 hectares, it is oriented NW, it is fairly rectangular, elongated, and it is surrounded by 6 blocks.

This select group of indicators captures well-defined properties of the urban blocks and, by extension, of the street network, that we deem *significant* and *discriminative*, i.e., apt at capturing characters of the form, particularly in the Montréal context, that differentiate dissimilar environments. Such a method allows to identify homogenous sub-groups in the dataset. Our goal is, hence, to subject these metrics to a k-means cluster analysis in order to find clusters of blocks sharing similar characteristics. The following section revisits cluster analysis and describes the process for creating clusters of city blocks.

Clustering Procedure

Cluster analysis is convenient method that allows for classifying observations into groups. Elements in a particular group, or cluster, share similar characteristics in regards to their attributes or variables. For identifying discontinuities in the urban tissue, we perform a k-means clustering aimed at categorizing urban blocks in regards to the set of indicators described in section 3.4. K-means is an unsupervised algorithm which assumes no pre-existing labels in the data observations; therefore, the number of clusters sought must be specified beforehand. We use a common method called *'the elbow method'* for finding the optimal number of categories. In figure 4.3.4, we see that the curve bends around the sixth iteration, indicating that at that point there is no gain in adding a new cluster (Kodinariya & Makwana, 2013).

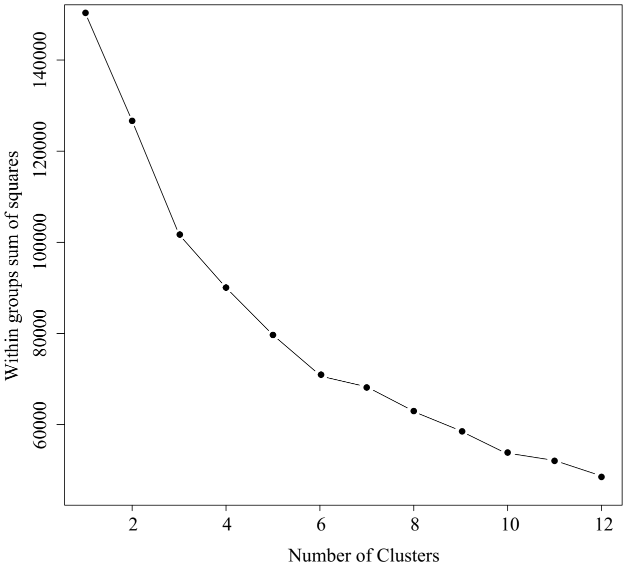


Figure 4.4: Optimal number of clusters.

We perform the cluster analysis in QGIS using the *'Attribute based cluster'* plugin. Results are satisfactory and we can easily identify 6 categories exposing properties of the indicators of our choice. For instance, we see how similar patterns are placed in different groups because of a change of orientation in blocks; or how large irregular blocks on the shores get clustered together. Figure 4.3.5, below, summarizes the results of the k-means clustering, displaying as well a sample of each block type, their spatial distribution across the Island of Montréal, and averages. It is important to note that the goal of this process is not to perform a thorough classification of urban blocks but rather to identify patterns that would help in delineating MNAs.

Once mapped and colour-coded according to cluster membership, the spatial distribution of blocks is revealed: some areas are characterized by aggregated blocks of the same category (i.e., characterized by their homogeneity), while other areas manifest heterogeneity, displaying a recognizable mix of block types that distinguish them from surrounding areas that are either internally homogeneous or that present a different mix.

In consequence, we can argue that in the Island of Montréal there exist two types of blocks aggregates: internally homogenous and heterogenous. Internally homogenous aggregates are constituted by blocks belonging to the same cluster, typically of block types 2, 3, or 4, while heterogenous aggregates are formed by a mix of blocks generally associated with block types 1, 5 and 6. The figure 4.3.6 below presents the results of the cluster analysis of city blocks while figure 4.3.7 displays all clusters combined.

					Average Values						
	Block Properties	**Block Sample**	**Spatial Distribution**		**Area (hectares)**	**Perimeter (m)**	**RAP***	**Orthogonality**	**Orientation**	**Compactness**	**Number of Neighbours**
1	Small, orthogonal and compact. Interspersed WNW orientation			n = 1875	11.30	427.56	23.86	0.91	27.97	0.77	4.57
2	Medium-sized, orthogonal and elongated. Predominantly clustered along shores. NNW orientation.			n = 1690	16.85	594.75	25.81	0.90	66.30	0.65	4.68
3	Medium-sized, and orthogonal. Forming inner-city clusters. NW orientation.			n = 3080	16.61	631.41	25.50	0.97	26.21	0.56	6.02
4	Medium-small, orthogonal and slightly compact. Interspersed. NE orientation.			n = 1786	13.23	499.40	23.76	0.90	-61.01	0.69	4.54
5	Large, irregular, and with very low compactness Forming suburban clusters. Varying orientation.			n = 1194	27.22	905.47	27.05	0.69	-32.26	0.58	5.06
6	Irregular superblocks, with dead-ends and very low compactness. Scatterd with some clusters in the suburbs. Varying orientation.			n = 951	39.57	1279.88	28.8	0.52	45.11	0.50	6.29
		0 600 m		**Total = 10576**							

Figure 4.5: City Blocks by Type (clusters).

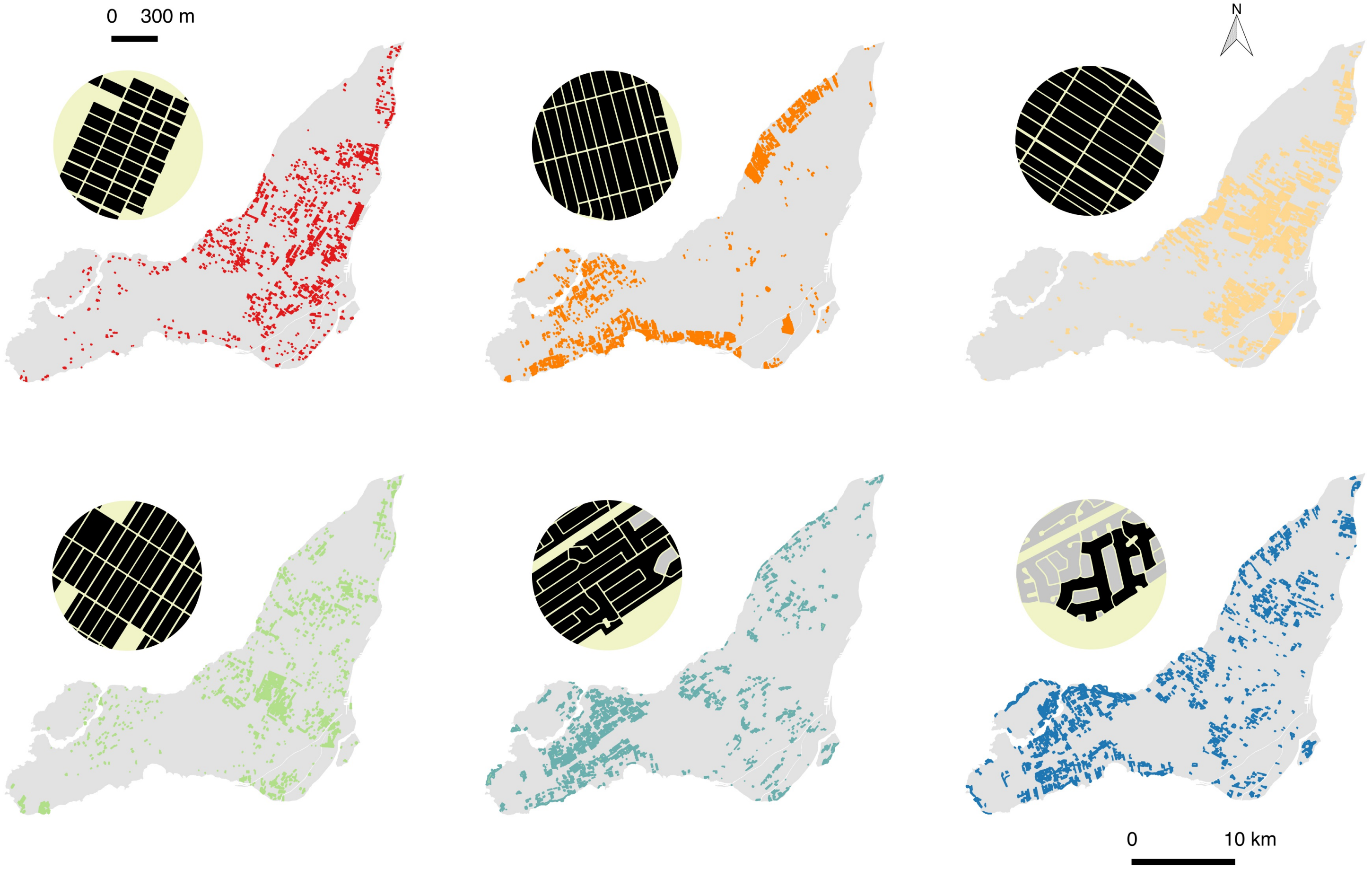


Figure 4.6: Spatial Distribution of City Blocks by Cluster Membership and Samples.

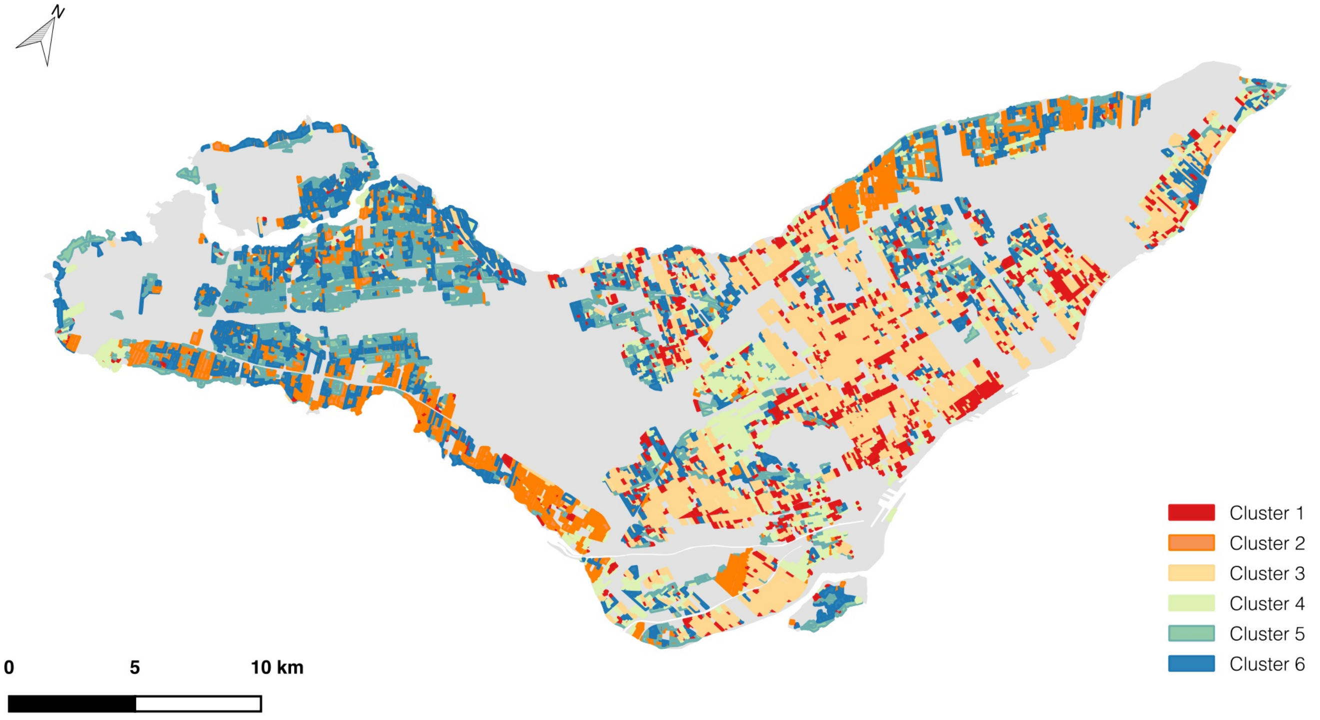


Figure 4.7: Cluster Analysis of City Blocks.

Space Syntax Analysis

Space syntax consists of a set of tools for analysing the configurational properties of the space (see section 3.6). In morphological analyses, space syntax provides a series of parameters pertaining to the road network, which are derived from a connectivity graph (Figure 2.2.7). Space syntax is, in essence, a measure of the accessibility of every street in relation to all other streets in the system using planar graphs (Kofi, 2010).

Prior to running space syntax analysis, it is necessary to generate axial lines for the whole street system in the Island of Montreal. Here, we rely on an automated process performed using the ArcGIS extension Axwoman based on *"natural roads."* Axial lines are generated from street centerlines using OpenStreetMap data. Street segments forming axial lines are joined following the Gestalt principle for a good continuation. Thus, a road segment is joined to an adjacent segment only if a pre-set deflection angle falls within certain threshold; in our case, 45 degrees, which is the default value proposed by Axwoman (Jiang, Zhao & Yin, 2008). Nevertheless, the outcome of this automated process was not perfect and many inconsistencies were found, which required extensive manual editing, a procedure that is not unusual for this type of analysis.

Once the street layer is transformed into a set of axial lines, we carry out the space syntax analysis. Axwoman's algorythm estimates 8 parameters: *Connectivity*, *Control*, *Total Depth*, *Global Depth*, *Local Depth*, *Mean Depth*, *Global Integration*, and *Local Integration*. We add the variable Intelligibility, which is the ratio between connectivity and local integration (this parameter is not computed by the software). The analysis is performed twice for whole street network including and excluding controlled-access highways.

The following section will address specifically the question of urban thoroughfares and the fact, in particular, that some of these act as boundaries. Let it just be mentioned for that that space syntax analysis can help identify thoroughfares. Integration is an estimate of how accessibility a given axial is from all other axial lines in the system (global integration) or at a given radius (local integration). Gkanidou et al. (2015) argue that integration is measure of a street's potential as an attractor of movement. Thoroughfares give access to large sectors of a city. They also have a high arteriality level. As a consequence of such conditions, they have a high integration value and they appear as such when mapped. Figure 4.3.8 shows local integration values and compares the results of the analysis considering both, controlled-access highways as a part of the arterial system, and as a first-order urban barrier, in which case are excluded from the space syntax analysis.

The integration map highlights spatial patterns in the street system, as tightly meshed networks, for instance, will be comprised of highly integrated streets, contrarily to sectors where *"loops and lolipops"* prevail. The said map can also reveal spatial disconnects in the network that denote the presence of boundaries between aggregates. Used in combination with mapping of various clusters, the integration map allows for triangulation as following sections will illustrate.


Local Integration - Road Network *Including* Controlled-Access Highways

Local Integration - Road Network *Excluding* Controlled-Access Highways

Figure 4.8: Local Integration Measures

Assessing Spatial Discontinuities

This section sets about identifying boundaries, or second-tier spatial discontinuities. Thoroughfares, or segments of those often mark spatial discontinuities when they are at the limit of differing street patterns. Cadastral boundary lines can similarly denote shifts in street network patterning or poor connection between adjacent zones. We will see as well that the historical agricultural allotment system often informs current conditions of the urban tissue.

The Question of Thoroughfares

Caniggia & Maffei (2001) suggest that street specializing as heavy transportation routes are often located at the periphery of tissues, where they act as anti-nodal dividing axes. By their nature, what Gauthier & MacDougall (2014) have termed thoroughfares, often assume such a function in the street network and such a position and role in the built landscape. This is the reason why MacDougall (2011) has used thoroughfares as boundaries in constructing his fragmentation geometry two. In this research, geometry two is constructed on different grounds. Preliminary empirical work conducted on the street network of the Island of Montréal pointed to the fact that thoroughfares, or some portion of these, do not always assume the function of boundary. Further, spatial discontinuities were revealed that are not associated with thoroughfares. As a consequence, the identification of thoroughfares is still very useful for the analysis, but is not sufficient when aiming at apprehending second-tier spatial discontinuities.

Gauthier coined an operational definition of thoroughfare, in which the latter is depicted as *"a component of the street network such as a boulevard or an expressway, that is granted* *with a high level of arteriality (connected to street of similar topological level or to a controlled-access highway); which spans over the length of several morphological neighbourhood areas that it provides access to; which often crosses first order barriers (such as railways, canals, etc.), and which tend to be located at the periphery of morphological neighbourhood units where it acts as an anti-nodal dividing axis."* (Gauthier, 2015, not paginated). Based on such criteria, a map of thoroughfares on the Island of Montréal was produced, which was also triangulated with the results of space syntax integration analysis, as well as with the georeferenced cartographic representation of the old agricultural road network of 1890. The map in Figure 4.3.9. presents the results of that analysis.

Old Agricultural Allotment System and Road System

We resort to historical data to achieve a more accurate delineation of MNAs. In order to do this, we use a 1890-map of the Island of Montréal showing early subdivisions of land as well as the first roads traced on the island (Figure 4.3.9). The information provided by this single map is very useful as we can see how historical roads are often associated with current highly integrated streets (Figure 4.3.8); how in some neighbourhoods the configuration or orientation of the street network is informed by the former agricultural allotment, and finally; how old agricultural parcels dividing lines inform current spatial discontinuities in residential tissues and street network.

So far his chapter has covered the approaches and methods, and has presented partial results of the preliminary analyses carried out to support the outlining of morphological neighbourhood areas (MNAs). The following sections move onto the process of creating FG2 per se, and in so doing, of delineating MNAs.

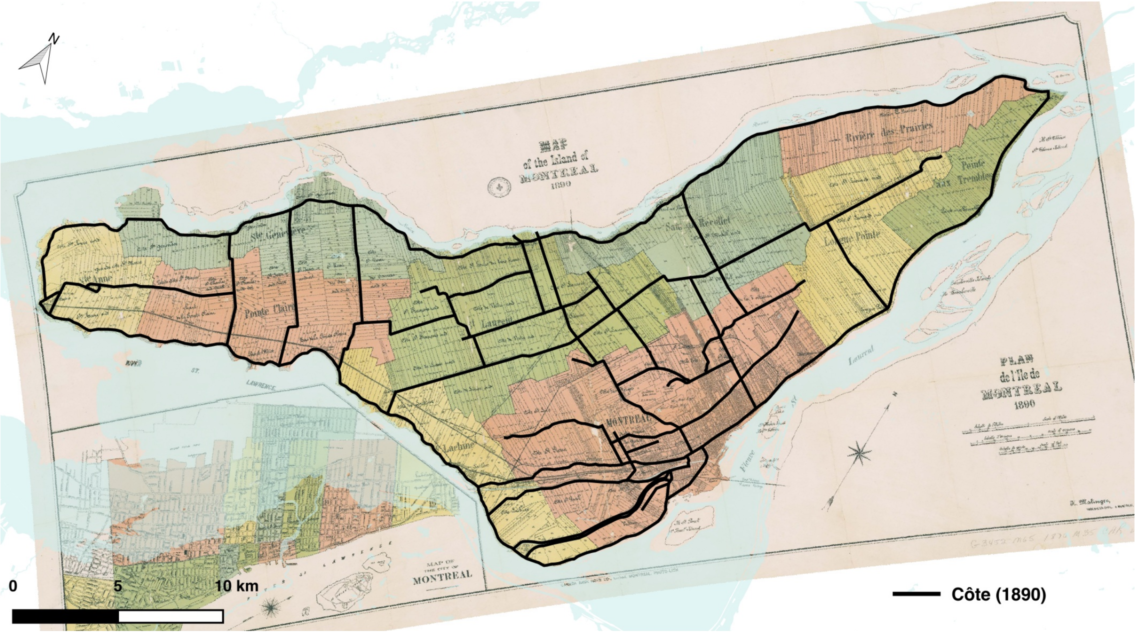


Figure 4.9: Island of Montréal, 1890. Source: BANQ (2015)

Bringing About FG2

This section describes and expands on the procedures performed for outlining morphological neighbourhood areas in geometry one. As previously discussed, an MNA is a zone comprised of predominantly residential tissues that display street network and block geometrical patterns that distinguish it from surrounding residential tissues, from which it is separated either by first-order urban barriers or by second-order urban boundaries. As a consequence, the creation of FG2 can be described as a two-fold exercise, which entails pattern recognition of street network and block geometries as well as the identification of spatial discontinuities. The work mobilizes both qualitative methods (for the identification of morphological features and the assessment of spatial relationships between these), and quantitative methods for the analysis of geometrical and topological properties of street networks and urban blocks. The last steps in the process involves morphological interpretation to decipher significant spatial relationships. This operation is facilitated by the preceding work, which consisted in: mapping urban blocks by type (according to geometrical properties); mapping streets according to their topological status the system (i.e., their level of integration); mapping urban thoroughfares; and finally, mapping old the agricultural allotment system (since it has informed later urbanization patterns).

In section 4.3, page 63, we introduced seven indicators describing properties of the city blocks which we classified as metrological, morphometric and compositional. Metrological parameters capture dimensions, morphometric variables refer to their configuration, and lastly, compositional indicators capture topological characteristics. Using those parameters we proceeded to create a taxonomy of city blocks applicable to Montréal. This categorization, along with the results of space syntax analysis, serve as the basis for the delineation of MNAs. Outlining MNAs, however, is not a straightforward or automatic process. Here, we face some difficulties while carrying out the task as in some circumstances there is no apparent contrasting elements within a patch revealing distinctiveness; it is in such cases when we resort to bringing into the analysis the historical allotment system and the *"contrada"* structure.

For delineating MNAs, we first proceed to to examine all 132 patches from geometry one. We identify 89 patches requiring no treatment whatsoever, as they are internally cohesive, and 43 large patches demanding further examination (Figure 4.3.10).

Following, with a map displaying clusters of city blocks and roads whose local integration value is higher than 7.00, which can be indicative of a thoroughfare, we proceed to explore patches requiring treatment in geometry one. After having isolated urban blocks (with their respective cluster membership), within the 43 patches to further examine, we notice that

Figure 4.10: Patches of FG1 requiring treatment or not.

spatial discontinuities are most often marked by a change in orientation in the street layout followed by arterial roads acting as boundaries. Below, we present some illustrative cases:

- **Case 1: Differing Block Geometries.** Here we present a residential patch displaying a predominantly orthogonal grid in the area of Verdun. Change of orientation in the street layout indicates the presence of two morphological areas. However, a small sector on a side of a highly integrated road shows as well a different street pattern configuration, evident in the indicators of orthogonality and compactness. As a result, this urban patch is split in 3 morphological areas (Figure 4.3.11).


Block Type

Space Syntax - Local Integration

Urban Thoroughfares

Morphological Neighbourhood Areas

Figure 4.11: FG1 - Patch 87.

- **Case 2: Differing Street Networks - Topological Properties.** As seen in Figure 4.3.12, this patch does not seem to display any internal homogeneity in regards to the configuration of its urban tissue. Different types of blocks are interspersed across the patch making it difficult to delineate cohesive zones, although different *'mixes'* of block types can be observed in different areas (e.g., some sectors are characterized by orthogonality, some area not, etc.. The block geometry alone does not allow for a proper delineation. Here, local integration provides further evidences of differing street patterning; in particular when combined with the urban thoroughfares map. In the latter case, thoroughfares assume the status of *"anti-nodal dividing axis"* as per Cannigia & Maffei (2001) formulation. The subdivision of this patch results in 9 MNAs.

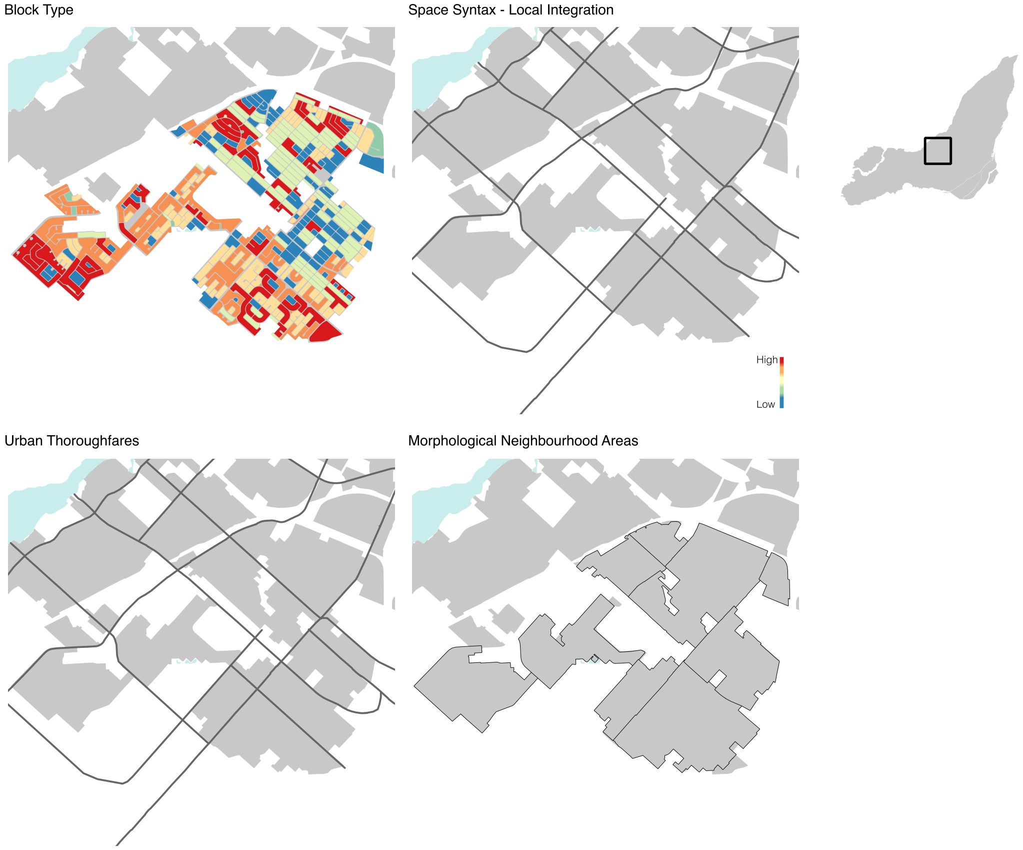
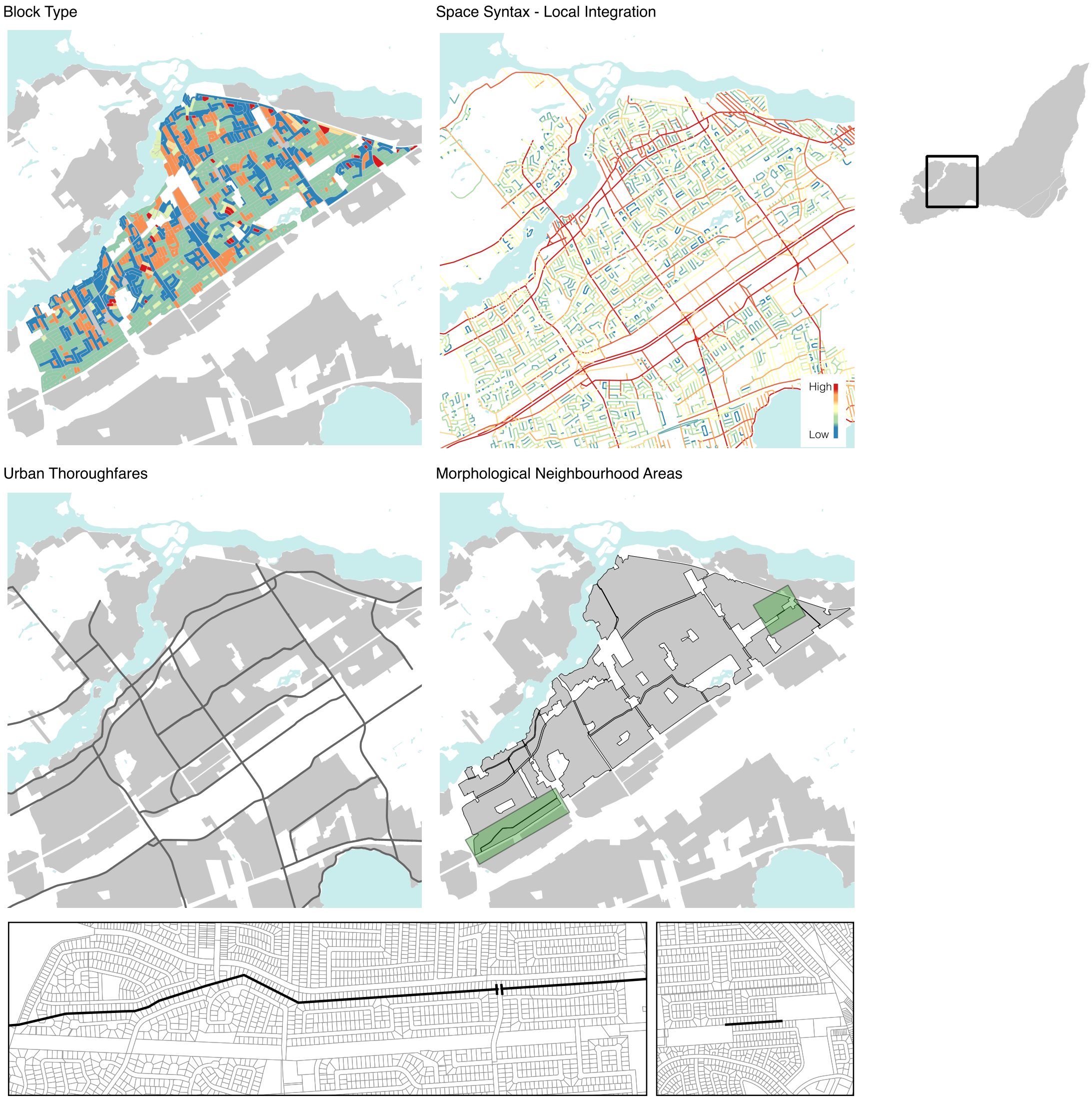


Figure 4.12: FG1 - Patch 19.

- **Case 3: Street Network Topology and Contrada Structure**. Again, block geometry alone is not enough to distinguish zones within patch 33 in geometry one (Figure 4.7.4). This is a large patch in the West Island sector of Montréal exhibiting a pattern in which irregular blocks, with low orthogonality and compactness, are predominant. Major thoroughfares helpto delineate morphological areas within this FG1 patch. Further evidence of spatial discontinuities are also revealed by the allotment system, and in particular, by the contrada structure. In the inset figures in 4.3.13

we observe long back-to-back pertinent strips denoting little or no direct connections between adjacent zones and hence acting as boundaries. Twenty morphological areas were found within this patch.


Block Type

Space Syntax - Local Integration

Urban Thoroughfares

Morphological Neighbourhood Areas

Figure 4.13: FG1 - Patch 33.

- **Case 4: Spatial Discontinuities Informed by Former Agricultural Allotment**. This area in particular is characterized by large irregular blocks. A certain level uniformity is evident in the street layout, though modest changes in orientation and configuration of blocks denote variation of patterns. Outlining morphological zones is not straightforward. To examine this patch further we included the 1890-agricultural allotment system. We noticed that the different configurations within this patch are informed by the old agricultural system of the Island of Montréal. The seemingly subtle shifts in blocks and street network patterning appeared more clearly hence enabling for identifying five morphological zones within this FG1 patch.

Figure 4.14: FG1 - Patch 10.

Fine Tuning MNAs Boundaries

The procedures described in the previous section were applied, alone or in combination, to the 43 patches in FG1 requiring examination. This resulted in

252 patches, which, added to the 89 original patches that did not need treatment sums up to 341 morphological areas larger than 2 hectares in the Island of Montréal. It is worth

mentioning that, since here we make use of a more sophisticated approach for outlining MNAs, our results somewhat differ from those obtained by MacDougall (2011) in his analysis and delineation of *"fragmentation geometry two"* as he identified 296 urban patches based on first-order barriers and thoroughfares.

The final steps for delineating MNAs involved a meticulous refinement of the patch boundary using satellite imagery and the allotment system in order to:

- Make MNAs boundary match the allotment system;
- Remove residual, fringe, unoccupied areas;
- Slightly overlap MNAs when the dividing factor is a road. Overlapping is aimed at capturing properties of interconnectivity among morphological zones. Figure 4.3.15 shows the results of this refining process and Figure 4.3.16 presents the results of the cluster analysis carried out on MNAs.

Figure 4.15: Correction of MNAs Boundaries.

Figure 4.16: Morphological Neighbourhood Areas (2016).

Conclusion

This chapter has outlined the process for identifying morphological units within the urban tissue. The process involved a semi-automated phase built around spatial indicators pertaining to urban blocks which allowed to clearly identify discontinuities by means of clusters of blocks sharing similar properties. Subsequently, we carried out a meticulous procedure, involving parameters of space syntax, allotment system, and historical information to expose latent patterns in the urban tissue and find morphological zones. Last, we perfected the morphological neighbourhood areas by eliminating noise in fringe areas and by pairing their perimeter to the allotment system.

Chapter 5

Taxonomy of Morphological Neighbourhood Areas

5.1 Introduction

With neighbourhood morphological areas already outlined, we then proceed to identify and compute parameters aimed at capturing their internal properties. Here, we differentiate between local and global indicators. Some of theses are derived from urban blocks and space syntax analyses while others are specifically estimated for MNAs. Following, we perform the statistical analysis, which involves, first, a principal component analysis (PCA) aimed at reducing the dimension of the dataset in order to identify the most significant variables. Finally, we run a hierarchical clustering analysis (HC) to categorize MNAs in groups.

5.2 Variables

For creating our taxonomy of MNAs we resort to a series of variables aimed at capturing properties of MNAs and/or *'part-to-whole'* relationships. Our indicators include measures of the MNAs themselves while others bring into the classification topological attributes of the street network and geometrical properties of urban blocks.

Global Variables

For global, or pan-island indicators we resort primarily in space syntax metrics. Space syntax indicators for the whole system, including and excluding controlled-access highways, are averaged by morphological neighbourhood area. The process results in 16 variables that are appended to the MNA dataset.

Our second global indicator is a measure of MNA interconnectivity. Here, we identified all roads segments linking at least two MNAs, computed the percentage of such links crossing a first-order urban barrier and add the to the MNAs dataset.

Local Variables

We select a group of variables from which we seek to reveal internal properties of the neighbourhood morphological areas. Here, we find primarily compositional/topological indicators derived from urban blocks and space syntax analysis. Nonetheless, we add as well two compositional and one morphometric parameters pertaining to MNAs.

Properties of the Urban Block

Using the urban block for identifying patterns in the urban tissue proved to be a very effective method for clustering blocks. In section 4.3.1, page 63, we identified 7 block variables. Three of these indicators do not play a significant role in determining types of MNAs and may even add noise to the data analysis; therefore, they were excluded from this analysis. We select 4 blocks geometry variables: *Ratio Area-Perimeter*, *Compactness*, *Orthogonality*, and *Number of Neighbours*. These indicators are averaged by morphological neighbourhood area and appended to the MNAs dataset.

Local Measures for Space Syntax

Here, we run space syntax analysis for every neighbourhood morphological area. This process requires clipping the street network to MNAs and then carrying out the process independently for all 341 MNAs. The outcome of this analysis, along with those obtained in section 4.5 are averaged by MNA and appended to the MNAs dataset, which, including global parameters, results in 27 space syntax variables: *Connectivity*, *Control*, *Total Depth*, *Global Depth*, *Local Depth*, *Mean Depth*, *Global Integration*, *Local Integration*, and *Intelligibility,* each measured at global scale with highways, global scale without highways, and MNA scale. Figure 5.2.1 shows how the results of the analyses vary depending on the scale.

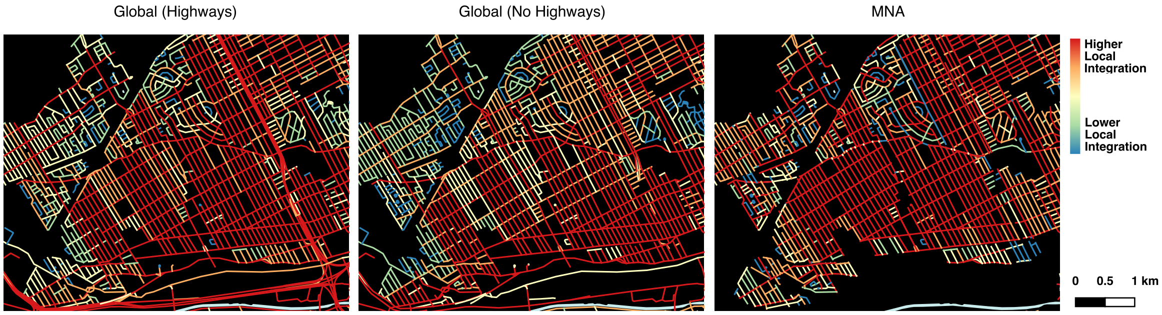


Figure 5.1: Space syntax local integration measures at three scales of analysis.

Internal Meshing

For quantifying MNAs internal connectivity we compute the link-to-node ratio which refers to the number of street segments between intersections and intersections. Higher link-to-node values are indicative of tighter meshing and therefore of greater internal connectivity within the street system.

Compactness

The existing literature provides a wide range of methods for measuring the compactness of a circle (Angel et al., 2010). Here, we have selected two indicators for assessing the compactness of morphological neighbourhood areas. The first estimation is based on t the ratio between the area of the MNA and its perimeter. In addition, we include as well the Are Exchange index, a measure of compactness developed by Angel & Parent (2010) intended for differentiating between elongated and circular geometries. This metric was already applied to urban blocks and explained in detail in section 4.3.

Data Sample and Table

Figure 5.1 below presents a list of 32 variables computed for quantifying the internal properties of morphological neighbourhood areas and their respective classification by type and extent.

	Indicator	Description	Type	Extent
1	Node_Ha	Nodes per hectare	Compositional	Local
2	Conn_Id	Link-to-node ratio	Compositional	Local
3	MNA_comp	MNA compactness	Morphometric	Local
4	B_con_pe	MNA connections per perimeter	Compositional	Local
5	B_avcmp	Block average compactness	Morphometric	Local
6	B_avnei	Block average number of neighbours	Compositional	Local
7	B_avor	Block average orthogonality	Morphometric	Local
8	B_avrap	Block average ratio area perimeter	Metrological	Local
9	PP_conn	Connectivity - SSX - Local	Compositional	Local
10	PP_cont	Control - SSX - Local	Compositional	Local
11	PP_MD	Mean depth - SSX - Local	Compositional	Local
12	PP_GI	Global integration - SSX - Local	Compositional	Local
13	PP_LI	Local integration - SSX - Local	Compositional	Local
14	PP_TD	Total depth - Local	Compositional	Local
15	PP_LD	Local depth - SSX - Local	Compositional	Local
16	PP_Inte	Intelligibility - SSX - Local	Compositional	Local
17	AR_Conn	Connectivity - SSX - All roads	Compositional	Global
18	AR_Cont	Control - SSX - Global	Compositional	Global
19	AR_MD	Mean depth - SSX - Global	Compositional	Global
20	AR_GI	Global integration - SSX - Global	Compositional	Global
21	AR_LI	Local integration - SSX - Global	Compositional	Global
22	AR_TD	Total depth - SSXC - Global	Compositional	Global
23	AR_LD	Local depth - SSX - Global	Compositional	Global
24	AR_Inte	Intelligibility - SSX - Global	Compositional	Global
25	NH_Conn	Connectivity - SSX - Global (no highways)	Compositional	Global
26	NH_Cont	Control - SSX - Global (no highways)	Compositional	Global
27	NH_MD	Mean depth - SSX - Global (no highways)	Compositional	Global
28	NH_GI	Global integration - SSX - Global (no highways)	Compositional	Global
29	NH_LI	Local integration - SSX - Global (no highways)	Compositional	Global
30	NH_TD	Total depth - Global (no highways)	Compositional	Global
31	NH_LD	Local depth - SSX - Global (no highways)	Compositional	Global
32	NH_inte	Intelligibility - SSX - Global (no highways)	Compositional	Global

Table 5.1: List of Variables for Morphological Neighbourhood Areas.

5.3 Hierarchical Clustering on Principal Components

For developing our taxonomy of morphological neighbourhood areas, we implement a principal component analysis (PCA) followed by a hierarchical clustering (HC). PCA is a statistical method widely used for reducing large datasets to a fewer number of uncorrelated variables called "*principal components*." PCA is used to reveal patterns in the data emphasizing variation. Our aim here is to identify the smaller number of component explaining most of the variability in our data. The principal components are clustered using hierarchical clustering; the entire statistical process is performed in RStudio.

Correlation Matrix

Before performing the principal component analysis we need to carry out an exploratory analysis of our variables. Highly correlated variables may affect PCA results as tend to overemphasize the contribution of certain components. For that reason, our first step is to produce the correlation matrix of all 32 variables and remove all variables whose significance values are above 0.49 or below -0.49 (Figure 5.3.1).

Upon examination of the correlation matrix we retain 11 indicators; however, two additional variables are removed: *MNA connections per perimeter* and *Control -SSX - Local* due to a significant number of outliers and to a quasi-categorical distribution, respectively. Table 5.2 presents summary statistics for the 9 remaining MNAs variables.

	Node_Ha	Conn_Id	MNA_comp	B_avcmp	B_avnei	B_avor	AR_GI	NH_LI	PP_MD
Min.	0.00	0.00	0.32	0.37	0.00	0.43	1.58	1.34	1.00
1st Qu.	0.71	1.47	0.63	0.59	3.86	0.74	2.27	3.19	2.13
Median	0.85	1.62	0.75	0.62	4.94	0.82	2.57	4.07	2.64
Mean	0.87	1.65	0.72	0.62	4.54	0.81	2.53	4.14	2.68
3rd Qu.	1.02	1.82	0.82	0.66	5.65	0.91	2.82	5.07	3.13
Max.	1.97	3.00	0.92	0.80	7.46	0.99	3.54	7.22	5.55

Table 5.2: List of Variables for Morphological Neighbourhood Areas.

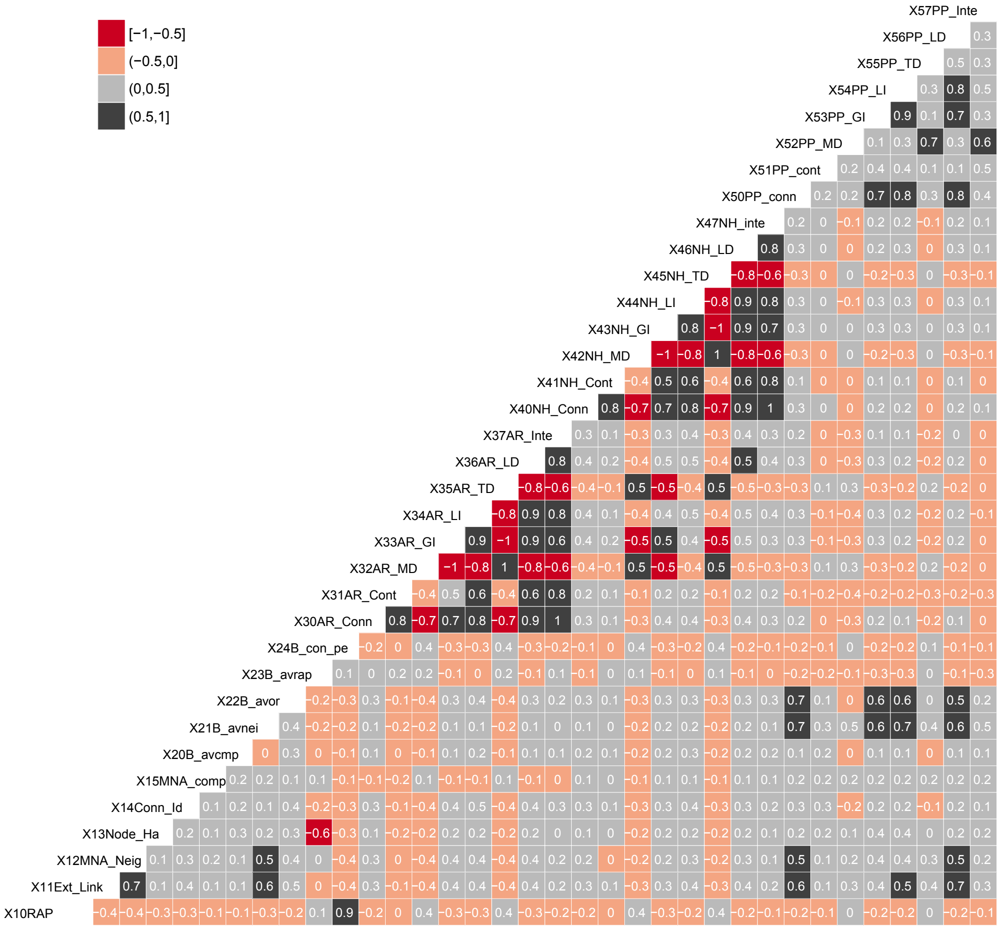


Figure 5.1: Correlation matrix of MNA indicators.

Data Preparation

The process of data preparation involves, first, normalizing the variables. Normalization adjusts the values of variables measures at different scales to make them comparable. Figure

5.3.2 presents a boxplot of MNA indicators. We observe that all 9 variables' means are close to zero. In addition, this graph also identifies 43 observations acting as outliers. Upon further examination, we established that 19 MNAs, given their dimensions and characteristics, did not qualify as outliers and were not excluded from the MNAs dataset (Figure 5.3.3). Finally, we performed a logarithmic transformation to the MNAs dataset to lessen the influence of the remaining outliers or any other extreme values.

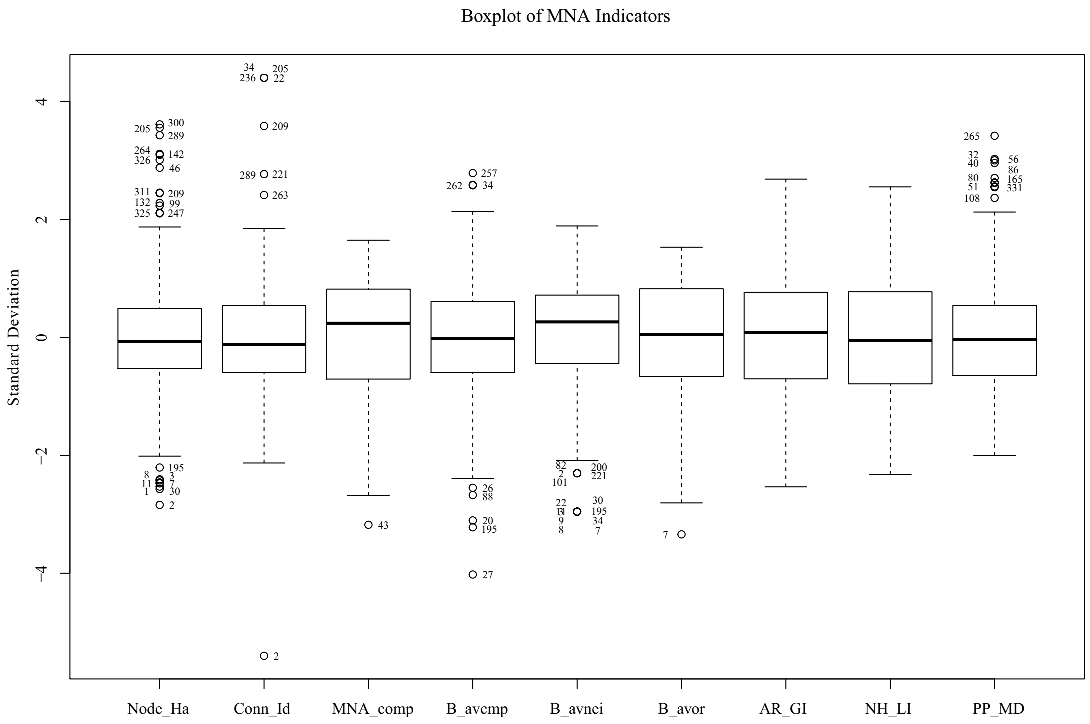


Figure 5.2: Boxplot of MNA indicators

Principal Component Analysis

PCA is an heuristic approach that seeks to explain the most significant characteristics of the data in a reduced number of axes, or principal components, without much loss of the

Figure 5.3: Outliers

information (Legendre & Legendre, 2012). The decision in regards to how many components to retain is usually arbitrary and can be based on the percentage of the explained variance. Here, we look at the eigenvalues. Eigenvalues are an estimate of the significance of the axes (Legendre & Legendre, 2012). Eigenvalues values of less than 1.00 imply that the component accounts for less variability than a single variable and, therefore, are not retained in the analysis (Girden and Kabakoff, 2010).

Our first iteration of the principal component analysis is run on a matrix composed of 9 variables and 317 observations. As seen in figure 5.3.4, the first 3 principal components account for most of the variability in the data (eigenvalues > 1.00); in consequence, we proceed to perform the first iteration of the PCA retaining 3 components.

At this point we need as well to specify the number of clusters we are seeking in the data. We tested, compared, and analyzed different results of the dendrogram in GIS. We run iterations ranging from 2 to 12 clusters. Classifying the MNAs in two groups (clusters)

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Standard Deviation	1.62	1.30	1.04	0.94	0.84	0.81	0.76	0.68	0.54
Eigenvalues	2.62	1.70	1.09	0.89	0.71	0.65	0.58	0.46	0.30
Proportion of Variance	0.29	0.19	0.12	0.10	0.08	0.07	0.06	0.05	0.03
Cumulative Proportion	0.29	0.48	0.60	0.70	0.78	0.85	0.92	0.97	1.00

Table 5.3: Importance of principal components.

implies that seemingly quite different MNAs fall in the same category. On the contrary, classifying MNAs in twelve groups might imply that distinctions are made between groups that differ only marginally. We determined that 8 groups seem to capture internal properties deemed appropriate for creating a taxonomy of morphological neighbourhood areas in the Island of Montréal.

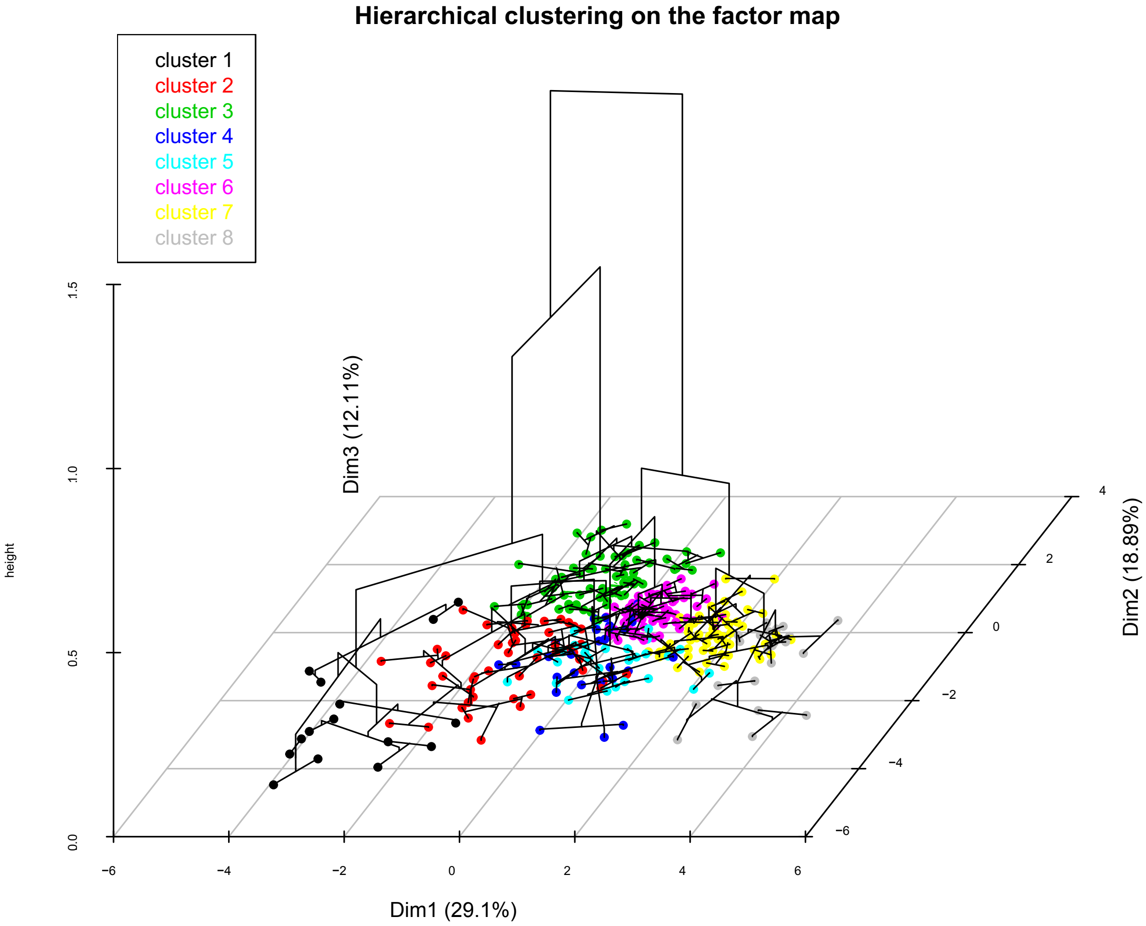


Figure 5.4: Hierarchical clustering on the factor map

As shown in table 5.3, the first 3 principal components capture a only 60% of the variability in the data (29.1% in Dim1, 18.89% in Dim2 and 12.11% in Dim3), which represents a rather weak figure. In consequence, we proceed to identify and isolate the most contributing variables in the PCA for re-running the algorithm.

For finding the most contributing variables we resort to the *sum of the cos2*. The *cos2* is used to test the quality of the representation. The closer the *cos2* is to 1.00 the more represented the variable is in the principal components. In figure 5.3.5, we present all 9 variables and observations plotted and colour-coded by their *cos2* contribution. The longer the arrow (*cos2*) the more the variable contributes to the principal components. The most important variables are those that are correlated with the first and second principal components. Variables with a lower contribution may be removed to simplify and optimize the analysis. In our case, we observe that *MD_PP* (Mean Depth - SSX - Local), *B_avnei* (Block average number of neighbours) and *B_avor* (Block average orthogonality) are the most significant variables. In consequence, in our second iteration, we retain these three variables, dismiss the remaining 6 variables, and proceed to re-run the principal component analysis.

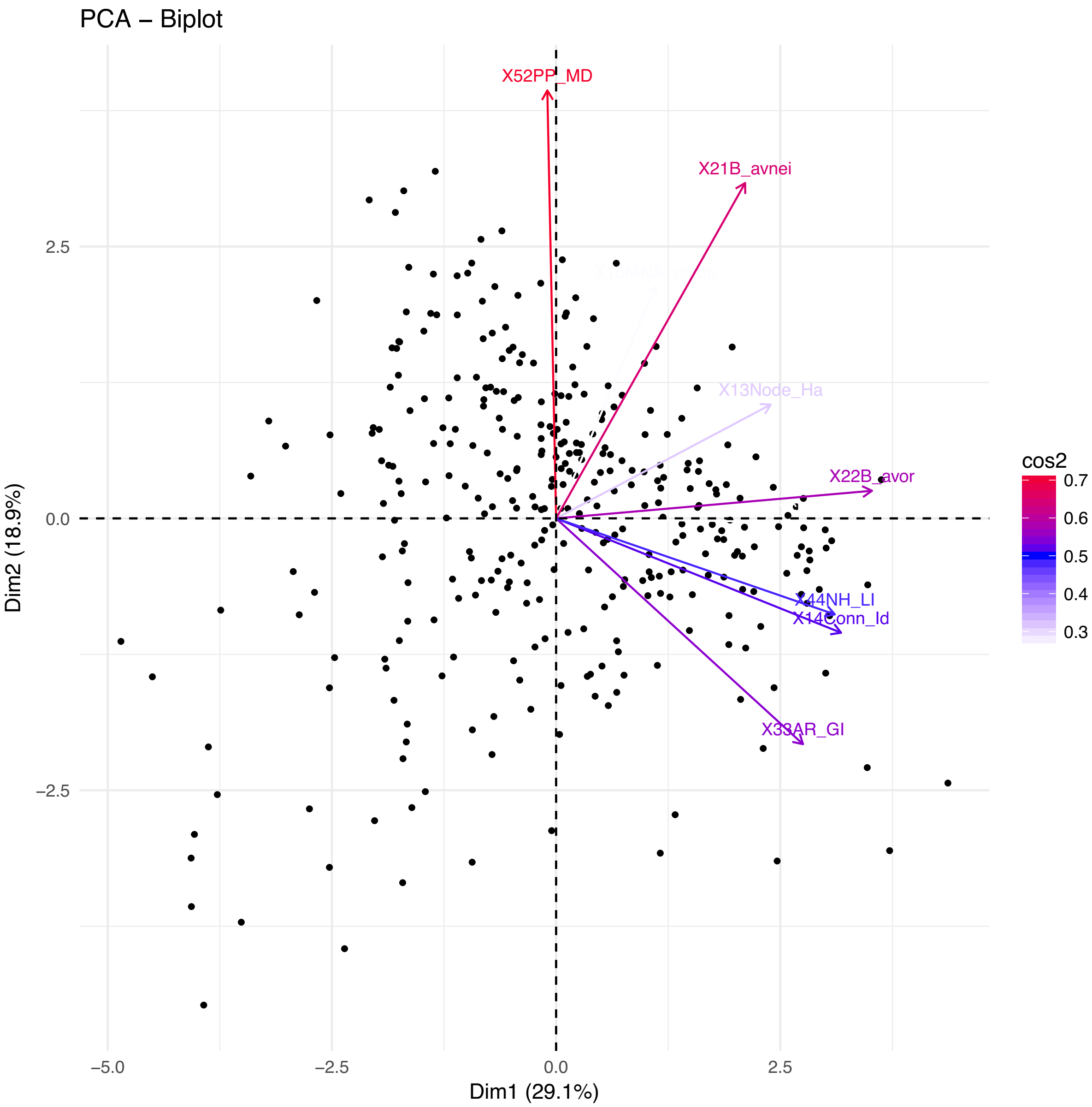


Figure 5.5: Contribution of variables to principal components.

For running the second iteration of the PCA, again, we first determine the number of components to retain indicated by eigenvalues > 1.00. As shown in table 5.4, we retain the two first principal components and then proceed to run the principal component analysis and the hierarchical clustering with an eight-group partition. The cumulative proportion increases to a high 86.2%, meaning that these two components, comprehending 3 MNA

	PC1	PC2	PC3
Standard Deviation	1.16690	1.10660	0.64330
Eigenvalues	1.36156	1.22464	0.41379
Proportion of Variance	0.45380	0.40820	0.13790
Cumulative Proportion	0.45380	0.86210	1.00000

Table 5.4: Importance of principal components.

indicators, are extracting most of the information in the data. The results of the hierarchical clustering subsequent to the PCA are shown in figure 5.3.6 and mapped in Figure 5.3.7.

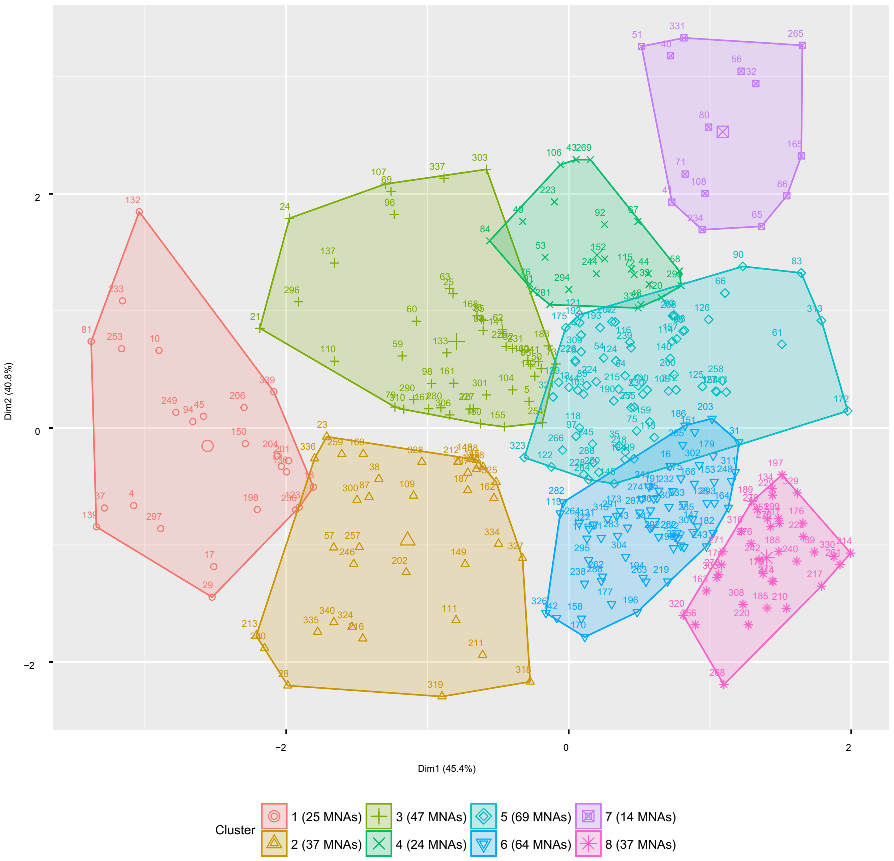


Figure 5.6: MNAs clusters.

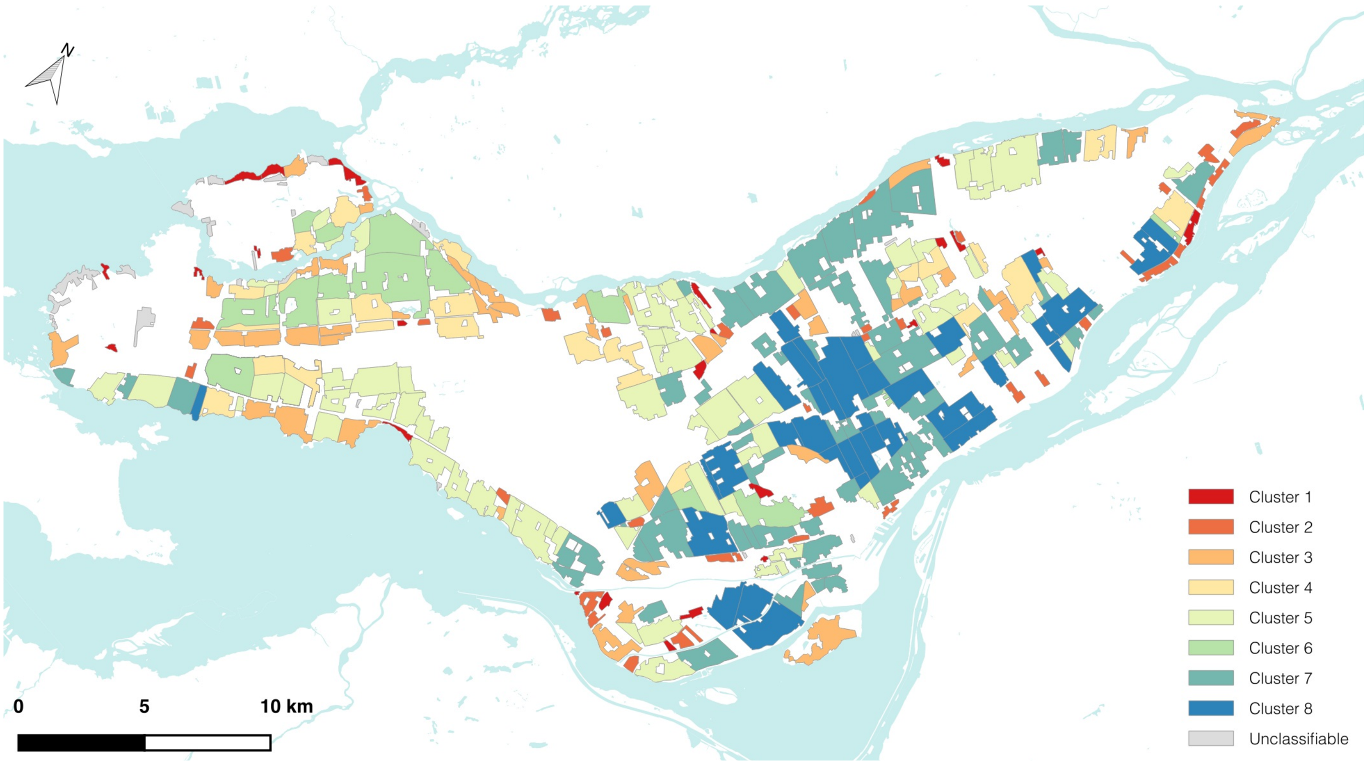


Figure 5.7: Hierarchical clustering of MNAs mapped representing eight clusters.

Interpretation of PCA Results

For interpreting the results of the PCA and the hierarchical clustering we need to look at the biplot (Figure 5.3.8). This figure shows variables and individuals colour-coded by cluster membership. The figure includes as well the loadings (contribution) of each variable to every dimension. We see that the first principal component is strongly correlated with B_avnei (the vector representing this variable is almost parallel to the Dim1 axis). This means that the average number of neighbours per block is a significant factor for MNAs along the Dim1 axis, where most of the variability occurs.

The second principal component, on the other, hand, is explained by both PP_MD and B_avor with the former on the positive quadrant and the latter in the negative quadrant. The distances among observations in the biplot are approximations of their euclidean distances in multidimensional space; closer observations are more similar to each other than distant observations. We can proceed now to describe how these indicators explain the clustering using the biplot in combination with radar graphs.

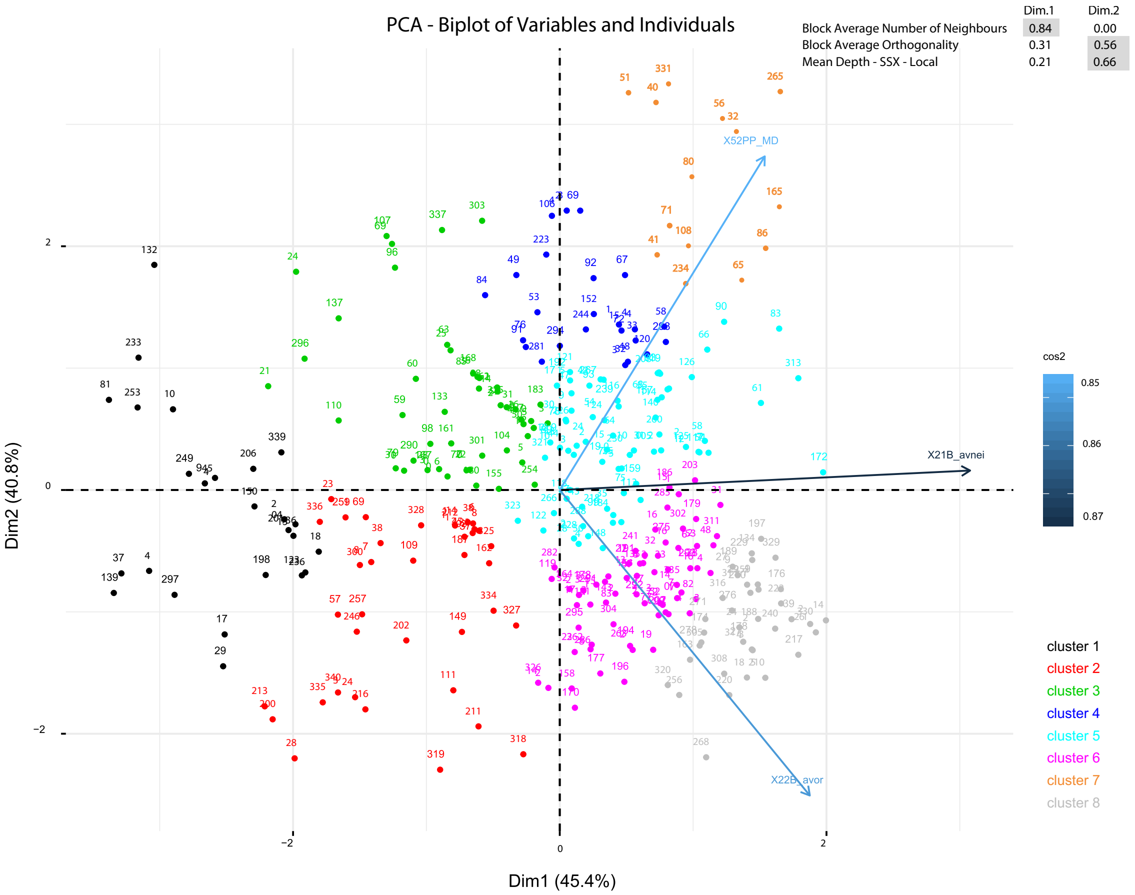


Figure 5.8: Biplot of Variables and Individuals

Cluster 1: this cluster (n=25) characterizes by a set of MNAs which principally are on the opposite end of the B_avnei vector, meaning these patches are constituted mainly by few, and potentially large and isolated blocks. We see as well that neither the vectors or opposites of *PP_MD* and *B_Avor* seem to affect this group. MNAs in this cluster are interspersed across the island, are predominantly small and elongated, and present a cul-de-sac street pattern. Another important characteristic of this cluster is that all 25 MNAs in this group are next to a first-order urban barrier, be it either natural, as those along the shore or specialized tissues (Figures 5.3.9 and 5.3.10).

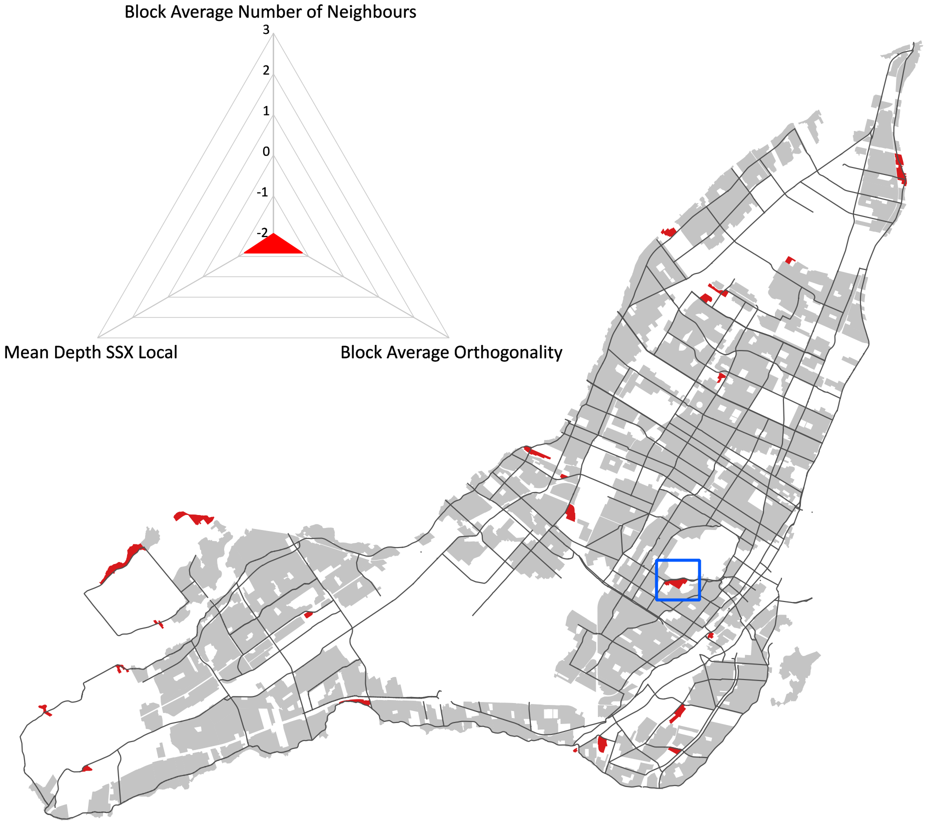


Figure 5.9: Cluster 1.

Figure 5.10: Sample of cluster 1.

Cluster 2: we see that most observations of this cluster (n=37) are located at the opposite end of PP_MD, meaning that MNAs in this group have a rather low mean depth, indicative good internal connectivity. Also, we see that some MNAs are clustered along the Dim1 axis, opposite to the B_avnei vector, denotative of isolated blocks or blocks with very few neighbours. These are small and predominantly compact patches, scattered, with a rather orthogonal but interrupted grid. Here we also see that all 37 patches in this group are bordering a first-order urban barrier (Figure 5.3.11 and 5.3.12).

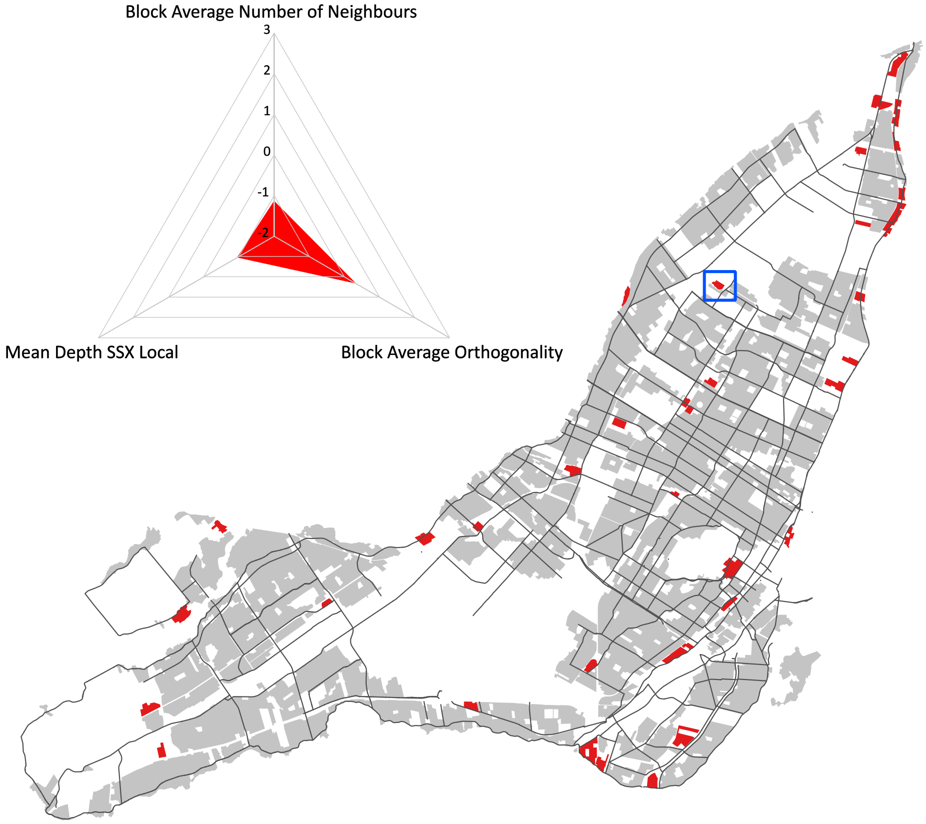


Figure 5.11: Cluster 2

Figure 5.12: Sample of cluster 2

Cluster 3: this group (n=47) is composed by medium-sized patches scattered across the island. In the biplot this group can bee located on the opposite end of B_avor, suggesting that these MNAs have a very low block orthogonality, therefore, displaying a rather curvilinear street layout. Likewise, there is a concentration of patches along the Dim1 axis, also on the opposite side of the vector, indicative of blocks with few neighbours. Here we se as well most of the 47 MNAs next to first-order urban barriers and are enlongaged, hence, located at peripheral, or anti-polar locations in the system (Figures 5.3.13 and 5.3.14).

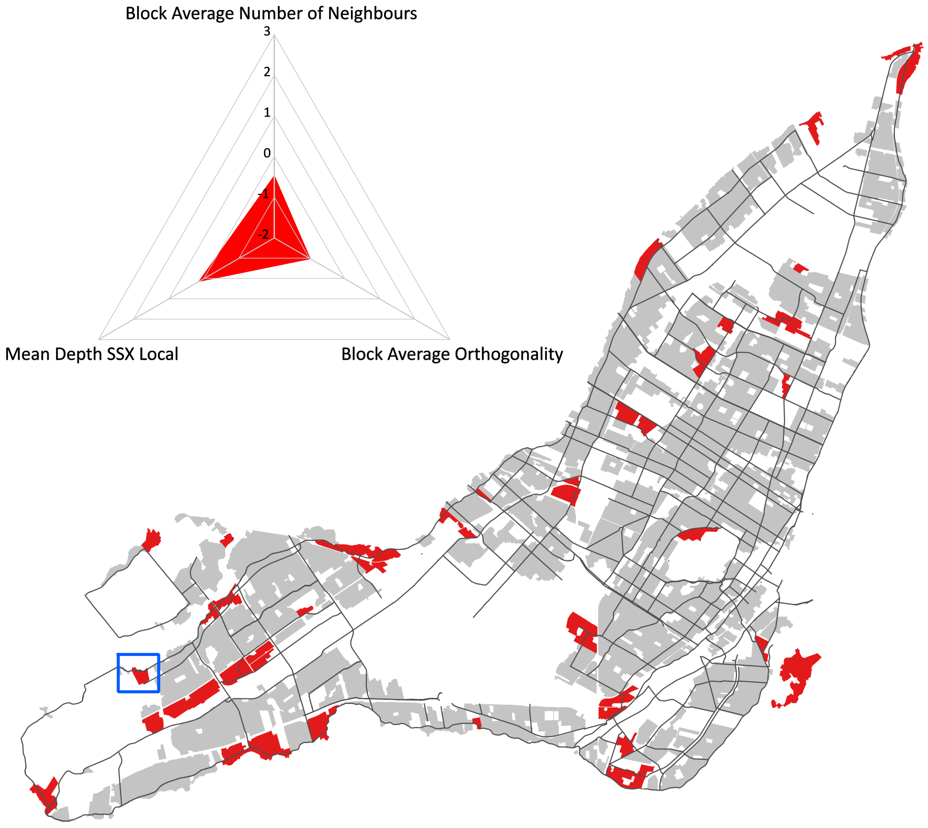


Figure 5.13: Cluster 3

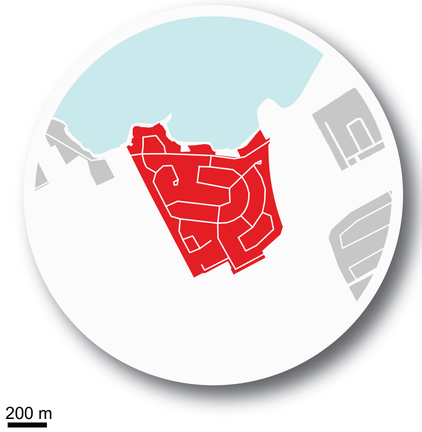


Figure 5.14: Sample of cluster 3

Cluster 4: here we find large MNAs (n=24) located on the mid to high-end of the *PP_ MD* vector, indicative of poor internal meshing, and to the opposite side of the *B_ avor* vector, which may denote an irregular, curvilinear, street pattern. *B_ avnei* does not seem to have much of an impact on the internal structure of these MNAs Here. we see a split with some of the 24 MNAs in the group bordering other MNAs and some next to first-order urban barriers (Figure 5.4.15 and 5.4.16).

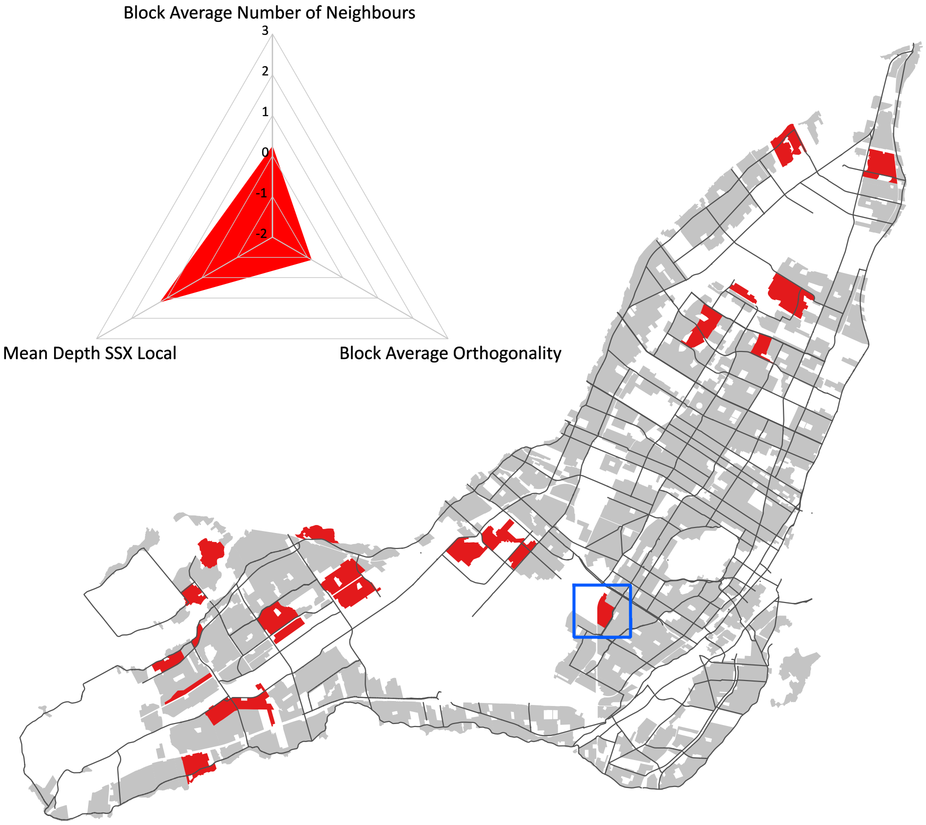


Figure 5.15: Cluster 4

Figure 5.16: Sample of cluster 4

Cluster 5: this cluster (n=69) is comprised of predominantly medium-size patches scattered across the island. We see this group at the origin of the Dim1 and Dim2 axes. Here, all three indicators seem to influence the internal configuration of the patch. Most notably it is *PP_ MD*, with medium to somewhat high values which reveals low internal connectivity. We notice that some observations are located along the *B_ avnei*, close to the origin. From this, we can assume that blocks within this MNA are not isolated. In regards to *B_ avor*, the group is found close the origin and even on the opposite side of the vector which may denote an rather irregular or interrupted grid street configuration. Here we start to see how as block orthogonality increases, evidencing predominantly gridiron patterns, MNAs are less likely to be adjacent to first-order and tend ratther to be in close proximity to other MNAs (Figures 5.4.17 and 5.4.18).

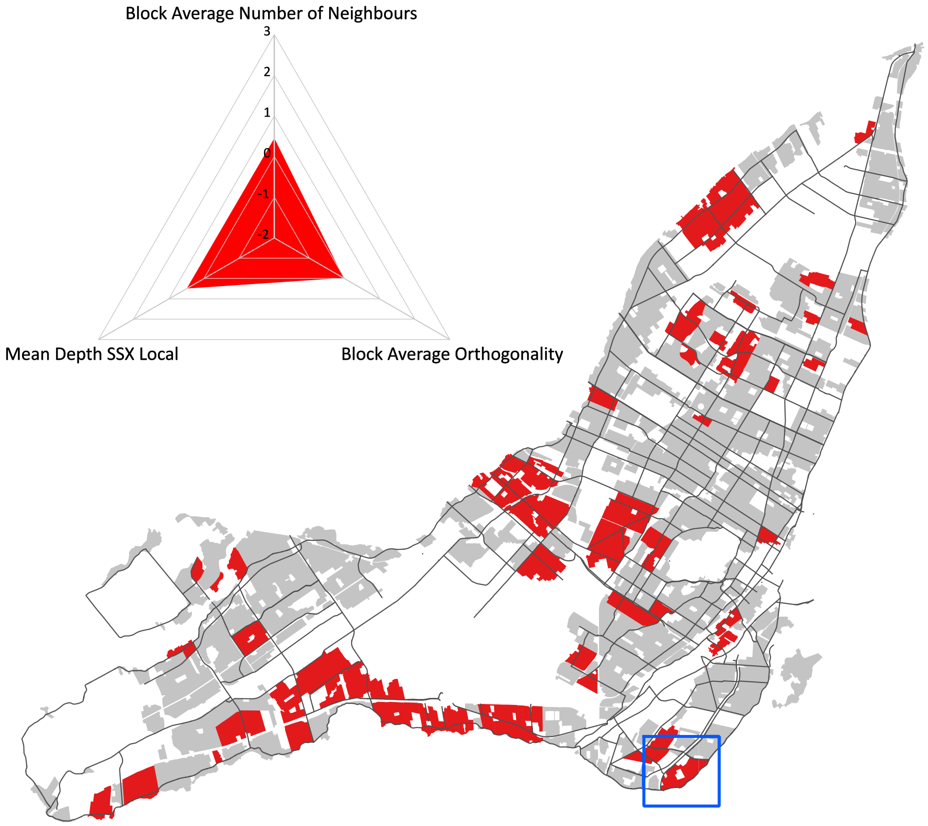


Figure 5.17: Cluster 5

Figure 5.18: Sample of cluster 5

Cluster 6: we see this group of MNAs (n=64) clustered along he mid-end of the *B_ avor* vector. This may be denotative of an internal configuration predominantly orthogonal although with some interruptions or few non-orthogonal blocks. B_avnei, influence here seems medium-low and being the group located at other end of PP_MD suggest a good internal connectivity. MNAs in this groups exhibit some degree of compactness, with very few exceptions. Likewise, they are systematically neighbouring other residential areas (Figures 5.3.19 and 5.3.20).

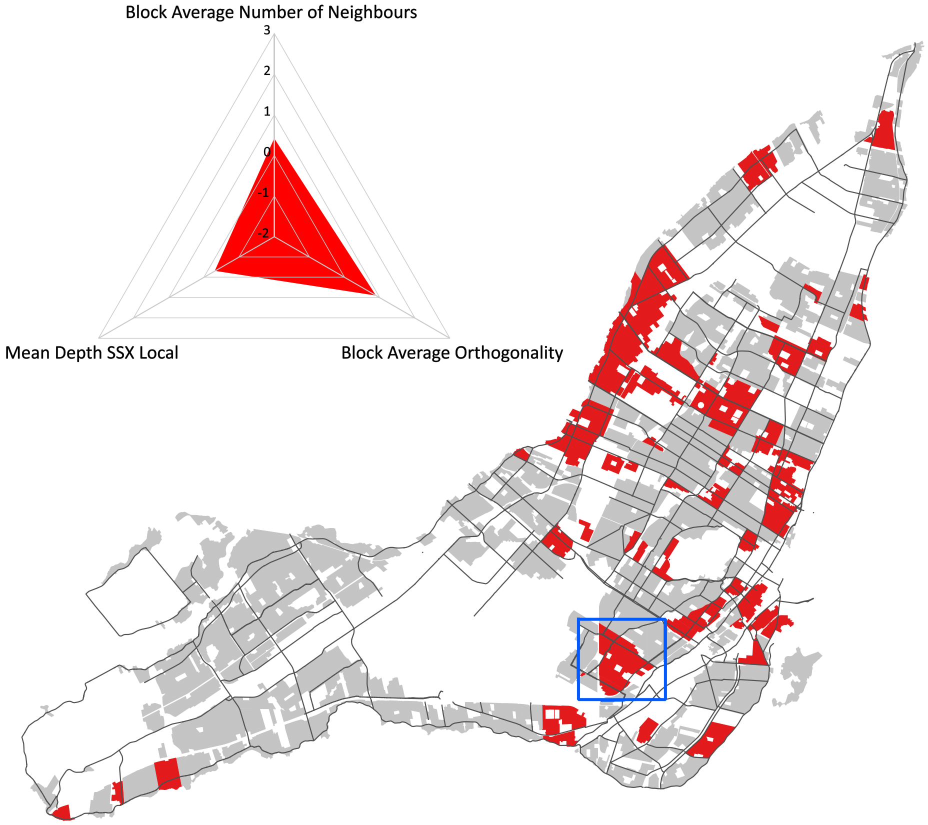


Figure 5.19: Cluster 6

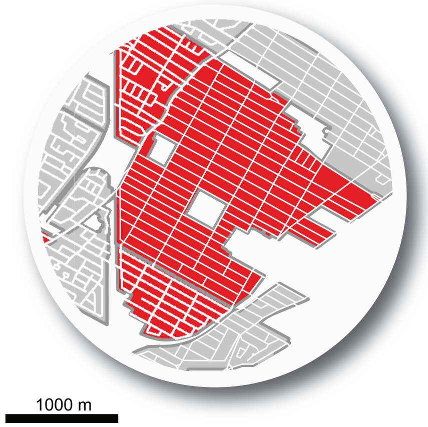


Figure 5.20: Sample of cluster 6

Cluster 7: here we found MNAs (n=14) clustered along the higher of *PP_MD*, denoting a very low internal connectivity. Block orthogonality in this group also seems very low, which suggests that we are in the presence of a non-orthogonal street configuration. *B_avnei*, is low but does not seem to have a significant impact on this partition Residential patches in this group do not seem quite in proximity of first-order urban barriers and neighbour other MNAs. (Figures 5.3.21 and 5.3.22).

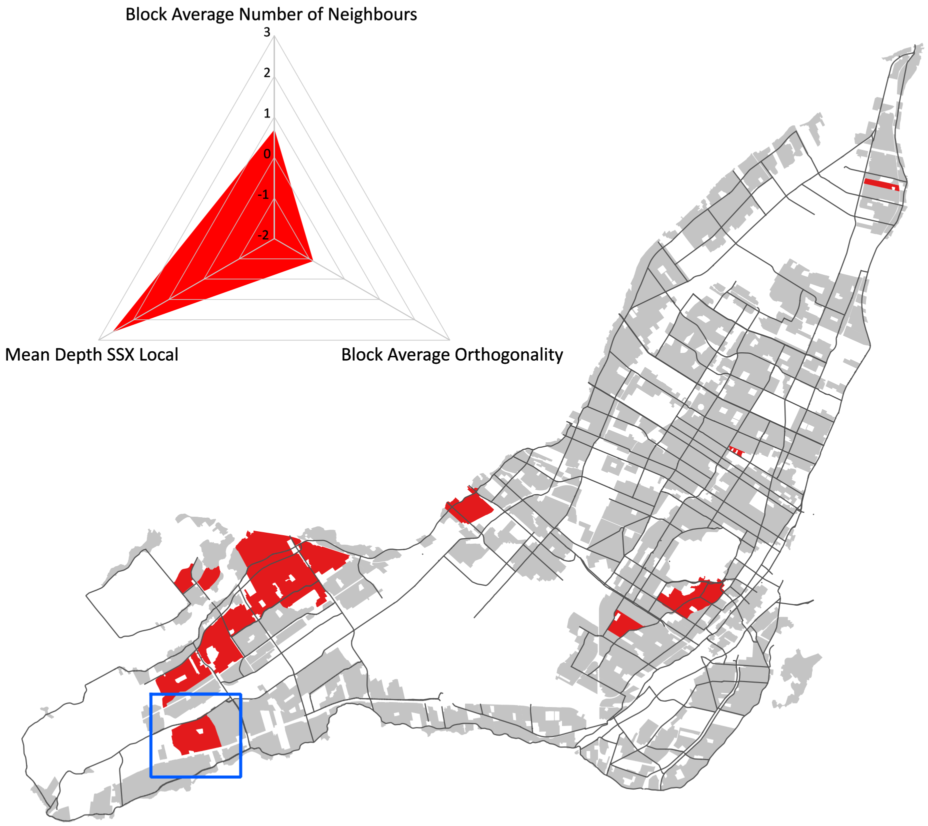


Figure 5.21: Cluster 7

Figure 5.22: Sample of cluster 7

Cluster 8: we see that observations in this group (n=37)are located predominantly at the higher end of *B_ avor*, indicating that blocks are predominantly orthogonal, therefore, so is the street pattern. The groups is also found at the other end of *PP_ MD*, suggesting a good internal connectivity and meshing. *B_ avnei* is found at the mid-end of the vector from which we can assume that blocks are not isolated. Patches are from medium to large in size, generally compact, and mostly clustered in the center of the island where they are neighbouring other residential areas (Figure 5.3.23 and 5.3.24).

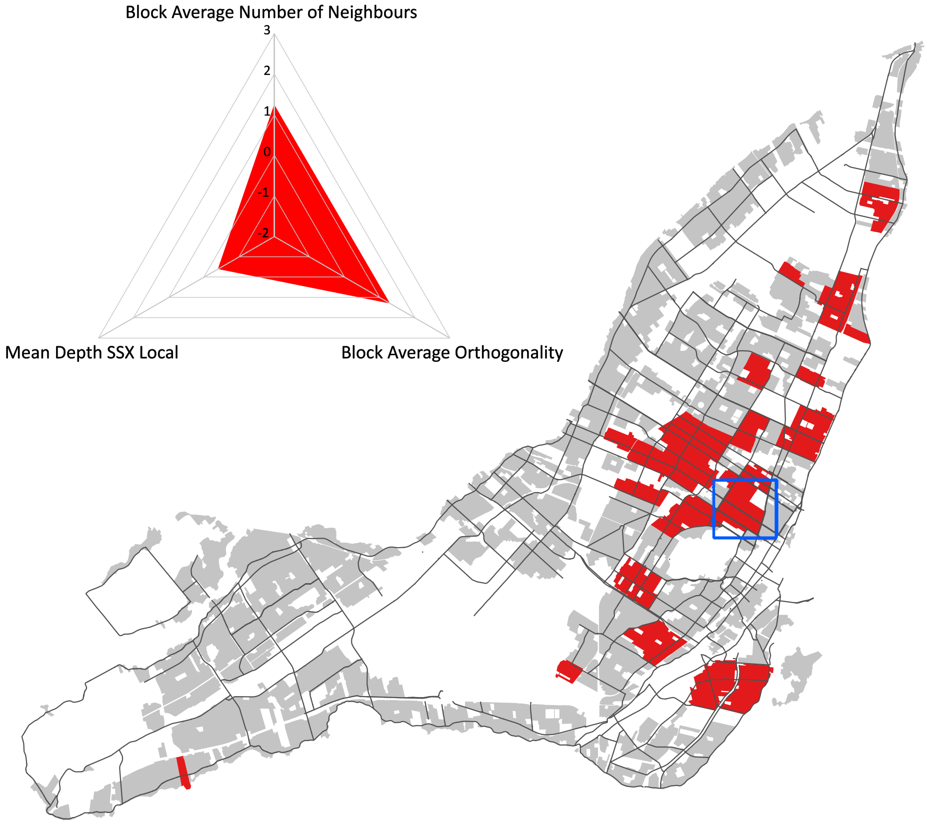


Figure 5.23: Cluster 8

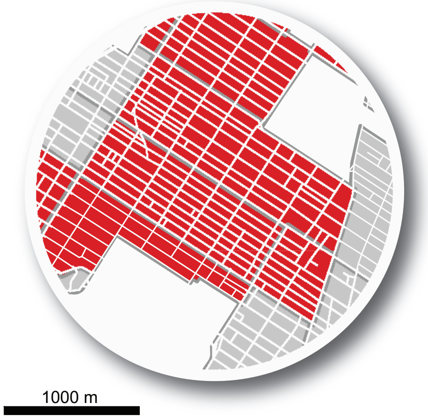
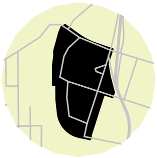
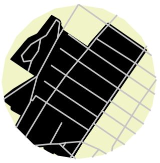
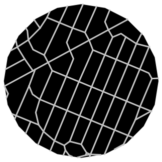
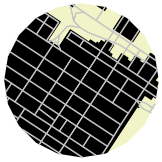
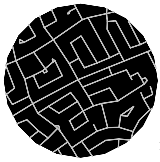
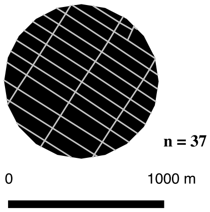


Figure 5.24: Sample of cluster 8

5.4 Conclusion

We have characterized morphological neighbourhood areas using a statistical approach that combines principal component analysis and hierarchical clustering. We began our analysis with 32 indicators; all aimed at capturing different geometrical and topological properties of MNA's street systems (including *'part-to-whole'* spatial relationships). At an early stage in the analysis we found out that only 9 of such variables where significant for the analysis, as many variables were highly correlated, thus, measuring the same or redundant characteristics of the form. During our study, we also detected outliers. From a total of 341 initial MNAs, the algorithm identified 43 observations as outliers. Upon verification, we determined that only 24 MNAs were true outliers, that were then excluded from the analysis. This does not entail that these MNAs are irrelevant; rather, their geometrical properties are so capricious that carrying out the analysis with them would have skewed the results significantly. In order words, these are too singular to be integrated in the statistical classification procedure. We conclude that in the Island of Montréal we can find 8 types of neighbourhoods as per compositional (*B_avnei, PP_MD*) and morphometric (*B_avor*) indicators. Figure 5.4.1 summarizes the results of the hierarchical clustering of morphological neighbourhood areas.

Cluster Sample	**Type of Configuration**	**Mean Depth**	**Block Average # of Neighbours**	**Block Average Orthogonality**
 **n = 25**	Small and irregular with a cul-de-sac street pattern and loose meshing	1.85	2.40	0.70
 **n = 37**	Small and compact with interrupted grid pattern and somewhat tight meshing	2.02	3.37	0.85
 **n = 47**	Medium size and irregular with curvilinear street pattern with very loose meshing	2.88	4.19	0.72
 **n = 24**	Medium size and compact with curvilinear street pattern and loose meshing	3.68	5.05	0.73
 **n = 69**	Medium size with irregular grid pattern with a somewhat tight meshing	3.15	5.30	0.82
 **n = 64**	Large with orthogonal street pattern with a very tight meshing	2.51	5.25	0.91
 **n = 14**	Large and compact with non-orthogonal street patterns with a loose meshing	4.78	5.56	0.72
 **n = 37**	Large, predominantly compact with orthogonal street pattern with a tight meshing	2.45	6.27	0.96

Total = 317

Figure 5.1: Clusters of MNAs with average values per indicator.

Chapter 6

Discussion and Conclusion

Mobilizing and combining methods from several disciplines and theoretical approaches – namely, typo-morphology, space syntax, landscape fragmentation, geographical information science, and statistics – this research's objectives were two-fold. First, it aimed at making a methodological contribution to the study of residential built environments centered on their street networks and tissues forms. Secondly, it wished to produce useful knowledge on Montréal's Island built landscape per se.

Building upon the work of MacDougall (2011) and Gauthier (2015, 2016), the methodological contribution entailed devising a method for identifying and spatially delineating residential areas based on morphological criteria (Chapter 4). More specifically, morphological areas are analytically defined based on *"internal"* geometrical and topological characteristics that distinguish them from surrounding residential areas from which they are separated by either first-tier of second-tier spatial discontinuities (respectively manifested as first order barriers or boundaries). The work entailed exploring and developing further the notion of boundaries, in order to distinguish between arterial boundaries (of the thoroughfare variety), and cadastral bisecting line boundaries. Hence defined, what we termed morphological neighbourhood areas after Gauthier (2015), can serve as geographical unit of reference for comparative morphological analysis, or other types of enquiries that investigates the relationship between urban form and social of environmental conditions for instance. We posit that such spatial/geographical unit of reference is more opportune and potent for certain types of analysis than administrative subdivision zones such as census tracts or dissemination areas that are routinely used in urban studies and urban planning studies. A second methodological contribution of the research (Chapter 5) consisted in developing a set of morphological, including geometrical and specific topological indicators (each consisting in a variable) to be used for quantitative analysis resulting in the characterization, the classification, and then the mapping in GIS, of differing urban residential tissues types (though excluding the building fabrics for the moment).

Beyond, the strict methodological considerations, our work allowed us to engage the reflection on some theoretical conceptualizations from typomorphology and space syntax. Caniggia & Maffei‘s theoretical models of street hierarchy, nodality, and tissue formation processes proved complementary with the formulations of connectivity and integration developed by Bill Hillier and Julienne Hanson. Our approach has allowed to see to which extent these theories complement each other and/or to which extent quantifiable attributes of street networks, most notably those developed by Hillier and Hanson, can capture properties of the road system that are the result of long-term morphogenetic processes.

Our research has produced interesting findings on Montréal’s urban form. The Chapter 4 has demonstrated that there exist 341 morphological neighbourhood areas in the Island of Montréal. Chapter 5 has demonstrated those can be clustered in 8 types of MNA’s based on the morphological, geometrical and topological properties of their street networks and blocks by using the variables *block average number of neighbours*, *block average orthogonality*, and space syntax's *mean depth* measured at MNA level, which explain 86.2% of the clustering. A detailed analysis of each cluster has allowed us to stress their intrinsic characteristics, the characteristics that distinguish clusters from each other, as well as to map the spatial distribution of the MNAs that belong to each of the clusters.

Those analyses trace a contrasted portrait in the Island of Montréal. Furthermore, we can start appreciating how such a portrait of the city fabrics based on the morphological, geometrical and topological properties of their street networks and blocks can lead to a more profound interpretation of the inherent conditions of the tissues and of the implications in terms of potential and constraints to support social life in general and sustainable living more broadly. Though this study did not touch on the third sub-system of the tissue, i.e. the buildings' fabric, it could be argued that it focused on the most vital (there cannot be lots and buildings without a route giving access to it) and resilient sub-system by centering on the street system. In addition, by delving into the geometrical properties of the street network that are directly linked to the block geometrical properties, the analysis *"captures"* and partially accounts for some important morphometric, metrological conditions of the sub-system of the allotment. In doing so, the results of the analysis already leads to interesting interpretations, while pointing to fascinating future research.

We can argue, for instance, that the topology of the street network alone has a significant impact on the urban neighbourhoods spatial make-up and functioning; not only in regards to measures of accessibility, as those provided by space syntax, but also in relation to transportation and housing. For instance, in residential areas characterized by irregular and elongated configurations it is practically impossible to deploy a grid system. Thus, when lots are created and housing is developed it follows a logic compatible with the patch configuration. Here, we most often see curvilinear residential roads, where the only type of housing possible is detached houses.

However, in the case of Montréal, curvilinear configurations are also found in large, more compact, suburban neighbourhoods, at both east- and west-ends of the island developed in the automobile era after WWII. As shown by our measures of Mean Depth, MNAs responding to curvilinear configuration may hinder the possibility for the development of virtual communities or places for social interaction since the configuration of the street alone makes any attempt of internal exploration by foot tiresome or impossible. We can argue that status of MNAs in this group in the system is condemned to poor accessibility and low densities. The arrangement of the street layout in a hierarchical structure with very few points of entry/exit makes any attempt of increasing their accessibility, and perhaps their density, extremely costly and maybe even trivial.

On the other side of the spectrum we find orthogonal grids. These are neighbourhoods developed in the early 1920s and 1930s. A predominantly rectilinear street configuration allows for the optimization of the use of the lot. Several stories buildings, infill developments, and attached properties provide a dense and very accessible urban environment which allows for the emergence of local commercial streets which act as cores to their respective neighbourhoods.

In this project, we have introduced a method for finding a *'morphological signature'* of the street system in morphological neighbourhood areas in the Island of Montréal, which is based on quantitative indicators. We believe that our approach is applicable to other urban areas. However, we acknowledge that our methodology is highly sensitive to our definition of neighbourhood. There remains to see if our methodology, applied to geographical units such as census tracts, dissemination areas, or administrative boundaries, produces similar results.

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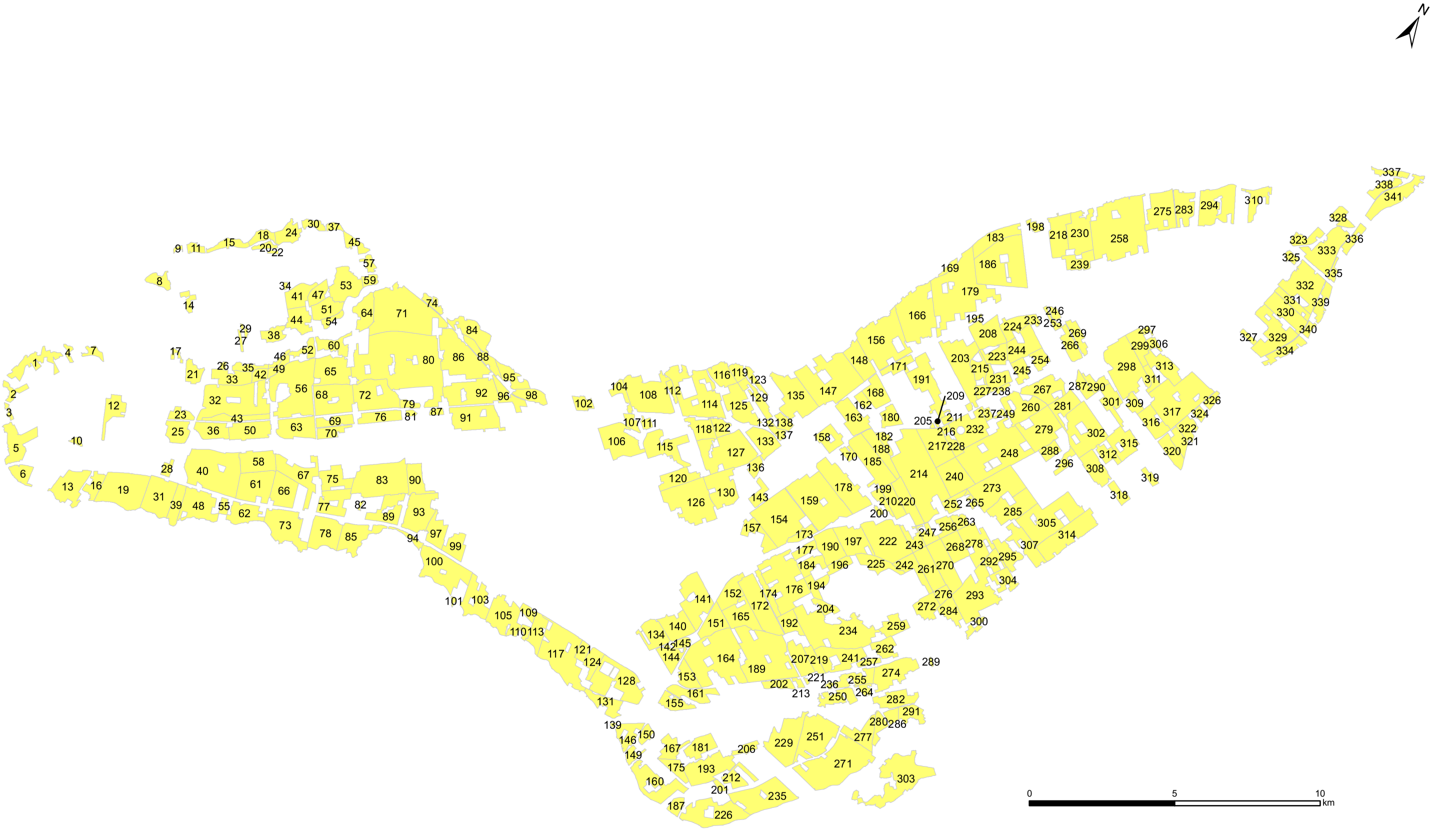
Appendix A

Reference Map


N
0
5
10
km

Appendix B

Thirty-two Indicators for 341 MNAs

MNA	Node_Ha	Conn_Id	MNA_Comp	B_con_pe	B_avcmp	B_avnei	B_avor	B_avrap	PP_conn	PP_cont	PP_MD	PP_GI	PP_LI	PP_TD	PP_LD	PP_Inte	AR_Conn	AR_Cont
1	0.082	1.333	0.450	4182.513	0.498	1.333	0.604	44.816	1.333	1.000	1.333	0.474	0.474	2.667	2.667	2.813	16.250	8.443
2	0.000	0.000	0.502	1635.598	0.581	1.000	0.638	54.323	1.000	0.000	1.000	-1.000	-1.000	1.000	1.000	-1.000	61.000	32.239
3	0.133	1.000	0.418	1007.056	0.471	0.000	0.543	23.692	1.000	0.000	1.000	-1.000	-1.000	1.000	1.000	-1.000	32.000	16.298
4	0.384	1.250	0.517	931.338	0.564	2.000	0.694	26.901	1.333	1.000	1.333	0.474	0.474	2.667	2.667	2.813	21.000	10.757
5	0.533	1.413	0.682	1940.487	0.594	4.769	0.771	24.462	3.417	1.000	2.678	1.487	1.978	61.583	17.750	2.298	8.375	2.842
6	1.251	1.612	0.846	1061.802	0.725	5.706	0.867	18.554	4.250	1.000	2.399	1.751	2.335	55.167	21.417	2.427	6.870	1.638
7	0.112	1.500	0.682	2521.644	0.686	0.000	0.428	48.822	1.000	1.000	1.000	-1.000	-1.000	1.000	1.000	-1.000	31.000	16.128
8	0.127	1.000	0.714	0.000	0.716	0.000	0.503	51.793	1.333	1.000	1.333	0.474	0.474	2.667	2.667	2.813	1.667	0.895
9	0.693	1.000	0.602	1157.188	0.581	0.000	0.575	30.050	1.000	0.000	1.000	-1.000	-1.000	1.000	1.000	-1.000	32.000	16.972
10	1.076	1.444	0.790	1372.557	0.649	2.500	0.587	22.489	2.571	1.000	2.000	0.979	1.524	12.000	5.429	2.628	7.750	2.513
11	0.117	2.000	0.721	1046.101	0.759	0.000	0.756	52.174	1.000	1.000	1.000	-1.000	-1.000	1.000	1.000	-1.000	14.333	9.031
12	0.514	1.379	0.753	4805.821	0.548	4.706	0.683	24.818	2.889	1.000	2.608	1.273	1.714	44.333	12.667	2.270	3.000	0.998
13	0.473	1.646	0.820	781.575	0.708	5.286	0.758	34.066	3.357	1.000	2.698	1.598	1.978	72.857	20.500	2.101	5.690	1.541
14	0.922	1.176	0.537	2804.222	0.754	1.500	0.832	22.675	2.000	1.000	2.133	1.300	1.306	19.200	9.600	1.538	6.900	3.120
15	0.303	1.300	0.534	1879.564	0.581	3.250	0.706	37.521	1.714	1.000	1.714	1.016	1.016	10.286	10.286	1.687	10.875	6.595
16	0.464	1.833	0.719	437.125	0.607	5.769	0.857	32.052	2.667	1.000	2.629	1.157	1.474	36.800	10.667	2.304	12.000	3.411
17	0.650	1.167	0.618	2228.600	0.707	2.000	0.803	16.706	1.500	1.000	1.500	0.625	0.625	4.500	4.500	2.400	16.500	8.731
18	0.401	1.500	0.683	719.564	0.528	2.833	0.780	33.143	1.750	1.000	2.036	1.250	1.208	14.250	8.250	1.400	12.636	7.431
19	0.501	1.614	0.870	1109.817	0.641	5.925	0.759	35.710	3.017	1.000	3.329	1.557	1.992	193.085	25.458	1.937	11.750	3.995
20	0.543	1.625	0.562	1035.155	0.426	2.000	0.489	27.145	1.600	1.000	1.800	0.929	0.876	7.200	4.800	1.722	3.167	1.359
21	0.737	1.296	0.833	992.882	0.596	2.667	0.652	22.766	2.842	1.000	2.626	1.352	1.640	47.263	13.579	2.101	7.381	2.863
22	0.550	3.000	0.580	478.133	0.531	0.000	0.633	15.313	1.000	1.000	1.000	-1.000	-1.000	1.000	1.000	-1.000	4.333	1.635
23	0.642	1.611	0.718	853.145	0.627	3.400	0.717	20.788	2.182	1.000	2.055	1.730	1.735	20.545	12.727	1.261	3.571	1.419
24	0.394	1.368	0.820	897.747	0.551	3.500	0.548	34.601	2.000	1.000	2.897	0.898	1.087	34.769	7.846	2.227	6.824	3.901
25	0.823	1.600	0.924	1038.795	0.642	4.118	0.691	24.770	2.560	1.000	3.143	1.195	1.592	75.440	14.400	2.143	3.941	1.390
26	1.111	1.500	0.809	332.290	0.461	4.800	0.620	18.553	2.000	1.000	1.333	0.875	0.875	4.000	4.000	2.286	12.429	5.417
27	0.824	1.167	0.380	0.000	0.367	1.333	0.842	14.148	1.500	1.000	1.667	0.667	0.605	5.000	3.500	2.250	1.750	0.921
28	0.312	1.200	0.771	1850.138	0.577	2.000	0.939	33.055	1.333	1.000	1.333	0.474	0.474	2.667	2.667	2.813	4.750	1.642
29	0.507	1.667	0.529	1546.508	0.665	2.000	0.819	14.041	1.333	1.000	1.333	0.474	0.474	2.667	2.667	2.813	19.000	8.941
30	0.095	1.500	0.607	1199.150	0.542	0.000	0.579	67.182	1.000	1.000	1.000	-1.000	-1.000	1.000	1.000	-1.000	20.500	12.797
31	0.589	1.542	0.878	945.019	0.627	6.268	0.866	30.030	3.476	1.000	2.883	1.688	2.216	118.190	27.190	2.059	19.452	6.666
32	0.779	1.344	0.676	982.434	0.588	5.586	0.727	26.247	3.111	1.000	5.218	1.104	1.898	558.315	20.037	2.819	4.698	1.325
33	0.812	1.750	0.640	188.805	0.574	5.526	0.752	25.709	2.649	1.000	3.575	1.156	1.658	128.703	15.189	2.291	11.114	3.970
34	0.270	3.000	0.825	395.526	0.789	0.000	0.862	35.859	1.000	1.000	1.000	-1.000	-1.000	1.000	1.000	-1.000	6.000	2.203
35	1.079	1.500	0.512	417.103	0.574	6.267	0.759	23.281	2.222	1.000	2.144	2.159	2.263	36.444	23.111	1.029	12.273	5.676
36	0.965	1.441	0.748	711.233	0.626	4.136	0.731	23.696	2.611	1.000	3.173	1.358	1.705	111.056	16.944	1.922	4.390	1.604
37	0.305	1.250	0.725	842.532	0.638	1.667	0.696	49.704	1.333	1.000	1.333	0.474	0.474	2.667	2.667	2.813	20.500	12.797
38	0.736	1.308	0.797	1516.950	0.644	2.909	0.829	23.480	2.533	1.000	2.429	1.387	1.527	34.000	11.867	1.827	5.353	2.283
39	0.478	1.522	0.550	602.458	0.641	7.455	0.904	29.538	2.154	1.000	2.103	1.714	1.770	25.231	15.077	1.256	30.826	11.075
40	0.684	1.440	0.844	1917.163	0.626	4.970	0.682	29.753	2.920	1.000	5.198	1.054	1.806	514.580	17.960	2.770	4.192	1.257
41	0.908	1.550	0.832	366.399	0.580	5.862	0.697	23.357	2.583	1.000	3.946	1.151	1.611	185.458	16.000	2.244	5.660	2.023
42	0.907	1.619	0.851	222.473	0.593	6.231	0.687	24.031	2.545	1.000	2.779	1.276	1.567	58.364	13.091	1.995	18.182	6.732
43	0.693	1.333	0.317	995.028	0.561	5.273	0.633	23.165	2.333	1.000	3.922	0.711	1.480	66.667	9.222	3.282	3.182	1.096
44	0.963	1.373	0.877	540.461	0.577	5.621	0.737	22.439	2.800	1.000	3.572	1.179	1.778	139.300	16.600	2.375	7.450	2.868
45	0.653	1.211	0.607	1588.543	0.542	2.727	0.647	23.326	2.727	1.000	1.800	2.604	2.959	18.000	15.818	1.047	8.417	4.655
46	1.750	1.304	0.430	331.576	0.555	7.400	0.789	16.121	1.938	0.946	2.100	2.151	2.148	29.250	19.688	0.901	14.296	6.693
47	1.086	1.659	0.792	384.709	0.643	5.789	0.698	24.940	2.400	1.000	2.757	1.435	1.803	66.160	18.400	1.672	5.447	1.879
48	0.721	1.456	0.847	1061.504	0.635	5.538	0.755	26.002	2.894	1.000	3.414	1.375	1.858	157.021	20.681	2.105	14.760	5.254
49	0.973	1.833	0.503	258.119	0.535	6.615	0.513	40.918	2.045	0.977	2.524	1.507	1.600	49.455	17.227	1.357	17.606	7.026
50	0.562	1.609	0.689	710.323	0.517	4.655	0.772	25.454	2.889	1.000	2.986	1.331	1.710	77.630	15.481	2.170	6.655	2.361
51	1.353	1.571	0.821	559.832	0.586	5.400	0.616	24.953	2.308	1.000	4.827	1.007	1.628	308.923	17.508	2.292	5.643	2.482
52	0.720	1.619	0.645	687.389	0.533	5.846	0.639	24.164	2.667	1.113	2.244	1.513	1.732	29.167	13.833	1.763	35.294	13.247
53	0.723	1.357	0.870	1557.421	0.684	4.765	0.702	23.413	2.762	1.000	3.519	1.276	1.735	144.286	16.381	2.165	7.022	3.039
54	1.003	1.444	0.466	475.258	0.540	6.286	0.693	19.320	1.857	1.000	2.495	1.274	2.359	32.429	15.571	1.458	4.571	2.040
55	0.791	1.583	0.743	437.986	0.526	7.250	0.672	21.333	2.364	1.000	2.564	0.948	1.326	25.636	8.909	2.493	48.727	18.397

MNA	Node_Ha	Conn_Id	MNA_Comp	B_con_pe	B_avcmp	B_avnei	B_avor	B_avrap	PP_conn	PP_cont	PP_MD	PP_GI	PP_LI	PP_TD	PP_LD	PP_Inte	AR_Conn	AR_Cont
56	0.769	1.517	0.796	1598.748	0.583	5.645	0.701	25.302	3.084	1.000	5.160	1.080	1.910	546.991	18.860	2.856	5.255	1.505
57	0.920	1.313	0.687	1181.862	0.741	2.857	0.832	24.413	2.667	1.000	1.833	2.158	2.297	14.667	10.667	1.235	6.333	3.338
58	0.733	1.523	0.782	685.342	0.579	6.333	0.707	28.002	2.773	1.000	3.370	1.368	1.792	144.909	20.136	2.027	18.105	4.680
59	0.957	1.111	0.806	1002.943	0.588	4.625	0.641	22.868	2.615	1.000	2.231	1.373	1.657	26.769	12.462	1.905	13.231	6.441
60	0.653	1.406	0.615	977.336	0.672	4.000	0.683	23.905	2.737	1.000	2.848	1.160	1.608	51.263	12.000	2.359	22.421	6.966
61	0.690	1.530	0.877	984.005	0.665	6.325	0.843	30.102	2.979	1.000	3.613	1.280	1.823	166.213	18.383	2.328	5.963	1.698
62	0.661	1.467	0.795	1135.543	0.604	4.571	0.721	27.107	2.759	1.000	3.000	1.376	1.831	84.000	18.897	2.005	20.484	7.437
63	1.073	1.442	0.757	586.686	0.682	3.690	0.719	24.702	2.815	1.000	3.391	1.494	1.959	179.741	24.667	1.884	3.966	1.232
64	0.806	1.472	0.772	1200.450	0.620	5.750	0.765	28.779	3.069	1.033	2.834	1.584	1.947	90.690	21.483	1.937	21.649	6.954
65	1.037	1.454	0.885	345.665	0.593	6.306	0.758	25.564	2.886	1.000	4.109	1.227	1.848	283.543	20.086	2.351	5.714	1.747
66	0.879	1.403	0.888	644.656	0.600	6.226	0.770	29.562	2.913	1.000	3.591	1.267	1.774	161.609	17.000	2.300	6.736	1.936
67	0.776	1.457	0.564	1109.946	0.585	5.235	0.728	26.299	2.863	1.000	3.995	1.154	1.690	199.765	16.039	2.480	14.655	3.799
68	0.776	1.416	0.835	587.613	0.590	5.472	0.815	26.385	3.067	1.000	3.581	1.415	1.806	211.267	19.667	2.167	7.348	2.003
69	0.820	1.545	0.500	1750.206	0.472	4.000	0.585	21.726	3.077	1.000	3.363	1.070	1.872	84.077	13.385	2.875	4.222	1.314
70	0.780	1.444	0.639	1635.621	0.667	3.571	0.818	21.249	2.556	1.000	2.961	1.054	1.534	50.333	11.444	2.425	7.167	2.418
71	0.832	1.451	0.831	723.098	0.620	5.632	0.711	27.004	3.167	1.000	4.300	1.487	1.983	614.958	26.306	2.129	8.588	2.636
72	0.701	1.515	0.833	437.384	0.605	5.176	0.760	28.317	2.850	0.994	3.731	1.310	1.708	209.483	17.017	2.176	6.280	1.750
73	0.642	1.464	0.821	2184.159	0.627	4.674	0.781	29.825	3.250	1.000	3.086	1.634	2.124	145.042	25.500	1.989	15.388	5.386
74	0.313	1.000	0.621	2912.070	0.661	2.500	0.745	21.668	2.000	1.000	1.333	0.875	0.875	4.000	4.000	2.286	15.750	3.719
75	0.574	1.615	0.768	627.251	0.579	5.500	0.828	28.212	2.840	1.036	2.760	1.455	1.729	69.000	16.280	1.951	15.969	3.920
76	0.754	1.475	0.545	928.930	0.597	4.421	0.731	23.001	2.800	1.000	3.483	1.002	1.653	83.600	12.400	2.795	3.680	1.098
77	0.830	1.484	0.792	1372.558	0.622	5.613	0.800	24.752	3.353	1.000	2.783	1.613	2.066	91.824	22.647	2.079	8.833	2.116
78	0.678	1.333	0.897	1085.280	0.648	4.556	0.807	32.035	2.800	1.000	3.281	1.365	1.704	127.950	17.300	2.051	15.239	5.546
79	0.905	1.600	0.645	474.306	0.601	4.000	0.714	19.898	2.111	1.040	2.278	1.248	1.719	22.778	10.778	1.691	3.769	1.612
80	0.829	1.400	0.786	567.998	0.582	5.278	0.734	25.752	3.121	1.000	4.884	1.440	1.927	1128.302	24.638	2.167	5.471	1.511
81	1.132	1.375	0.806	272.258	0.487	2.333	0.533	17.642	2.333	1.000	1.733	1.343	1.515	8.667	5.667	1.737	7.286	2.138
82	0.633	1.500	0.561	907.367	0.607	1.000	0.531	15.450	1.000	1.000	1.000	-1.000	-1.000	1.000	1.000	-1.000	9.000	2.532
83	0.640	1.473	0.801	712.605	0.568	6.095	0.838	28.642	2.931	0.990	4.227	1.279	1.789	357.460	19.023	2.292	8.618	2.188
84	0.602	1.532	0.645	647.587	0.552	4.045	0.699	26.029	2.828	1.000	3.677	0.989	1.823	102.966	13.172	2.859	20.425	6.540
85	0.729	1.217	0.769	2003.027	0.586	4.036	0.741	27.819	2.615	1.000	3.236	1.399	1.770	122.974	20.154	1.869	13.024	4.404
86	0.711	1.480	0.762	606.034	0.637	5.373	0.837	27.174	3.314	1.000	4.947	0.999	1.992	341.343	20.000	3.319	10.213	2.984
87	1.234	1.692	0.727	448.069	0.709	3.200	0.807	20.081	2.800	1.000	2.111	1.294	2.152	19.000	10.000	2.164	7.667	2.078
88	0.627	1.690	0.426	386.302	0.453	5.000	0.670	25.471	2.480	1.000	2.637	1.595	1.800	63.280	20.240	1.555	40.321	12.871
89	0.485	1.514	0.737	1046.083	0.579	4.964	0.799	27.632	2.880	1.000	2.997	1.273	1.710	71.920	15.040	2.262	4.708	1.136
90	0.858	1.314	0.721	619.270	0.609	6.231	0.770	23.407	2.909	1.000	3.833	0.982	1.696	122.667	13.212	2.963	4.632	1.517
91	0.693	1.402	0.725	1649.606	0.590	4.098	0.764	22.843	2.625	1.000	3.651	1.264	1.811	171.583	21.125	2.076	4.592	1.521
92	0.683	1.398	0.682	858.018	0.618	5.104	0.710	25.970	2.581	0.984	3.854	1.287	1.603	221.387	17.806	2.005	5.359	1.598
93	0.909	1.570	0.842	468.169	0.595	5.300	0.810	24.871	3.333	1.001	3.693	1.292	1.914	191.947	19.649	2.580	6.500	1.762
94	0.335	2.167	0.407	640.453	0.583	1.833	0.712	28.179	1.750	1.000	2.214	0.996	1.397	15.500	7.750	1.757	32.556	10.299
95	0.725	1.667	0.618	431.656	0.539	4.688	0.757	24.416	2.435	1.000	2.921	1.271	1.581	64.261	14.609	1.916	31.750	10.334
96	0.649	1.433	0.533	961.044	0.614	3.889	0.610	22.158	2.444	1.056	3.327	0.970	1.537	63.222	11.778	2.519	5.579	1.859
97	0.786	1.587	0.840	565.385	0.639	4.821	0.830	25.339	3.417	0.999	2.752	1.454	2.037	71.542	18.667	2.350	8.129	2.050
98	0.787	1.485	0.676	388.465	0.593	4.176	0.720	25.006	2.667	1.000	2.519	1.572	1.687	50.381	16.381	1.696	25.500	8.365
99	1.553	1.342	0.851	1633.398	0.672	5.147	0.870	21.266	3.220	1.000	2.800	1.728	2.241	112.000	28.000	1.863	4.684	1.310
100	0.853	1.527	0.755	1207.761	0.639	5.429	0.819	25.232	3.905	1.000	3.075	1.833	2.322	190.667	32.857	2.130	9.091	2.546
101	0.973	1.500	0.753	496.079	0.637	1.000	0.683	22.018	2.000	1.000	1.000	1.000	1.000	2.000	2.000	2.000	57.333	21.841
102	0.959	1.333	0.847	1235.521	0.658	4.000	0.824	25.871	2.800	1.000	2.448	1.333	2.011	34.267	14.800	2.101	24.800	7.875
103	0.752	1.612	0.767	1036.724	0.651	5.000	0.798	22.648	3.188	1.025	2.913	1.521	1.934	93.219	20.375	2.096	13.048	4.425
104	0.671	1.381	0.555	1236.570	0.654	4.500	0.771	24.053	2.429	1.000	2.791	0.993	1.503	36.286	10.143	2.446	43.000	13.772
105	0.784	1.449	0.861	1299.144	0.734	5.786	0.811	24.995	4.000	1.062	2.995	1.667	2.295	129.167	27.238	2.400	17.404	5.729
106	0.698	1.529	0.854	940.998	0.583	4.515	0.682	29.527	2.844	1.000	4.230	1.155	1.724	266.469	16.719	2.463	12.952	3.296
107	1.213	1.385	0.757	554.763	0.592	3.375	0.625	24.054	2.200	1.000	3.721	0.792	1.448	70.700	10.200	2.779	23.923	6.077
108	0.921	1.456	0.826	638.484	0.626	5.026	0.789	24.785	3.306	1.000	4.663	1.230	2.059	452.286	24.857	2.688	18.957	5.769
109	0.253	1.600	0.759	661.956	0.741	3.000	0.863	40.941	2.429	0.976	2.498	1.263	1.501	68.429	5.286	1.924	28.333	6.742
110	0.822	1.455	0.780	841.846	0.607	4.857	0.564	20.336	3.000	1.267	1.667	1.803	1.863	11.667	9.667	1.664	64.625	24.683

MNA	Node_Ha	Conn_Id	MNA_Comp	B_con_pe	B_avcmp	B_avnei	B_avor	B_avrap	PP_conn	PP_cont	PP_MD	PP_GI	PP_LI	PP_TD	PP_LD	PP_Inte	AR_Conn	AR_Cont
111	0.786	1.800	0.893	552.501	0.737	3.200	0.958	20.056	2.286	1.000	2.000	1.002	1.224	12.000	6.286	2.281	9.429	2.488
112	0.871	1.929	0.559	192.201	0.637	4.615	0.774	26.104	2.211	1.000	2.930	1.091	1.413	52.737	11.053	2.026	43.684	13.251
113	0.718	1.600	0.667	489.227	0.586	6.000	0.808	22.964	3.952	1.205	2.550	1.670	2.191	63.762	20.810	2.366	28.133	9.000
114	0.767	1.507	0.685	965.272	0.610	4.744	0.868	23.287	3.500	0.918	3.862	1.460	2.237	332.171	29.605	2.398	13.949	3.979
115	0.968	1.450	0.668	1782.176	0.650	4.294	0.825	21.564	3.508	1.016	4.244	1.123	2.109	250.407	20.525	3.125	6.206	1.582
116	1.012	1.586	0.870	342.621	0.624	5.294	0.786	22.319	3.128	1.000	3.293	1.354	1.884	125.128	19.436	2.311	27.725	7.693
117	0.830	1.573	0.779	599.572	0.641	5.553	0.882	26.293	4.000	1.000	3.469	1.691	2.554	280.976	38.390	2.366	13.654	4.082
118	0.915	1.741	0.829	303.053	0.657	4.944	0.819	24.776	3.152	1.000	2.746	1.639	2.026	87.879	22.788	1.923	21.585	4.956
119	0.824	1.905	0.831	175.077	0.551	5.100	0.838	24.412	3.077	1.000	2.103	1.573	1.906	25.231	13.538	1.956	49.200	13.790
120	0.744	1.440	0.699	424.892	0.596	4.464	0.855	28.277	2.667	1.000	4.180	1.015	1.663	183.911	14.222	2.628	9.488	2.500
121	1.158	1.357	0.791	409.300	0.759	3.889	0.837	17.914	2.200	1.000	3.926	0.745	1.342	74.600	8.800	2.952	7.609	2.068
122	1.064	1.794	0.840	247.033	0.670	5.083	0.805	23.144	3.579	1.000	2.298	1.645	2.170	41.368	18.316	2.176	28.482	6.562
123	0.777	1.375	0.440	1005.246	0.586	2.800	0.781	19.912	2.800	1.000	1.867	1.602	1.880	16.800	12.400	1.748	39.900	12.343
124	0.919	1.550	0.755	345.936	0.613	4.810	0.823	23.865	2.720	1.000	3.387	1.058	1.574	81.280	12.480	2.572	9.455	2.346
125	1.015	1.627	0.750	462.805	0.650	5.121	0.892	22.248	4.120	1.057	3.598	1.428	2.258	219.480	26.840	2.886	14.964	3.289
126	0.963	1.610	0.863	445.064	0.637	5.392	0.837	24.785	3.538	1.000	3.828	1.571	2.171	394.269	29.692	2.252	9.155	2.147
127	0.814	1.755	0.784	330.779	0.641	5.732	0.858	24.311	4.274	1.000	3.308	1.724	2.483	238.192	36.548	2.479	12.596	2.442
128	0.757	1.549	0.649	1149.051	0.601	5.520	0.932	23.905	4.186	1.000	2.801	1.827	2.697	117.628	33.860	2.292	8.383	1.753
129	0.810	1.771	0.410	391.632	0.606	3.800	0.864	20.990	2.714	1.000	3.503	1.047	1.791	94.571	14.143	2.591	20.793	4.624
130	1.025	1.817	0.853	305.507	0.702	5.190	0.926	22.157	4.739	1.000	2.739	1.941	2.577	123.261	34.043	2.442	15.274	2.996
131	1.000	1.889	0.618	514.568	0.674	4.864	0.894	19.543	4.250	1.000	2.381	2.062	3.046	73.813	35.625	2.061	21.700	6.544
132	1.566	1.125	0.787	188.274	0.566	1.833	0.541	12.904	2.000	1.000	2.972	0.611	1.179	23.778	5.556	3.273	11.200	2.527
133	0.668	1.468	0.803	1822.753	0.671	3.833	0.743	28.364	3.286	1.000	2.963	1.359	1.947	80.000	17.714	2.417	8.033	1.930
134	0.762	1.528	0.854	831.711	0.559	6.476	0.907	22.412	3.769	1.000	2.726	1.563	2.195	68.154	21.308	2.411	11.136	2.646
135	0.783	1.685	0.793	901.670	0.585	5.088	0.919	24.644	4.553	1.000	2.770	1.931	2.556	127.404	34.426	2.358	34.375	8.618
136	0.383	1.556	0.798	347.951	0.706	2.750	0.753	51.046	2.000	1.000	2.000	1.155	1.178	14.000	8.000	1.731	31.100	7.239
137	1.394	1.192	0.753	281.935	0.520	3.417	0.622	21.786	2.353	1.000	2.985	1.023	1.496	47.765	11.529	2.300	13.966	2.916
138	0.929	1.500	0.802	433.215	0.645	4.154	0.807	20.249	2.923	1.000	2.410	1.243	1.880	28.923	11.231	2.352	9.444	1.942
139	1.289	1.667	0.846	351.109	0.655	2.000	0.673	12.495	2.000	1.000	1.000	1.000	1.000	2.000	2.000	2.000	43.000	10.559
140	0.741	1.533	0.880	593.840	0.576	5.757	0.796	22.555	2.952	1.000	3.190	1.484	1.831	130.810	21.905	1.989	8.028	2.213
141	0.586	1.387	0.767	1645.865	0.626	4.000	0.769	29.394	3.083	1.000	3.306	1.471	1.869	155.375	21.000	2.096	5.723	1.621
142	1.822	1.833	0.879	145.297	0.616	5.000	0.904	16.178	2.000	1.000	1.600	1.091	1.145	6.400	5.200	1.833	15.250	2.931
143	1.095	1.486	0.655	0.000	0.645	4.667	0.943	22.869	3.556	1.000	2.680	1.240	2.210	45.556	14.222	2.866	4.421	1.098
144	1.296	1.462	0.820	481.240	0.660	5.091	0.783	20.927	3.273	1.000	2.847	1.553	1.966	91.091	20.727	2.107	10.595	2.331
145	1.303	1.542	0.766	440.914	0.720	4.438	0.789	20.161	3.143	1.000	2.231	1.470	1.786	29.000	12.857	2.138	14.647	3.157
146	0.798	1.436	0.747	1198.547	0.625	3.900	0.822	24.135	3.300	1.000	2.526	1.436	1.917	48.000	15.900	2.298	9.100	2.253
147	0.680	1.705	0.833	506.584	0.636	5.344	0.951	26.574	5.873	0.994	2.724	2.199	2.956	163.436	45.582	2.671	46.265	11.085
148	0.882	1.609	0.727	237.038	0.680	4.804	0.894	23.150	3.974	1.008	2.747	1.709	2.226	99.605	24.395	2.326	56.280	14.214
149	0.940	1.526	0.787	657.719	0.645	3.846	0.882	19.851	3.000	1.000	1.978	1.399	1.705	17.800	10.200	2.145	17.600	3.932
150	0.517	1.364	0.793	490.314	0.673	2.667	0.706	28.394	2.222	1.000	1.944	1.515	1.559	15.556	10.222	1.467	11.556	2.647
151	1.016	1.639	0.791	269.960	0.626	5.822	0.856	22.192	3.227	0.781	2.922	1.732	2.255	134.432	31.364	1.863	16.961	2.967
152	0.826	1.525	0.787	487.763	0.578	5.719	0.681	26.019	2.974	0.996	3.331	1.297	1.876	124.179	17.282	2.294	19.196	3.241
153	0.859	1.575	0.781	647.694	0.569	6.074	0.882	21.342	3.727	1.000	2.641	1.452	2.023	55.455	16.273	2.567	36.955	7.068
154	0.906	1.703	0.915	429.710	0.706	6.090	0.831	27.599	4.706	1.000	3.110	1.960	2.702	261.224	44.518	2.401	10.489	1.872
155	0.937	1.634	0.681	1336.971	0.622	4.348	0.797	21.533	3.043	1.000	2.636	1.473	2.198	58.000	20.261	2.067	11.760	2.861
156	0.818	1.714	0.847	720.755	0.626	5.106	0.918	24.078	5.781	0.957	2.657	2.307	3.105	170.047	53.563	2.506	37.546	9.011
157	1.021	1.796	0.427	530.826	0.657	5.838	0.784	22.856	3.278	1.000	3.284	1.316	1.919	114.944	18.278	2.490	12.714	2.064
158	0.803	1.775	0.832	2015.748	0.561	4.519	0.966	22.429	4.421	1.000	2.018	2.161	2.928	36.316	24.632	2.045	16.952	2.707
159	0.804	1.649	0.829	1091.654	0.670	5.283	0.852	26.932	4.628	1.000	3.007	2.095	2.816	255.605	51.837	2.209	10.167	1.846
160	0.938	1.551	0.634	1703.633	0.608	3.741	0.828	22.082	3.458	1.000	3.464	1.471	2.071	200.915	22.847	2.350	6.250	1.504
161	1.122	1.552	0.518	967.388	0.639	3.806	0.769	21.526	3.211	1.000	2.863	1.654	2.126	105.947	25.421	1.941	7.575	1.966
162	0.858	1.375	0.792	593.931	0.584	4.167	0.844	24.959	2.364	1.000	2.309	1.236	1.337	23.091	8.909	1.912	5.818	1.254
163	0.789	1.778	0.729	187.465	0.615	5.721	0.967	24.277	5.040	1.000	2.233	2.098	2.608	53.600	25.200	2.402	13.577	1.772
164	0.659	1.793	0.826	478.026	0.584	5.674	0.942	25.729	5.354	1.000	2.819	2.134	2.978	180.400	48.923	2.509	22.561	4.007
165	0.874	1.741	0.790	228.936	0.632	6.018	0.776	27.870	3.318	1.157	4.875	1.077	1.978	389.977	19.909	3.080	21.403	3.541

MNA	Node_Ha	Conn_Id	MNA_Comp	B_con_pe	B_avcmp	B_avnei	B_avor	B_avrap	PP_conn	PP_cont	PP_MD	PP_GI	PP_LI	PP_TD	PP_LD	PP_Inte	AR_Conn	AR_Cont
166	0.780	1.860	0.860	434.813	0.573	5.395	0.919	22.571	5.448	1.000	2.895	1.962	2.762	165.034	39.793	2.777	39.113	9.438
167	0.752	1.595	0.804	592.904	0.604	3.111	0.817	23.599	3.091	1.000	2.974	1.200	1.774	62.455	13.818	2.575	8.160	2.049
168	0.749	1.596	0.828	424.504	0.574	4.500	0.695	27.664	3.111	1.000	2.957	1.317	1.846	76.889	16.296	2.362	8.000	1.410
169	1.442	1.636	0.567	206.105	0.606	3.875	0.723	22.838	2.375	1.000	1.917	3.356	3.618	28.750	25.375	0.708	17.957	5.179
170	0.903	2.059	0.846	548.972	0.533	4.417	0.988	23.994	3.091	1.000	2.000	1.645	1.812	20.000	11.455	1.879	14.500	1.978
171	1.032	1.513	0.644	451.763	0.567	4.808	0.901	18.578	3.273	1.000	2.299	1.866	2.933	48.273	27.455	1.754	5.042	1.026
172	0.729	1.845	0.563	184.330	0.668	6.079	0.962	29.217	4.316	0.915	3.805	1.406	2.607	254.947	35.526	3.070	23.357	3.634
173	1.219	1.667	0.606	465.842	0.722	5.316	0.874	21.007	3.571	1.044	2.354	1.755	2.312	49.429	21.952	2.035	10.739	1.957
174	1.248	2.061	0.411	146.939	0.668	5.864	0.954	19.352	3.909	1.000	2.377	1.734	2.639	49.909	22.455	2.255	25.700	3.757
175	1.125	1.535	0.685	301.275	0.640	4.227	0.805	21.868	2.615	1.000	3.584	1.189	1.763	136.205	17.590	2.200	6.622	1.526
176	0.598	1.893	0.780	283.105	0.629	6.261	0.972	27.801	5.184	1.000	2.855	1.892	2.770	137.061	35.224	2.739	25.354	4.083
177	0.611	2.000	0.598	254.687	0.513	5.357	0.918	27.600	3.400	1.000	1.800	1.656	1.943	16.200	11.400	2.054	19.000	3.596
178	0.838	1.907	0.605	883.263	0.530	6.375	0.956	21.992	6.364	1.000	2.292	2.319	2.954	73.333	32.545	2.744	17.212	2.657
179	0.875	1.851	0.797	454.781	0.614	5.290	0.929	23.541	4.744	1.000	3.211	2.103	2.729	385.289	52.777	2.256	27.080	6.758
180	0.857	1.618	0.865	559.502	0.638	4.056	0.797	22.437	3.000	1.000	2.674	1.352	1.725	50.800	14.600	2.219	8.421	1.532
181	1.005	1.603	0.774	568.805	0.556	4.065	0.973	22.529	3.733	1.000	2.807	1.506	2.159	81.400	20.400	2.479	6.567	1.542
182	1.348	1.781	0.623	218.364	0.639	6.364	0.888	19.379	3.250	1.000	2.208	1.662	2.118	33.125	16.750	1.955	20.217	3.005
183	0.870	1.586	0.537	373.829	0.593	4.795	0.754	24.027	3.073	1.000	3.065	1.551	2.014	122.585	23.659	1.982	27.966	7.611
184	0.814	1.914	0.671	215.434	0.658	5.276	0.852	27.046	3.500	1.026	2.670	1.455	2.013	58.750	17.500	2.405	35.750	6.668
185	0.703	2.087	0.583	222.477	0.592	6.494	0.970	24.512	6.786	1.000	2.071	2.550	3.145	55.929	31.786	2.661	37.200	4.996
186	0.850	1.639	0.841	492.409	0.607	5.183	0.894	24.676	4.258	1.000	3.258	1.889	2.490	299.720	39.226	2.255	13.867	3.190
187	1.052	1.423	0.862	494.664	0.670	4.667	0.776	25.225	3.538	1.000	1.910	1.896	2.108	22.923	15.538	1.867	14.231	3.506
188	1.146	1.875	0.475	168.959	0.609	6.621	0.938	22.910	4.387	1.000	2.361	2.058	2.888	70.839	33.548	2.132	27.500	3.572
189	0.641	1.858	0.848	415.257	0.616	6.159	0.921	26.327	5.931	1.000	2.717	2.195	3.018	154.862	47.931	2.702	22.410	3.944
190	0.651	1.759	0.840	147.316	0.620	5.095	0.822	29.835	3.000	1.021	3.006	1.544	2.071	117.237	24.263	1.943	16.390	2.831
191	0.876	1.615	0.601	1017.731	0.521	4.986	0.924	19.957	4.545	1.000	2.877	1.751	2.448	123.727	28.273	2.596	8.979	1.601
192	0.847	1.600	0.840	243.711	0.595	5.632	0.702	29.665	2.889	1.000	2.900	1.360	1.832	75.407	17.259	2.124	15.972	2.816
193	0.802	1.579	0.725	403.860	0.600	4.684	0.800	23.546	3.379	1.000	3.533	1.435	2.153	201.379	25.379	2.354	5.455	1.252
194	1.003	1.927	0.699	215.242	0.685	5.250	0.939	25.357	4.087	1.000	2.186	2.130	2.407	48.087	24.609	1.919	22.111	4.214
195	0.194	1.000	0.444	1242.286	0.418	0.000	0.833	29.320	1.000	0.000	1.000	-1.000	-1.000	-1.000	1.000	-1.000	1.000	0.020
196	1.000	1.759	0.642	280.615	0.664	4.952	0.978	27.459	3.158	1.000	2.140	1.929	2.426	38.526	22.947	1.637	12.121	2.359
197	0.922	1.874	0.848	180.171	0.711	6.085	0.939	26.965	3.787	1.000	3.079	1.639	2.256	141.617	26.511	2.310	18.758	3.159
198	0.756	1.417	0.758	1021.010	0.737	2.286	0.786	21.087	2.500	1.000	1.893	1.253	1.431	13.250	8.000	1.995	36.200	11.712
199	1.303	1.886	0.557	219.398	0.664	5.136	0.959	22.558	3.040	1.000	2.583	1.571	2.050	62.000	20.320	1.935	31.862	4.908
200	1.073	1.857	0.753	307.126	0.561	1.000	0.976	29.079	2.000	1.000	1.952	0.999	1.156	11.714	7.143	2.003	10.000	2.116
201	0.956	1.500	0.710	360.627	0.557	3.000	0.729	23.980	2.250	1.000	1.929	1.281	1.342	13.500	8.250	1.757	5.875	1.620
202	1.053	1.313	0.567	1373.988	0.653	3.250	0.881	24.261	3.294	1.000	1.919	2.633	2.742	30.706	24.706	1.251	11.059	2.781
203	1.019	1.669	0.626	423.226	0.628	5.500	0.889	22.185	3.671	1.000	3.277	1.806	2.345	275.247	35.294	2.033	10.647	2.268
204	0.621	1.588	0.672	336.883	0.744	2.000	0.795	25.581	2.000	1.000	2.449	1.193	1.438	29.385	10.923	1.676	16.824	3.454
205	1.957	3.000	0.816	133.383	0.675	1.667	0.799	14.063	1.600	1.000	1.800	0.929	0.876	7.200	4.800	1.722	39.400	8.096
206	0.413	1.889	0.608	886.108	0.553	2.000	0.737	24.486	2.000	1.000	2.500	0.861	1.075	20.000	6.444	2.324	9.222	2.251
207	0.587	1.806	0.691	283.962	0.576	5.667	0.925	23.206	3.900	1.063	2.352	1.795	2.252	51.750	21.300	2.172	40.957	8.329
208	0.898	1.448	0.874	304.424	0.580	5.460	0.799	25.088	3.167	1.000	3.604	1.400	1.928	212.633	20.033	2.261	14.544	3.086
209	1.617	2.750	0.704	107.618	0.652	1.500	0.951	26.801	2.000	1.000	1.333	1.000	1.000	4.000	4.000	2.000	52.250	11.452
210	1.119	1.983	0.636	184.026	0.647	6.560	0.983	20.004	5.130	1.000	2.150	2.169	2.783	47.304	25.130	2.365	43.571	6.209
211	1.294	1.692	0.834	191.474	0.587	3.800	0.954	20.120	2.750	1.000	1.643	2.134	2.488	11.500	10.750	1.288	30.000	5.628
212	0.777	1.667	0.663	1228.478	0.551	3.700	0.827	21.896	3.400	1.000	2.542	1.448	1.962	48.300	16.200	2.348	4.400	1.138
213	0.752	2.167	0.664	286.453	0.746	2.000	0.881	19.784	2.400	1.000	1.400	1.478	1.478	5.600	5.600	1.623	29.833	7.838
214	0.614	1.980	0.722	294.397	0.599	7.017	0.973	26.373	7.962	1.000	2.562	2.338	3.334	133.245	46.000	3.406	41.341	5.616
215	1.095	1.818	0.793	173.793	0.621	5.757	0.767	25.981	3.103	1.000	2.722	1.541	1.973	76.207	19.655	2.013	14.617	2.903
216	1.219	2.000	0.862	178.887	0.657	2.143	0.969	27.346	2.667	1.000	1.944	1.507	1.576	15.556	9.333	1.770	35.071	6.412
217	0.900	1.926	0.790	155.823	0.622	7.091	0.960	24.549	6.207	1.000	2.175	2.336	2.972	60.897	30.621	2.657	32.307	4.531
218	0.708	1.621	0.703	500.296	0.615	5.410	0.837	25.205	4.071	1.000	2.635	1.637	2.255	71.143	21.643	2.488	40.359	10.899
219	1.231	1.659	0.601	310.742	0.715	5.962	0.907	21.515	3.895	1.000	1.912	2.504	3.560	34.421	28.526	1.556	48.714	9.535
220	0.560	2.216	0.540	186.876	0.565	6.342	0.975	33.004	4.625	1.000	1.958	2.096	2.506	29.375	18.125	2.206	68.543	9.990

MNA	Node_Ha	Conn_Id	MNA_Comp	B_con_pe	B_avcmp	B_avnei	B_avor	B_avrap	PP_conn	PP_cont	PP_MD	PP_GI	PP_LI	PP_TD	PP_LD	PP_Inte	AR_Conn	AR_Cont
221	0.768	2.500	0.735	747.523	0.760	1.000	0.939	15.694	1.333	1.000	1.333	0.474	0.474	2.667	2.667	2.813	16.333	3.622
222	0.767	1.852	0.865	213.325	0.671	6.535	0.959	26.071	5.458	1.000	2.632	2.083	2.754	123.708	36.292	2.621	21.301	3.166
223	1.039	1.640	0.810	215.760	0.560	5.419	0.626	25.638	2.686	1.000	3.491	1.168	1.658	118.686	14.800	2.300	14.122	3.123
224	0.970	1.679	0.773	216.489	0.566	4.806	0.818	24.944	3.030	1.000	3.163	1.341	1.801	101.212	16.727	2.260	14.600	3.449
225	0.930	1.704	0.632	264.459	0.664	4.500	0.740	27.961	2.711	1.000	2.975	1.624	2.197	130.889	29.289	1.669	16.532	3.001
226	1.029	1.527	0.653	804.283	0.631	4.894	0.779	22.988	3.739	1.000	3.095	1.862	2.363	210.435	35.797	2.008	8.813	2.170
227	1.008	1.950	0.859	162.977	0.589	4.938	0.711	22.469	3.067	1.200	2.211	1.400	1.881	26.533	11.867	2.191	20.900	4.431
228	1.057	1.963	0.718	158.246	0.608	5.654	0.793	23.193	3.000	1.000	2.132	1.565	1.808	27.714	14.143	1.917	38.143	5.509
229	0.728	1.822	0.795	377.954	0.590	6.463	0.912	24.910	4.565	1.000	2.703	1.958	2.596	121.652	34.565	2.331	8.537	1.307
230	0.730	1.512	0.800	357.919	0.612	4.915	0.859	26.425	3.362	1.000	3.317	1.452	1.941	152.596	20.638	2.315	36.017	9.538
231	0.937	1.696	0.821	238.631	0.600	5.385	0.686	27.840	3.259	1.000	2.550	1.680	2.000	66.296	20.444	1.940	16.800	3.574
232	1.062	1.882	0.846	209.479	0.634	5.250	0.916	21.900	4.464	1.000	2.809	1.989	2.737	154.500	42.893	2.244	17.831	2.599
233	0.866	1.667	0.854	520.366	0.506	2.500	0.525	26.446	2.250	1.000	2.036	1.085	1.351	14.250	7.750	2.074	22.571	6.074
234	0.869	1.555	0.663	394.804	0.644	5.347	0.782	25.735	3.446	1.000	4.277	1.448	2.127	551.708	28.031	2.380	16.434	3.177
235	0.836	1.688	0.714	1008.007	0.594	5.788	0.907	23.547	5.404	1.000	2.482	2.282	2.914	114.170	42.766	2.369	13.021	2.897
236	0.411	3.000	0.853	529.465	0.760	2.500	0.804	17.999	1.600	1.000	2.000	0.634	0.696	8.000	4.000	2.525	7.000	1.077
237	1.096	1.786	0.786	325.402	0.651	5.111	0.730	20.608	2.889	1.000	1.750	2.285	2.361	14.000	11.333	1.264	9.235	1.685
238	1.077	2.000	0.607	290.166	0.594	5.000	0.910	16.215	2.222	1.000	1.944	1.500	1.659	15.556	10.222	1.481	9.923	2.188
239	1.089	1.564	0.714	397.714	0.639	4.229	0.876	21.424	3.257	1.000	3.874	1.042	1.921	131.714	17.086	3.125	12.487	3.053
240	0.748	2.090	0.873	112.385	0.646	6.716	0.953	27.902	4.909	1.000	2.367	2.132	2.710	75.758	32.182	2.303	38.878	5.435
241	0.879	1.795	0.676	209.749	0.699	5.118	0.902	28.217	3.300	1.000	2.765	2.078	2.535	163.133	43.433	1.588	24.843	4.687
242	1.067	2.000	0.550	170.542	0.692	6.254	0.954	23.207	4.267	1.000	2.407	1.989	2.441	69.800	27.200	2.145	27.850	3.792
243	1.136	2.000	0.714	201.797	0.673	5.545	0.955	22.492	3.560	1.034	2.560	1.645	2.124	64.000	20.840	2.164	25.822	3.543
244	1.019	1.708	0.778	202.282	0.576	5.424	0.706	25.406	3.220	1.000	3.371	1.528	2.031	195.492	23.627	2.107	12.959	3.112
245	0.981	1.571	0.795	472.603	0.638	4.864	0.846	21.964	3.043	1.000	2.787	1.341	1.776	61.304	14.870	2.269	6.966	1.781
246	0.837	1.500	0.805	717.713	0.707	3.333	0.822	20.651	1.600	1.000	1.600	0.763	0.763	6.400	6.400	2.096	5.714	1.747
247	1.516	1.936	0.747	209.691	0.710	5.000	0.937	18.449	4.000	1.000	2.623	1.621	2.178	62.960	19.840	2.468	23.146	3.027
248	0.757	1.873	0.717	209.287	0.610	5.745	0.924	25.513	4.878	1.000	2.934	2.170	3.090	237.659	59.415	2.248	26.336	3.643
249	0.781	2.000	0.713	362.403	0.552	3.000	0.598	18.534	2.000	1.000	1.500	0.904	0.904	6.000	6.000	2.212	10.000	1.820
250	1.429	1.627	0.567	1166.620	0.715	4.583	0.891	17.944	3.676	1.000	2.838	1.658	2.157	102.162	23.351	2.217	13.294	3.514
251	0.901	1.782	0.842	454.428	0.652	6.242	0.939	23.658	5.057	1.000	2.673	2.095	2.923	139.019	43.245	2.414	8.420	1.272
252	1.436	1.909	0.713	138.747	0.699	6.086	0.878	19.993	3.615	1.000	2.117	2.544	2.769	52.923	33.923	1.421	33.022	4.512
253	0.410	2.000	0.401	475.381	0.614	2.000	0.592	22.153	2.000	1.000	2.067	0.763	1.081	10.333	4.667	2.622	11.750	3.099
254	0.972	1.613	0.875	436.228	0.593	4.750	0.797	24.878	2.900	1.000	2.658	1.353	1.685	50.500	14.300	2.143	10.923	2.943
255	1.441	1.763	0.523	293.244	0.711	4.724	0.874	19.683	3.522	1.000	3.306	1.438	2.261	148.783	25.348	2.449	25.566	7.108
256	0.802	2.033	0.847	174.733	0.697	5.690	0.979	27.411	3.750	1.000	2.008	2.072	2.268	30.125	18.500	1.810	24.844	2.853
257	1.020	1.353	0.571	288.272	0.802	2.444	0.888	25.993	1.800	1.000	2.222	1.261	1.855	20.000	11.000	1.428	12.818	2.460
258	0.806	1.571	0.898	1059.833	0.603	5.563	0.872	25.363	4.246	1.000	3.499	1.862	2.470	423.361	40.934	2.281	13.688	3.494
259	0.711	1.750	0.834	588.905	0.628	2.706	0.797	28.101	2.952	1.000	2.448	1.636	2.120	48.952	21.238	1.805	41.607	8.369
260	0.934	1.745	0.744	339.014	0.587	5.776	0.807	21.872	3.811	1.000	3.120	1.644	2.291	162.264	27.736	2.319	21.385	3.547
261	1.218	2.020	0.632	121.946	0.646	6.990	0.972	19.303	6.059	1.054	2.454	2.127	2.898	85.882	31.824	2.848	27.662	3.592
262	1.096	1.898	0.832	278.071	0.789	4.719	0.944	24.722	4.571	1.000	2.248	1.911	2.487	44.952	20.952	2.393	51.143	10.003
263	0.916	2.391	0.879	148.511	0.722	5.000	0.964	20.572	3.333	1.000	2.324	1.479	1.977	32.533	14.000	2.254	26.640	3.243
264	1.817	1.692	0.810	230.048	0.716	5.143	0.858	16.692	3.000	1.000	2.142	1.742	2.162	32.125	18.250	1.722	15.391	4.333
265	1.204	2.188	0.574	206.629	0.685	5.846	0.726	20.425	2.385	1.096	5.549	0.593	1.314	160.923	8.385	4.024	37.952	5.754
266	0.879	1.615	0.636	440.231	0.673	4.250	0.872	22.715	2.636	1.000	2.922	1.224	1.786	61.364	15.182	2.154	11.039	2.949
267	0.933	1.580	0.771	469.574	0.612	5.047	0.778	24.141	3.455	1.000	3.430	1.341	2.026	147.500	19.727	2.576	18.056	3.465
268	0.668	2.182	0.850	163.304	0.664	6.340	0.988	26.670	6.429	1.000	1.505	3.530	3.530	19.571	19.571	1.821	31.973	3.710
269	1.146	1.405	0.545	588.613	0.565	4.471	0.710	19.065	2.500	1.017	4.461	0.799	1.502	133.833	11.100	3.127	5.613	1.508
270	1.008	1.971	0.584	143.829	0.657	5.979	0.967	23.086	4.604	1.000	2.803	1.921	2.522	137.333	33.146	2.397	37.065	5.854
271	0.581	1.817	0.738	426.910	0.544	6.009	0.936	26.649	6.000	1.000	2.369	2.648	3.256	118.471	53.216	2.266	13.818	2.355
272	1.083	1.919	0.888	241.697	0.706	5.400	0.936	24.555	4.194	1.000	2.512	1.883	2.347	75.355	26.000	2.227	45.093	7.717
273	0.749	2.042	0.745	142.755	0.586	6.243	0.979	24.431	6.098	1.000	2.383	2.385	3.802	95.317	47.951	2.557	26.116	3.402
274	0.897	1.849	0.712	469.046	0.728	5.000	0.912	23.713	4.333	1.000	2.724	1.845	2.420	111.667	28.905	2.348	26.271	6.777
275	0.685	1.718	0.821	528.951	0.620	5.368	0.906	22.918	3.895	1.000	2.856	1.645	2.240	105.684	24.632	2.368	22.539	5.933

MNA	Node_Ha	Conn_Id	MNA_Comp	B_con_pe	B_avcmp	B_avnei	B_avor	B_avrap	PP_conn	PP_cont	PP_MD	PP_GI	PP_LI	PP_TD	PP_LD	PP_Inte	AR_Conn	AR_Cont
276	1.415	2.054	0.899	85.435	0.707	5.974	0.960	21.736	3.304	1.000	2.601	1.529	1.924	57.217	17.565	2.161	44.681	7.737
277	0.964	1.821	0.713	280.437	0.663	5.796	0.911	25.509	4.893	1.138	2.270	2.363	2.816	77.179	37.179	2.070	18.327	3.558
278	0.824	2.086	0.738	211.302	0.637	5.653	0.974	24.563	5.125	1.000	2.429	1.998	2.699	75.313	29.000	2.564	42.710	6.728
279	0.749	1.881	0.858	208.481	0.589	5.870	0.954	25.277	4.163	1.000	2.871	1.845	2.447	137.796	32.653	2.256	28.000	4.439
280	0.920	1.607	0.596	305.461	0.669	4.333	0.730	26.854	2.583	0.872	2.362	1.725	1.963	51.125	20.917	1.498	13.036	2.506
281	1.100	1.652	0.760	236.439	0.604	4.548	0.751	23.135	2.917	1.000	3.426	1.410	1.836	161.000	20.333	2.068	22.631	4.211
282	0.976	1.875	0.581	951.472	0.695	4.561	0.878	22.190	4.581	1.000	2.482	1.903	2.467	74.452	26.000	2.407	14.960	2.735
283	0.796	1.782	0.772	621.415	0.606	5.022	0.910	19.939	4.435	1.000	2.375	1.774	2.536	52.261	22.522	2.500	32.435	8.680
284	1.341	1.985	0.810	194.317	0.734	4.442	0.897	22.047	4.056	1.000	2.819	1.642	2.328	98.667	24.722	2.471	58.226	10.599
285	0.967	1.865	0.707	164.140	0.635	5.211	0.901	21.602	3.593	1.000	3.129	1.654	2.303	165.852	29.667	2.172	16.831	2.018
286	1.041	1.955	0.892	311.596	0.623	5.400	0.891	21.855	3.833	1.000	1.833	2.057	2.244	20.167	14.167	1.863	11.211	2.019
287	0.789	1.667	0.689	521.038	0.586	5.647	0.867	21.187	3.467	1.000	2.276	1.503	1.947	31.867	13.867	2.306	26.125	4.039
288	0.962	1.759	0.824	174.706	0.669	4.538	0.884	29.259	2.154	1.000	2.880	1.403	1.558	72.000	16.769	1.536	10.849	2.004
289	1.919	2.500	0.613	855.833	0.759	1.333	0.909	17.961	2.000	1.000	1.952	1.135	1.152	11.714	6.571	1.762	45.429	13.281
290	0.555	1.824	0.734	366.784	0.633	3.545	0.763	27.625	2.267	1.000	2.686	1.108	1.646	37.600	11.067	2.046	28.400	4.866
291	1.116	1.646	0.774	444.351	0.652	5.306	0.875	21.861	3.909	1.000	2.312	1.826	2.194	48.545	20.091	2.140	8.536	1.652
292	1.252	1.957	0.813	202.812	0.645	5.143	0.938	21.817	3.680	1.000	2.550	1.625	2.136	61.200	20.480	2.265	48.114	8.458
293	1.083	1.872	0.817	235.386	0.688	5.349	0.953	21.180	5.120	1.000	2.942	2.078	2.775	217.733	46.027	2.464	36.327	6.325
294	0.743	1.373	0.829	2034.320	0.591	4.370	0.774	24.117	3.298	1.000	3.719	1.303	1.936	208.246	18.807	2.532	14.526	4.141
295	0.785	2.000	0.712	287.021	0.608	4.703	0.923	20.701	4.421	1.000	2.257	1.804	2.329	40.632	17.895	2.450	54.800	9.391
296	0.300	2.000	0.570	351.538	0.638	3.286	0.622	35.257	2.000	1.000	2.643	0.668	1.036	18.500	5.500	2.994	38.167	7.506
297	0.404	2.000	0.802	671.161	0.492	2.667	0.679	19.843	2.000	1.000	1.000	1.000	1.000	2.000	2.000	2.000	14.500	3.196
298	1.090	1.454	0.796	561.869	0.641	5.058	0.819	24.660	3.950	1.041	4.025	1.666	2.355	623.843	38.579	2.371	7.052	1.599
299	0.883	1.827	0.724	215.212	0.522	5.976	0.970	21.837	4.146	0.941	2.893	1.879	2.393	260.976	33.317	2.207	15.319	2.803
300	1.975	1.972	0.575	624.028	0.746	2.125	0.884	18.359	3.217	1.000	2.632	1.477	2.017	57.913	18.522	2.178	29.200	6.850
301	1.131	1.531	0.734	643.817	0.647	3.957	0.794	25.285	3.000	1.000	2.915	1.371	1.842	78.714	16.857	2.189	21.925	4.750
302	0.928	1.681	0.793	352.247	0.614	5.170	0.931	24.005	4.077	0.952	3.147	1.780	2.476	210.564	35.359	2.291	27.888	5.590
303	0.631	1.408	0.744	10535.288	0.646	3.795	0.675	26.887	2.897	1.000	4.168	1.276	1.781	320.923	20.949	2.271	3.525	1.070
304	1.305	1.875	0.747	430.801	0.731	4.769	0.950	20.463	3.852	1.000	2.459	1.804	2.268	63.926	23.556	2.136	23.711	3.585
305	0.577	2.053	0.677	237.785	0.614	5.813	0.961	27.920	5.160	0.921	2.313	2.515	3.445	97.160	50.760	2.052	28.520	4.092
306	0.958	1.500	0.800	362.521	0.653	4.667	0.715	20.538	2.000	1.000	2.190	0.825	1.136	13.143	6.000	2.424	4.846	1.332
307	0.742	1.852	0.520	387.206	0.650	5.674	0.924	23.138	5.038	1.182	2.482	1.792	2.529	61.077	23.038	2.811	54.406	9.125
308	0.930	1.921	0.722	276.773	0.671	6.207	0.969	20.856	6.348	1.162	2.108	2.488	3.213	61.130	35.391	2.551	39.615	7.616
309	0.898	1.760	0.799	341.361	0.649	4.500	0.811	21.010	2.409	0.965	3.399	1.065	1.422	185.182	11.318	2.262	17.444	3.815
310	0.505	1.800	0.612	2731.717	0.608	3.857	0.735	22.468	2.667	1.000	2.400	1.372	1.580	33.600	12.267	1.943	43.733	12.437
311	1.620	1.786	0.528	130.007	0.660	5.972	0.904	20.657	3.861	0.952	2.874	1.810	2.451	266.194	34.806	2.134	14.048	2.073
312	1.111	1.528	0.754	292.076	0.606	5.053	0.875	23.239	2.840	1.026	3.462	1.075	1.650	90.000	14.040	2.642	23.357	4.686
313	1.099	1.756	0.669	188.790	0.623	5.623	0.922	23.502	3.234	1.000	4.371	1.030	1.866	201.064	18.213	3.141	11.831	2.086
314	0.919	1.789	0.562	275.113	0.703	6.294	0.977	23.701	5.575	0.980	2.356	2.650	3.239	117.800	55.275	2.104	20.730	2.767
315	0.817	1.695	0.858	596.991	0.626	4.525	0.931	23.267	3.813	1.000	2.683	1.708	2.242	83.188	24.188	2.232	41.594	8.581
316	1.138	1.800	0.700	287.288	0.660	5.698	0.966	22.528	3.892	1.000	2.760	1.746	2.329	99.351	27.784	2.230	27.604	5.242
317	0.955	1.822	0.805	304.675	0.683	6.023	0.970	23.819	5.947	1.000	2.846	2.215	3.066	213.421	53.579	2.685	21.624	3.602
318	0.747	1.632	0.602	1297.619	0.503	4.167	0.984	22.707	3.778	1.000	1.583	2.311	2.384	12.667	11.333	1.634	33.222	10.151
319	0.678	1.727	0.634	633.324	0.484	3.200	0.990	26.837	3.143	1.000	1.524	1.783	1.871	9.143	8.286	1.763	46.500	14.660
320	0.767	1.784	0.628	461.920	0.585	6.000	0.938	21.307	5.067	1.000	1.810	2.285	2.665	25.333	18.133	2.217	33.600	10.010
321	0.970	1.618	0.759	304.738	0.652	5.000	0.772	23.384	2.696	1.000	2.715	1.411	1.794	59.739	17.652	1.910	26.618	8.375
322	1.028	1.769	0.865	259.623	0.666	4.692	0.906	25.226	3.478	1.000	2.427	1.652	2.162	53.391	20.174	2.106	27.083	8.154
323	0.586	1.682	0.562	896.028	0.603	5.000	0.781	24.082	2.462	1.000	2.231	1.407	1.832	26.769	13.538	1.750	10.267	2.576
324	0.918	1.571	0.891	321.879	0.618	2.667	0.910	22.407	3.250	1.000	1.643	1.762	1.874	11.500	9.250	1.844	39.000	11.908
325	1.513	1.300	0.799	882.695	0.665	4.400	0.818	17.922	2.857	1.000	2.275	1.427	1.822	29.571	13.429	2.002	4.000	1.088
326	1.791	1.545	0.741	490.980	0.720	4.095	0.964	16.802	3.800	1.057	2.071	1.852	2.632	31.067	19.000	2.052	20.875	6.094
327	0.945	2.091	0.528	567.465	0.591	4.600	0.870	23.463	2.500	1.000	1.929	1.271	1.416	13.500	8.000	1.967	6.800	1.143
328	1.046	1.471	0.784	0.000	0.619	3.200	0.834	24.129	3.050	0.852	2.610	1.421	1.891	52.200	16.450	2.146	16.667	3.675
329	0.737	1.750	0.664	684.935	0.592	5.971	0.972	24.774	4.500	1.000	3.141	1.598	2.602	135.045	31.136	2.816	9.325	1.660
330	0.892	1.934	0.613	276.931	0.654	6.662	0.988	21.345	5.212	1.000	2.644	1.901	2.524	84.606	25.455	2.741	15.735	2.976

MNA	Node_Ha	Conn_Id	MNA_Comp	B_con_pe	B_avcmp	B_avnei	B_avor	B_avrap	PP_conn	PP_cont	PP_MD	PP_GI	PP_LI	PP_TD	PP_LD	PP_Inte	AR_Conn	AR_Cont
331	0.807	1.552	0.452	239.363	0.582	5.950	0.606	18.425	2.250	1.000	4.815	0.625	1.374	110.750	9.083	3.602	12.875	2.633
332	0.662	1.522	0.845	530.438	0.603	5.093	0.790	25.214	3.088	1.000	3.632	1.381	1.874	203.404	21.333	2.235	12.281	2.722
333	0.708	1.648	0.706	678.097	0.612	5.730	0.895	24.109	4.316	1.000	2.535	2.041	2.747	93.789	36.526	2.114	12.500	2.449
334	1.284	1.508	0.479	0.000	0.654	4.161	0.875	21.058	3.500	1.000	2.106	2.671	3.381	56.857	40.643	1.311	14.071	3.948
335	0.593	1.375	0.618	732.037	0.542	2.333	0.908	21.337	1.600	1.000	1.600	0.763	0.763	6.400	6.400	2.096	53.000	17.028
336	1.227	1.265	0.439	1129.740	0.681	3.091	0.744	19.415	2.235	1.000	2.044	2.474	2.599	32.706	24.118	0.903	14.500	4.679
337	0.859	1.450	0.405	1675.796	0.689	3.385	0.674	19.965	2.143	1.000	4.099	0.556	1.247	53.286	7.000	3.853	28.308	8.964
338	0.691	1.667	0.556	832.517	0.674	5.111	0.741	21.707	3.692	1.000	1.872	2.053	2.334	22.462	16.615	1.799	5.154	1.087
339	0.810	1.226	0.485	1044.555	0.549	2.875	0.685	17.732	2.000	1.000	2.265	1.805	1.780	36.235	18.706	1.108	15.790	5.056
340	1.001	1.429	0.724	565.157	0.691	2.571	0.898	24.847	3.111	1.000	1.611	3.121	3.121	12.889	12.889	0.997	31.889	9.912
341	0.939	1.364	0.561	3245.265	0.638	4.848	0.750	24.054	3.171	1.000	2.894	1.689	2.444	115.756	30.683	1.877	8.245	2.581

MNA2	AR_MD	AR_GI	AR_LI	AR_TD	AR_LD	AR_Inte	NH_Conn	NH_Cont	NH_MD	NH_GI	NH_LI	NH_TD	NH_LD	NH_inte	Outlier	Cluster
1	4.996	2.742	3.718	46539.000	375.750	5.927	4.390	1.609	7.415	1.709	2.178	67324.463	42.927	2.569	Yes	0
2	3.996	3.538	7.491	37226.000	1257.000	17.240	22.000	6.968	5.015	2.708	3.913	45539.790	447.263	8.124	Yes	0
3	4.195	3.331	6.350	39075.500	830.000	9.606	13.617	4.105	5.893	2.216	4.017	53503.469	195.741	6.145	Yes	0
4	4.663	2.948	4.861	43435.333	499.667	7.123	5.234	1.601	6.618	1.986	2.258	60090.234	123.297	2.636	No	1
5	5.324	2.510	3.322	49594.708	185.375	3.337	12.786	4.494	5.558	2.412	3.544	50461.857	292.786	5.300	No	3
6	5.654	2.334	3.159	52662.348	129.739	2.944	5.621	1.555	6.775	1.865	2.704	61512.310	63.552	3.014	No	6
7	4.496	3.096	5.518	41883.000	689.000	10.014	16.788	6.913	4.904	2.757	4.679	44525.030	428.364	6.090	Yes	0
8	6.851	1.825	1.522	63815.333	39.667	0.913	14.200	2.741	5.724	2.269	4.410	51970.520	254.520	6.258	Yes	0
9	5.843	2.211	5.961	54427.333	224.667	14.472	14.333	9.031	7.264	1.716	3.349	65958.667	88.333	8.353	Yes	0
10	6.350	2.142	2.849	59145.750	179.250	3.619	32.000	16.972	5.943	2.158	5.961	53957.667	224.667	14.828	No	1
11	7.165	1.751	3.349	66741.667	88.333	8.187	10.875	6.595	7.139	1.738	3.602	64824.625	95.375	6.258	Yes	0
12	7.040	1.794	1.817	65576.333	18.222	1.672	21.216	6.956	5.413	2.502	3.482	49148.405	361.324	8.479	Yes	0
13	6.166	2.090	2.727	57432.310	73.621	2.723	20.500	12.797	6.764	1.847	4.864	61420.500	130.500	11.101	No	5
14	6.484	1.962	2.799	60400.000	88.700	3.517	7.500	2.549	6.675	1.993	2.796	60606.000	136.750	3.764	Yes	0
15	7.040	1.773	3.602	65578.250	95.375	6.134	3.167	1.359	7.926	1.557	1.679	71965.333	51.833	2.034	No	1
16	6.151	2.146	3.456	57295.933	159.467	5.593	7.022	3.039	6.960	1.825	2.570	63197.667	64.267	3.848	No	6
17	5.246	2.609	3.049	48865.500	347.500	6.324	3.000	0.998	7.365	1.693	1.815	66873.389	18.000	1.772	No	1
18	6.800	1.841	3.838	63340.546	107.909	6.863	6.824	3.901	7.907	1.577	2.354	71792.588	58.000	4.327	No	1
19	6.390	2.044	2.951	59526.650	130.517	5.748	19.897	4.626	4.955	2.728	4.562	44990.483	508.172	7.293	No	5
20	7.827	1.586	1.679	72905.000	51.833	1.996	4.333	1.635	7.260	1.717	2.297	65918.667	95.000	2.523	Yes	0
21	6.269	2.147	2.539	58398.810	151.762	3.437	15.750	8.645	5.505	2.437	2.968	49988.750	258.750	6.462	No	3
22	7.161	1.752	2.297	66701.667	95.000	2.473	6.333	3.338	7.264	1.696	3.198	65958.667	81.222	3.733	Yes	0
23	6.881	1.843	2.017	64095.429	29.286	1.938	15.500	8.358	5.256	2.555	3.620	47721.000	285.500	6.066	No	2
24	7.808	1.607	2.354	72727.647	58.000	4.246	16.429	7.366	5.854	2.199	4.957	53153.429	193.857	7.472	No	3
25	6.969	1.865	1.877	64916.000	60.941	2.113	3.571	1.420	7.156	1.750	2.016	64976.429	29.000	2.041	No	3
26	4.804	2.814	4.508	44748.000	318.143	4.417	4.698	1.326	6.495	2.014	2.519	58971.135	77.286	2.332	Yes	0
27	7.184	1.738	1.338	66917.000	31.250	1.007	1.667	0.895	6.951	1.787	1.522	63110.667	39.667	0.932	Yes	0
28	5.778	2.270	2.249	53823.000	56.750	2.093	8.888	2.161	6.118	2.134	3.158	55552.112	143.216	4.166	No	2
29	6.185	2.098	3.586	57608.667	141.667	9.058	6.900	3.120	6.584	1.919	2.799	59781.500	88.700	3.596	No	1
30	6.665	1.886	4.864	62086.000	130.500	10.869	12.636	7.431	6.899	1.804	3.838	62643.000	107.909	7.006	Yes	0
31	5.635	2.378	4.076	52489.095	280.167	8.179	5.723	1.621	6.576	1.959	2.566	59706.213	71.426	2.922	No	6
32	6.275	2.108	2.525	58451.319	78.748	2.228	3.182	1.097	7.100	1.790	2.017	64465.136	38.364	1.778	No	7
33	5.177	2.617	3.831	48226.591	266.068	4.247	12.000	5.369	5.061	2.623	4.426	45950.714	263.143	4.574	No	4
34	6.661	1.888	3.339	62045.000	141.000	3.179	18.412	3.603	5.271	2.514	4.779	47864.177	437.000	7.323	Yes	0
35	4.930	2.745	4.118	45918.818	297.182	4.470	17.273	6.598	4.946	2.751	4.564	44911.667	459.636	6.279	No	5
36	7.120	1.804	2.195	66319.415	45.659	2.433	6.655	2.373	6.190	2.091	2.720	56204.793	86.586	3.183	No	3
37	6.665	1.886	4.864	62086.000	130.500	10.869	15.000	2.938	5.963	2.151	4.559	54145.125	271.500	6.974	No	1
38	6.537	1.938	2.715	60893.412	78.059	2.763	5.643	2.482	6.842	1.860	2.616	62121.671	69.871	3.034	No	2
39	5.478	2.468	3.908	51029.000	344.826	12.489	6.000	2.203	6.760	1.848	3.339	61379.500	141.000	3.246	No	8
40	6.492	2.015	2.254	60472.048	70.712	2.081	8.393	2.224	5.839	2.276	3.050	53017.337	209.989	3.688	No	7
41	6.067	2.148	2.960	56512.200	94.180	2.635	7.450	2.868	6.241	2.052	3.279	56670.425	121.450	3.631	No	7
42	4.729	2.929	4.672	44054.667	557.394	6.207	10.909	3.947	5.396	2.474	3.793	48998.364	238.046	4.410	No	5
43	6.824	1.885	2.025	63568.318	39.818	1.688	7.238	2.847	6.487	2.047	2.518	58901.381	133.143	3.535	Yes/Reintroduced	4
44	6.141	2.101	3.279	57206.675	121.850	3.547	5.353	2.283	6.637	1.896	2.715	60262.471	78.059	2.823	No	4
45	7.082	1.755	3.862	65965.000	90.417	4.795	20.500	12.797	6.764	1.847	4.864	61420.500	130.500	11.101	No	1
46	4.797	2.844	4.390	44685.630	404.593	5.027	11.818	5.625	5.187	2.562	4.038	47098.394	239.939	4.613	Yes	0
47	5.793	2.282	3.037	53958.079	127.342	2.387	4.571	2.040	6.474	1.950	3.102	58786.524	99.905	2.344	No	5
48	6.001	2.227	3.187	55902.060	212.040	6.629	22.818	3.686	5.318	2.473	5.112	48284.327	384.891	9.227	No	4
49	4.678	2.941	4.782	43579.333	519.909	5.987	13.519	6.592	5.057	2.646	4.280	45914.778	315.444	5.109	No	4
50	5.940	2.210	2.733	55328.897	89.759	3.011	3.966	1.235	6.325	2.050	2.557	57433.672	70.655	1.934	No	3
51	6.742	1.901	2.616	62800.600	69.871	2.969	5.447	1.879	5.893	2.225	3.037	53509.026	126.500	2.448	No	7
52	4.519	3.091	5.596	42094.824	793.412	11.417	5.255	1.505	6.200	2.107	2.659	56298.091	97.491	2.494	No	3
53	6.860	1.864	2.570	63902.333	64.267	3.766	13.231	6.441	7.040	1.808	3.443	63919.846	108.462	7.318	No	4
54	6.375	1.994	3.102	59379.286	99.905	2.293	11.467	3.430	6.940	1.850	3.343	63015.467	109.467	6.199	No	5
55	5.578	2.492	4.640	51957.273	451.636	19.557	15.333	3.584	4.812	2.808	5.060	43694.000	636.000	5.460	No	5

MNA2	AR_MD	AR_GI	AR_LI	AR_TD	AR_LD	AR_Inte	NH_Conn	NH_Cont	NH_MD	NH_GI	NH_LI	NH_TD	NH_LD	NH_inte	Outlier	Cluster
56	6.010	2.197	2.665	55986.982	99.327	2.392	29.500	15.957	4.756	2.864	5.352	43182.500	511.500	10.301	No	7
57	7.165	1.730	3.198	66741.667	81.222	3.661	8.417	4.655	7.181	1.721	3.862	65201.583	90.417	4.891	No	2
58	6.083	2.291	3.372	56667.070	371.018	7.903	4.115	1.265	6.778	1.895	2.214	61542.615	55.827	2.172	No	4
59	6.940	1.847	3.443	64648.615	108.462	7.165	24.267	7.877	5.353	2.625	4.442	48608.067	549.867	9.244	No	3
60	4.893	2.807	3.928	45581.421	474.211	7.989	34.294	13.190	4.697	2.931	5.526	42648.941	700.412	11.702	No	3
61	6.153	2.172	2.585	57311.241	122.926	2.745	17.211	4.571	6.354	2.148	3.302	57689.491	295.912	8.014	No	5
62	5.542	2.456	3.799	51622.548	329.258	8.340	31.035	4.915	4.803	2.856	5.274	43612.138	739.793	10.865	No	3
63	6.081	2.161	2.562	56644.879	71.793	1.835	7.167	2.428	6.401	2.035	2.552	58118.389	125.500	3.523	No	3
64	5.305	2.581	3.489	49416.703	386.405	8.387	8.458	2.637	5.734	2.336	2.976	52060.170	228.850	3.620	No	5
65	6.258	2.124	2.619	58289.615	123.297	2.690	58.000	31.896	4.256	3.245	7.222	38643.000	908.000	17.874	No	7
66	6.126	2.190	2.556	57066.283	188.472	3.075	14.146	3.736	5.775	2.299	2.771	52440.327	234.764	6.152	No	5
67	5.620	2.396	2.802	52351.509	271.382	6.116	15.469	3.979	5.745	2.318	3.100	52161.406	267.031	6.673	No	4
68	5.926	2.239	2.759	55197.957	170.449	3.282	5.670	1.762	6.435	2.041	2.613	58424.945	116.154	2.778	No	5
69	6.382	2.063	2.244	59444.741	74.370	2.047	3.680	1.099	6.794	1.877	2.059	61685.280	37.920	1.960	No	3
70	6.168	2.138	2.566	57453.611	128.944	3.352	4.222	1.314	6.580	1.981	2.242	59748.074	73.482	2.132	No	3
71	5.614	2.411	2.985	52295.948	240.954	3.562	14.750	3.747	4.648	2.944	4.533	42205.750	574.750	5.010	No	7
72	6.237	2.104	2.568	58097.893	102.867	2.985	7.232	2.041	6.100	2.146	2.748	55388.391	154.044	3.370	No	4
73	5.418	2.498	3.924	50465.225	327.225	6.161	41.000	10.668	5.237	2.519	6.230	47550.333	592.333	16.274	No	3
74	4.414	3.165	4.671	41120.000	713.750	4.977	20.025	6.542	5.599	2.483	4.014	50840.700	437.625	8.066	Yes	0
75	5.560	2.431	3.128	51788.625	314.969	6.569	5.741	1.664	6.422	2.045	2.554	58311.870	100.259	2.807	No	5
76	6.563	1.967	2.061	61133.440	38.240	1.871	7.286	2.138	5.988	2.165	2.866	54372.857	104.714	3.366	No	4
77	5.762	2.331	3.143	53669.389	250.333	3.789	6.283	1.859	6.390	2.062	2.512	58022.113	145.755	3.047	No	5
78	5.580	2.426	3.265	51977.413	265.022	6.283	5.875	1.620	6.914	1.810	2.832	62777.875	93.625	3.245	No	5
79	6.813	1.857	2.107	63460.000	39.769	2.030	6.227	1.768	6.468	2.001	2.562	58726.293	95.053	3.111	No	3
80	6.146	2.166	2.560	57254.039	135.284	2.526	3.769	1.612	7.039	1.778	2.107	63914.615	39.769	2.120	No	7
81	5.761	2.281	2.867	53660.000	105.857	3.194	7.667	2.079	5.968	2.176	3.434	54185.556	123.667	3.524	No	1
82	4.792	2.846	4.175	44635.000	400.000	3.163	8.500	2.225	5.994	2.204	3.114	54422.167	205.500	3.856	Yes	0
83	5.668	2.378	3.070	52795.124	236.236	3.625	4.632	1.518	6.527	2.002	2.597	59262.921	86.526	2.314	No	5
84	5.485	2.565	4.027	51092.450	463.625	7.962	39.464	12.875	4.552	3.029	5.954	41328.357	841.464	13.028	No	4
85	5.399	2.518	3.624	50290.881	330.024	5.173	3.218	1.066	10.098	1.184	1.921	91688.897	24.295	2.717	No	3
86	5.865	2.307	2.881	54630.827	198.800	4.428	5.393	1.522	6.338	2.075	2.550	57547.206	123.486	2.600	No	7
87	5.732	2.299	3.447	53397.333	128.111	3.335	4.592	1.527	6.412	2.022	2.337	58218.571	76.225	2.271	No	2
88	4.437	3.145	5.976	41333.357	895.179	12.821	31.083	10.337	5.126	2.681	4.175	46539.278	533.750	11.593	Yes/Reintroduced	3
89	6.146	2.110	2.814	57249.833	61.542	2.231	9.000	2.533	4.952	2.717	4.160	44962.500	390.000	3.312	No	5
90	6.322	2.091	2.606	58891.053	91.105	2.215	3.882	1.398	7.252	1.766	1.866	65848.324	50.882	2.198	No	5
91	6.241	2.099	2.345	58130.612	78.265	2.188	5.579	1.860	5.733	2.308	2.841	52053.947	162.842	2.418	No	4
92	6.409	2.077	2.271	59702.297	141.734	2.580	10.000	2.988	6.050	2.206	2.864	54935.027	177.360	4.532	No	4
93	6.346	2.113	2.659	59114.532	133.307	3.076	4.708	1.136	6.369	2.012	2.814	57831.042	61.208	2.341	No	5
94	4.584	3.048	6.016	42703.222	923.000	10.681	10.684	2.019	5.642	2.288	3.744	51224.947	152.053	4.669	No	1
95	5.012	2.774	4.187	46689.139	573.139	11.444	24.967	8.368	4.953	2.762	4.221	44973.200	551.367	9.040	No	3
96	5.616	2.382	2.851	52311.211	168.947	2.342	20.000	10.643	4.922	2.737	4.728	44695.667	379.333	7.308	No	3
97	5.311	2.540	3.368	49474.548	176.323	3.201	11.627	2.075	5.472	2.422	3.946	49684.068	317.017	4.801	No	5
98	4.839	2.860	4.237	45072.200	585.500	8.916	19.000	8.941	6.284	2.049	3.586	57060.667	141.667	9.273	No	3
99	6.339	2.023	2.623	59044.000	53.158	2.315	16.381	3.678	5.775	2.290	2.929	52437.905	263.619	7.152	Yes/Reintroduced	5
100	5.702	2.329	3.254	53109.530	214.455	3.904	18.391	2.825	5.020	2.677	4.736	45582.087	455.609	6.870	No	5
101	4.699	2.918	6.278	43771.667	678.667	19.647	40.459	5.587	4.802	2.821	6.240	43602.659	793.800	14.343	Yes	0
102	5.239	2.717	4.458	48801.067	584.000	9.129	42.059	13.776	5.567	2.536	3.987	50546.647	556.647	16.587	No	2
103	5.857	2.253	3.211	54558.167	191.191	5.791	53.933	9.368	4.722	2.900	6.281	42875.567	933.067	18.600	No	5
104	5.391	2.648	3.998	50212.588	607.471	16.241	18.553	5.784	5.645	2.394	3.379	51257.766	300.936	7.751	No	3
105	5.450	2.441	3.908	50762.170	266.936	7.129	36.740	8.989	4.615	2.979	5.858	41907.610	823.987	12.332	No	5
106	5.921	2.280	2.926	55151.524	239.587	5.682	6.079	1.583	6.463	2.003	2.762	58685.968	101.952	3.035	No	4
107	5.443	2.529	3.499	50704.115	419.385	9.460	11.136	2.647	5.938	2.179	4.125	53913.636	148.682	5.110	No	3
108	5.472	2.500	3.403	50969.926	325.957	7.584	42.737	13.320	4.751	2.898	5.217	43135.579	732.842	14.748	No	7
109	5.497	2.414	4.611	51201.833	171.000	11.739	13.430	3.469	5.688	2.342	3.370	51647.688	246.289	5.736	No	2
110	4.907	2.824	5.523	45709.500	641.375	22.885	13.837	3.133	5.506	2.470	3.844	49995.306	462.612	5.601	No	3

MNA2	AR_MD	AR_GI	AR_LI	AR_TD	AR_LD	AR_Inte	NH_Conn	NH_Cont	NH_MD	NH_GI	NH_LI	NH_TD	NH_LD	NH_inte	Outlier	Cluster
111	4.871	2.796	4.264	45369.000	466.000	3.373	23.308	6.021	5.603	2.425	3.484	50876.500	386.000	9.611	No	2
112	4.627	3.013	5.238	43095.421	784.947	14.499	13.731	3.988	5.311	2.549	4.026	48222.500	368.654	5.387	No	3
113	5.412	2.481	4.737	50409.500	303.267	11.338	33.385	6.494	4.763	2.853	5.728	43246.923	724.615	11.703	No	5
114	5.201	2.631	4.039	48447.513	385.333	5.302	26.875	7.715	5.057	2.679	4.397	45913.050	475.575	10.032	No	5
115	6.241	2.102	2.779	58135.683	115.825	2.953	9.293	2.504	6.137	2.150	3.360	55726.585	166.805	4.321	No	4
116	4.935	2.778	4.436	45968.450	519.225	9.982	47.500	13.832	4.531	3.051	6.320	41139.650	944.600	15.569	No	5
117	5.728	2.304	4.026	53352.815	202.222	5.927	10.667	2.006	5.421	2.437	3.993	49219.333	423.879	4.376	No	5
118	5.320	2.568	4.201	49554.683	421.439	8.405	8.857	2.491	5.087	2.635	4.175	46190.143	405.714	3.362	No	5
119	4.406	3.177	6.379	41041.500	1028.700	15.486	39.100	12.347	5.194	2.624	3.662	47165.200	473.900	14.900	No	6
120	5.905	2.273	3.389	55009.195	184.366	4.175	40.464	8.388	4.807	2.842	6.153	43644.714	926.250	14.240	No	4
121	7.523	1.838	2.624	70079.304	67.696	4.139	5.484	1.522	6.437	1.991	2.353	58450.355	70.710	2.754	No	5
122	5.114	2.675	4.630	47633.296	503.815	10.648	21.073	4.932	5.560	2.429	4.177	50485.122	393.171	8.677	No	5
123	5.091	2.708	3.666	47425.100	517.100	14.736	11.650	4.023	6.798	1.890	2.942	61725.750	115.850	6.164	No	1
124	6.138	2.202	3.467	57177.636	151.879	4.294	28.200	4.889	5.488	2.452	4.661	49829.750	485.000	11.500	No	5
125	5.542	2.423	3.638	51622.273	283.000	6.176	9.889	2.632	5.164	2.638	4.125	46891.111	470.333	3.749	No	5
126	5.837	2.276	3.202	54375.526	161.845	4.023	27.889	6.509	5.288	2.556	4.618	48016.667	469.889	10.910	No	5
127	5.137	2.614	4.356	47847.438	326.191	4.818	4.222	1.109	7.480	1.667	2.465	67920.167	29.667	2.533	No	5
128	5.754	2.285	3.963	53593.915	178.553	3.669	15.618	2.978	5.290	2.510	4.677	48034.147	260.147	6.223	No	6
129	4.841	2.825	4.597	45094.000	550.793	7.360	14.327	3.297	5.700	2.329	3.602	51759.018	254.218	6.152	No	5
130	5.062	2.674	4.476	47155.113	337.339	5.712	4.750	1.665	6.047	2.136	2.234	54904.000	52.750	2.223	No	6
131	5.151	2.605	5.276	47985.000	408.833	8.330	25.667	8.091	5.282	2.521	4.419	47959.875	430.167	10.180	No	6
132	4.972	2.780	4.409	46310.200	536.000	4.028	8.444	1.985	5.611	2.398	3.445	50950.500	286.222	3.521	Yes/Reintroduced	1
133	6.069	2.194	2.898	56536.733	156.367	3.661	29.500	7.258	5.344	2.515	4.876	48524.800	403.700	11.730	No	3
134	5.815	2.243	4.128	54161.864	150.591	4.966	8.028	2.213	6.394	2.002	3.031	58059.917	64.417	4.010	No	8
135	4.719	2.938	5.084	43961.339	676.054	11.701	44.927	11.046	4.584	3.013	6.014	41622.838	876.515	14.912	No	6
136	5.077	2.702	4.938	47287.300	486.900	11.511	12.169	2.440	5.409	2.442	4.303	49111.371	294.056	4.982	No	1
137	5.156	2.685	4.121	48031.690	465.069	5.202	7.621	1.958	6.295	2.073	2.771	57157.207	125.069	3.677	No	3
138	5.446	2.504	3.545	50725.500	328.222	3.772	12.630	3.030	5.393	2.524	3.852	48968.333	388.704	5.004	No	2
139	4.792	2.829	6.293	44638.000	665.667	15.202	8.800	2.271	6.254	2.053	3.186	56788.950	149.400	4.286	No	1
140	6.317	2.039	3.031	58842.389	64.417	3.937	19.310	6.714	5.818	2.278	4.062	52823.857	258.405	8.475	No	5
141	6.499	1.995	2.566	60536.766	72.192	2.869	14.412	3.163	6.177	2.076	3.481	56085.412	172.059	6.941	No	3
142	5.548	2.361	4.577	51675.125	290.750	6.461	10.140	1.864	5.656	2.313	3.847	51360.086	196.075	4.383	Yes/Reintroduced	6
143	6.475	1.999	2.605	60317.263	49.263	2.212	14.771	3.045	5.394	2.460	4.390	48976.787	296.541	6.004	No	6
144	6.027	2.166	3.093	56143.024	166.643	4.892	36.227	7.073	5.547	2.451	4.469	50362.182	471.227	14.778	No	5
145	5.883	2.222	3.490	54803.294	188.765	6.591	10.452	2.335	6.360	2.022	3.086	57745.214	155.405	5.170	No	2
146	5.813	2.255	3.229	54145.400	163.200	4.036	16.500	3.885	6.040	2.128	4.051	54840.800	228.100	7.755	No	2
147	4.450	3.144	6.059	41449.118	961.618	14.714	54.920	14.186	4.771	2.904	5.589	43322.880	784.400	18.914	No	6
148	4.649	3.020	5.609	43305.560	861.600	18.633	7.857	1.422	5.664	2.357	3.115	51425.179	227.429	3.334	No	5
149	5.572	2.363	4.194	51900.000	259.400	7.447	10.111	2.728	6.172	2.081	3.424	56044.222	186.333	4.859	No	2
150	5.440	2.429	3.803	50671.667	225.778	4.757	13.923	3.499	6.255	2.042	3.953	56796.308	202.231	6.820	No	1
151	5.286	2.533	4.637	49234.902	414.686	6.697	18.848	3.240	5.841	2.256	3.800	53037.804	301.674	8.355	No	6
152	5.626	2.381	3.850	52408.283	325.196	8.062	20.955	3.539	5.409	2.443	4.658	49115.657	376.299	8.578	No	4
153	5.420	2.548	4.487	50484.818	504.409	14.506	22.073	4.009	5.281	2.526	5.160	47949.463	477.781	8.739	No	6
154	5.277	2.532	3.945	49155.872	227.553	4.143	30.391	11.109	5.710	2.331	3.833	51844.087	296.565	13.038	No	5
155	5.244	2.556	4.286	48850.600	327.280	4.601	16.765	2.971	5.495	2.403	4.624	49892.157	396.726	6.976	No	3
156	4.499	3.092	5.884	41908.078	880.507	12.142	38.352	9.410	4.630	2.977	5.689	42038.606	745.817	12.885	No	6
157	5.140	2.613	3.880	47876.143	274.524	4.866	10.652	1.971	6.200	2.093	3.452	56297.957	176.565	5.089	No	5
158	4.995	2.744	4.113	46528.762	456.286	6.178	33.411	8.594	4.855	2.819	5.046	44086.679	618.304	11.851	No	6
159	5.626	2.358	3.681	52403.611	186.189	4.312	16.265	2.713	5.434	2.475	4.456	49341.020	343.612	6.571	No	5
160	6.380	2.019	2.771	59426.817	91.083	3.095	12.635	3.273	6.105	2.185	2.912	55432.302	218.889	5.784	No	3
161	5.579	2.396	3.460	51963.400	222.275	3.161	10.417	2.824	5.413	2.446	4.074	49152.125	260.000	4.259	No	3
162	5.968	2.249	2.784	55595.636	97.455	2.587	8.211	1.543	5.713	2.323	2.747	51876.474	260.737	3.535	No	2
163	4.595	2.989	5.006	42800.346	548.731	4.543	57.333	21.967	4.773	2.849	6.286	43337.000	662.000	20.123	No	8
164	5.046	2.675	5.189	46999.244	504.610	8.433	7.200	1.970	5.721	2.319	3.414	51950.600	204.000	3.104	No	6
165	5.160	2.602	4.704	48069.567	408.716	8.227	14.680	5.284	6.108	2.166	3.177	55460.480	199.360	6.778	No	7

MNA2	AR_MD	AR_GI	AR_LI	AR_TD	AR_LD	AR_Inte	NH_Conn	NH_Cont	NH_MD	NH_GI	NH_LI	NH_TD	NH_LD	NH_inte	Outlier	Cluster
166	4.525	3.082	5.709	42145.916	797.845	12.692	26.520	6.741	4.825	2.842	5.162	43808.392	656.696	9.332	No	6
167	5.657	2.311	3.577	52691.560	183.280	3.531	15.022	5.649	5.811	2.297	3.117	52760.109	230.544	6.539	No	3
168	5.534	2.440	3.136	51545.107	247.857	3.279	5.818	1.261	6.080	2.186	2.774	55209.273	94.909	2.661	No	3
169	4.334	3.196	6.330	40366.174	930.826	5.619	27.356	7.592	4.876	2.820	4.716	44275.203	689.627	9.701	No	2
170	4.952	2.759	4.237	46123.357	413.071	5.256	10.263	1.676	5.366	2.471	3.635	48725.526	254.790	4.153	No	6
171	5.359	2.467	3.193	49916.250	155.375	2.044	17.319	5.762	5.559	2.372	3.903	50477.489	259.617	7.301	No	6
172	5.029	2.667	5.250	46843.250	434.321	8.757	22.259	4.034	5.089	2.623	5.449	46207.148	529.691	8.487	No	5
173	5.944	2.214	3.458	55363.783	186.044	4.852	9.744	1.824	6.171	2.110	3.642	56033.244	168.456	4.618	No	6
174	4.833	2.794	5.597	45014.850	496.300	9.198	24.456	4.062	5.158	2.573	5.285	46837.253	480.304	9.506	No	8
175	6.014	2.186	3.368	56022.865	153.054	3.029	6.017	1.500	6.777	1.864	2.726	61534.050	83.383	3.228	No	5
176	4.861	2.784	5.397	45283.405	536.722	9.106	34.813	6.642	5.124	2.611	5.423	46528.313	613.875	13.333	No	8
177	4.976	2.715	4.851	46349.882	479.353	6.997	1.750	0.921	7.284	1.703	1.338	66134.000	31.250	1.027	No	6
178	5.027	2.725	4.682	46828.865	409.750	6.317	9.714	2.115	5.540	2.417	3.392	50302.143	347.143	4.018	No	8
179	4.720	2.938	5.183	43965.272	697.944	9.217	17.609	5.181	4.438	3.087	6.301	40293.739	896.739	5.704	No	6
180	5.581	2.406	2.771	51982.105	288.842	3.500	12.692	1.760	5.046	2.663	4.646	45818.000	431.231	4.766	No	3
181	6.628	1.922	3.042	61742.133	79.767	3.417	4.400	1.138	7.388	1.669	2.452	67083.750	45.500	2.637	No	6
182	4.781	2.855	4.854	44531.261	520.304	7.081	14.071	1.973	5.202	2.600	4.179	47237.786	372.643	5.412	No	6
183	4.769	2.918	4.736	44418.593	734.441	9.583	13.571	3.169	5.285	2.536	3.811	47988.543	347.171	5.351	No	3
184	4.846	2.815	5.477	45135.719	670.375	12.701	16.136	2.821	5.614	2.324	4.286	50970.966	276.407	6.942	No	5
185	4.402	3.167	6.242	41000.455	980.982	11.747	24.768	3.232	4.867	2.780	5.266	44194.696	531.339	8.909	No	8
186	5.182	2.614	3.829	48265.695	370.191	5.305	35.400	11.716	5.716	2.392	2.737	51898.700	389.200	14.799	No	6
187	5.818	2.249	3.972	54196.769	219.308	6.329	8.707	2.168	6.902	1.828	3.210	62665.413	119.960	4.764	No	2
188	4.563	3.025	5.443	42502.724	665.086	9.092	8.954	2.573	5.902	2.220	3.189	53591.385	190.369	4.033	No	8
189	4.863	2.781	5.489	45302.277	557.181	8.058	9.941	2.778	5.100	2.611	4.216	46311.471	286.059	3.807	No	8
190	5.332	2.487	4.319	49667.915	294.322	6.591	18.468	3.154	5.582	2.350	4.434	50682.097	298.371	7.859	No	5
191	5.298	2.535	3.418	49350.872	242.851	3.542	5.042	1.026	5.455	2.404	3.189	49530.667	152.542	2.097	No	6
192	5.338	2.525	4.350	49726.806	365.694	6.327	25.000	3.799	5.165	2.562	5.446	46902.128	433.974	9.759	No	5
193	6.371	2.029	2.907	59345.291	106.509	2.688	6.297	1.527	6.355	2.031	3.296	57704.189	136.622	3.101	No	5
194	4.835	2.805	5.233	45033.222	533.500	7.884	16.235	3.463	5.165	2.573	4.609	46897.000	435.412	6.310	No	6
195	4.876	2.735	3.292	45424.000	99.000	0.366	14.378	3.461	5.472	2.460	3.993	49684.356	409.178	5.844	Yes	0
196	5.352	2.467	4.343	49854.636	255.152	4.914	21.083	4.167	5.153	2.578	5.121	46792.861	476.861	8.178	No	6
197	5.323	2.502	4.462	49585.307	318.984	7.497	20.290	7.441	5.656	2.379	3.779	51355.581	305.774	8.529	No	8
198	5.618	2.462	2.738	52334.300	429.600	14.706	39.282	10.813	5.134	2.680	4.664	46612.821	583.436	14.660	No	1
199	4.648	2.989	5.332	43297.276	812.897	10.659	20.831	3.151	5.233	2.569	4.947	47514.687	500.590	8.110	No	6
200	5.350	2.543	3.423	49837.571	376.571	3.932	48.727	18.501	5.676	2.429	4.647	51537.000	438.000	20.061	Yes/Reintroduced	2
201	6.552	1.939	2.835	61027.000	95.375	3.030	9.000	2.324	6.618	1.944	3.299	60093.000	162.111	4.631	No	1
202	4.976	2.702	4.392	46349.177	333.294	4.093	26.500	7.844	4.747	2.862	5.533	43101.000	602.833	9.259	No	2
203	5.200	2.599	3.893	48434.461	283.667	4.096	20.600	4.527	5.473	2.461	4.446	49691.550	433.400	8.369	No	6
204	4.883	2.776	4.686	45480.647	478.941	6.060	12.182	2.505	5.075	2.642	4.591	46080.727	481.273	4.610	No	1
205	4.336	3.181	6.895	40385.400	925.800	12.387	47.000	10.716	4.804	2.791	6.928	43623.500	862.000	16.842	Yes	0
206	6.107	2.155	3.349	56882.556	189.000	4.279	8.407	1.323	5.956	2.150	3.708	54077.278	132.333	3.910	No	1
207	4.667	2.949	5.698	43473.957	724.696	13.887	47.257	9.543	5.021	2.694	5.444	45587.314	672.114	17.544	No	6
208	5.629	2.465	3.769	52432.029	520.721	5.901	1.000	0.021	5.289	2.464	3.240	48021.000	95.000	0.406	No	5
209	4.330	3.188	7.206	40332.250	1032.750	16.389	33.182	6.472	4.933	2.784	6.026	44794.000	945.364	11.920	Yes	0
210	4.521	3.055	6.171	42113.714	874.000	14.264	33.926	4.674	4.709	2.898	5.988	42757.463	799.630	11.709	No	8
211	4.756	2.920	6.005	44303.154	934.154	10.275	8.894	1.614	5.414	2.458	3.395	49157.234	226.936	3.618	No	2
212	6.912	1.814	2.459	64389.400	46.800	2.426	5.309	1.251	6.749	1.887	2.880	61277.636	97.273	2.814	No	2
213	4.540	3.027	5.859	42289.833	717.833	9.856	12.405	2.074	5.456	2.416	3.793	49538.095	244.976	5.134	No	2
214	4.562	3.017	6.347	42498.859	864.682	13.705	67.571	10.027	4.548	3.008	7.221	41292.743	1125.286	22.463	No	8
215	4.971	2.750	4.399	46309.021	493.809	5.315	16.450	3.607	5.300	2.529	4.344	48122.150	462.350	6.506	No	5
216	4.547	3.034	5.850	42351.643	775.500	11.559	37.429	5.532	4.881	2.806	5.794	44317.679	878.929	13.340	No	2
217	4.654	2.940	5.973	43347.210	700.436	10.988	35.200	7.585	4.885	2.734	6.530	44359.200	733.600	12.875	No	8
218	5.024	2.774	4.682	46795.256	630.462	14.551	35.121	9.460	5.298	2.586	4.345	48109.121	494.466	13.583	No	5
219	4.820	2.853	5.503	44897.486	730.371	17.077	15.389	2.821	5.617	2.361	4.250	50999.556	328.167	6.518	No	6
220	4.321	3.219	7.293	40251.800	1236.714	21.292	22.512	3.003	4.879	2.765	5.417	44305.171	613.732	8.143	No	8

MNA2	AR_MD	AR_GI	AR_LI	AR_TD	AR_LD	AR_Inte	NH_Conn	NH_Cont	NH_MD	NH_GI	NH_LI	NH_TD	NH_LD	NH_inte	Outlier	Cluster
221	4.720	2.890	5.167	43967.667	677.667	5.653	39.044	8.304	4.924	2.749	5.530	44712.652	646.261	14.202	Yes	0
222	5.031	2.709	4.982	46865.627	539.229	7.863	27.083	3.768	4.817	2.829	5.691	43738.033	736.250	9.575	No	8
223	5.330	2.597	3.872	49646.571	508.000	5.438	14.250	3.098	5.780	2.355	3.744	52485.794	474.603	6.052	No	4
224	5.324	2.567	4.013	49595.622	443.489	5.687	22.143	6.087	5.180	2.581	4.936	47033.214	537.000	8.580	No	5
225	5.278	2.535	4.581	49167.638	324.915	6.522	11.515	2.307	5.717	2.264	4.251	51911.939	225.818	5.086	No	3
226	6.588	1.947	3.217	61371.120	126.307	4.526	12.854	2.893	6.097	2.094	4.320	55359.542	213.896	6.139	No	5
227	5.100	2.695	4.511	47509.000	488.500	7.757	14.277	2.910	5.373	2.488	4.344	48781.936	438.447	5.738	No	3
228	4.603	3.016	5.858	42877.250	957.286	12.647	16.866	2.577	5.030	2.677	5.241	45675.463	606.720	6.301	No	5
229	5.518	2.371	3.767	51397.870	147.870	3.601	8.167	1.306	5.980	2.140	3.846	54302.364	132.136	3.817	No	8
230	5.194	2.669	4.360	48377.948	533.707	13.495	12.180	2.990	5.898	2.263	3.830	53556.077	229.769	5.381	No	5
231	5.107	2.681	4.392	47572.925	513.850	6.266	9.308	2.132	5.432	2.404	4.229	49318.923	237.308	3.872	No	3
232	4.671	2.938	5.394	43513.482	687.084	6.068	9.118	1.724	5.446	2.423	4.295	49448.000	271.353	3.763	No	6
233	4.868	2.822	4.986	45341.500	601.429	8.000	12.685	3.120	5.469	2.441	3.876	49656.329	365.589	5.198	No	1
234	5.430	2.526	4.208	50581.462	443.063	6.506	6.391	1.644	6.304	2.023	2.929	57238.609	82.913	3.160	No	7
235	5.733	2.271	4.338	53398.542	225.646	5.733	7.760	2.075	5.971	2.155	3.508	54216.360	167.440	3.601	No	6
236	5.051	2.691	4.188	47048.250	481.000	2.601	14.652	4.311	5.111	2.603	5.145	46408.826	489.609	5.630	Yes/Reintroduced	1
237	4.889	2.749	4.379	45539.647	296.647	3.360	10.000	1.862	5.106	2.596	4.549	46358.429	335.429	3.852	No	2
238	5.080	2.642	4.406	47321.308	292.077	3.755	64.625	24.826	4.981	2.758	5.532	45225.875	622.625	23.434	No	6
239	5.797	2.324	3.853	53999.923	236.897	5.373	28.333	6.831	5.644	2.327	4.614	51242.833	160.667	12.174	No	5
240	4.712	2.893	6.170	43888.905	781.122	13.441	31.817	4.583	4.999	2.679	5.880	45388.433	632.883	11.875	No	8
241	4.753	2.874	5.592	44278.357	699.300	8.646	16.000	3.193	5.677	2.380	4.163	51546.636	414.014	6.724	No	6
242	4.650	2.972	5.742	43310.550	801.150	9.370	43.674	7.699	4.616	3.000	6.061	41914.163	1078.698	14.561	No	8
243	4.684	2.948	5.548	43634.844	738.578	8.758	42.905	6.234	4.760	2.865	6.106	43223.214	802.476	14.974	No	6
244	5.282	2.567	3.905	49203.480	400.603	5.048	6.966	1.801	5.859	2.218	3.316	53200.621	135.241	3.141	No	4
245	5.756	2.276	3.333	53617.828	139.931	3.060	10.769	2.969	5.882	2.238	3.337	53412.192	229.923	4.812	No	5
246	5.225	2.572	2.714	48668.429	258.857	2.222	27.967	9.089	5.598	2.371	4.637	50833.667	278.767	11.795	No	2
247	4.683	2.931	5.479	43624.293	685.244	7.897	24.594	2.883	4.950	2.726	5.617	44945.000	615.906	9.021	Yes/Reintroduced	6
248	4.842	2.824	5.610	45106.496	744.870	9.325	53.594	9.112	4.726	2.912	6.127	42907.719	931.656	18.408	No	6
249	4.865	2.770	4.566	45312.714	341.714	3.610	17.796	3.492	5.562	2.430	3.969	50501.185	470.796	7.324	No	1
250	5.151	2.607	4.155	47981.618	381.353	5.100	6.500	1.125	5.337	2.507	4.075	48464.000	423.000	2.593	No	5
251	5.401	2.435	4.005	50310.580	161.551	3.458	13.436	2.360	5.796	2.219	4.671	52628.164	247.800	6.055	No	8
252	4.714	2.897	6.028	43909.348	840.370	11.398	37.667	5.756	4.874	2.766	5.667	44252.714	626.619	13.616	No	6
253	4.888	2.793	4.063	45533.000	466.500	4.208	5.429	1.748	5.740	2.272	2.635	52115.857	215.714	2.389	No	1
254	5.642	2.384	3.363	52555.308	255.769	4.582	10.750	3.080	5.386	2.454	3.907	48908.125	382.500	4.380	No	3
255	4.795	2.834	5.311	44663.793	589.302	9.022	24.479	6.766	4.966	2.704	5.122	45089.417	528.188	9.052	No	5
256	4.805	2.843	5.642	44757.063	655.031	8.739	26.400	3.271	4.799	2.822	6.003	43576.040	767.360	9.355	No	8
257	4.925	2.760	4.657	45878.182	522.636	4.644	15.061	5.408	5.545	2.409	3.870	50346.020	291.102	6.253	Yes/Reintroduced	2
258	5.593	2.404	3.378	52094.250	258.969	5.693	22.051	5.900	5.215	2.607	4.522	47350.385	476.667	8.458	No	5
259	4.582	3.027	6.202	42685.357	992.393	13.746	24.129	4.697	4.909	2.744	5.543	44572.300	660.871	8.792	No	2
260	4.999	2.740	4.792	46562.985	645.169	7.805	7.898	2.565	5.713	2.306	3.529	51875.694	262.469	3.426	No	5
261	4.638	2.985	5.746	43198.554	805.041	9.269	43.383	7.723	4.652	2.960	6.089	42238.213	998.872	14.654	No	8
262	4.569	3.042	6.110	42556.429	996.071	16.813	6.567	1.546	6.818	1.846	3.038	61910.567	77.900	3.557	Yes/Reintroduced	6
263	4.660	2.943	6.031	43403.720	809.920	9.051	32.717	4.523	4.920	2.735	5.996	44672.130	796.196	11.962	Yes/Reintroduced	6
264	4.976	2.699	5.220	46347.130	531.652	5.702	23.830	7.087	4.929	2.725	5.193	44755.793	525.113	8.744	Yes/Reintroduced	6
265	4.733	2.886	5.680	44084.762	656.238	13.151	36.234	5.847	4.780	2.843	5.780	43399.935	740.468	12.746	No	7
266	5.523	2.418	3.141	51441.962	249.346	4.566	35.622	6.347	4.871	2.791	5.541	44227.102	777.786	12.764	No	5
267	5.373	2.551	3.992	50049.019	509.130	7.079	25.886	3.632	5.109	2.635	5.554	46393.741	696.206	9.825	No	5
268	4.730	2.897	6.019	44058.081	725.487	11.038	42.161	6.753	4.693	2.910	6.385	42610.952	976.000	14.490	No	8
269	6.096	2.135	2.387	56785.677	76.581	2.629	10.346	2.866	5.820	2.243	3.083	52847.654	218.962	4.614	No	4
270	4.593	3.008	5.837	42778.935	811.377	12.322	31.703	3.742	4.872	2.779	5.995	44233.432	683.162	11.409	No	8
271	5.475	2.394	4.725	51002.418	271.273	5.772	17.500	3.583	5.814	2.215	4.604	52787.577	236.769	7.902	No	8
272	4.462	3.151	6.120	41559.140	1176.209	14.312	16.149	2.986	5.561	2.367	4.535	50493.830	300.319	6.821	No	6
273	4.692	2.917	6.242	43703.372	907.930	8.954	16.571	2.006	5.080	2.671	5.329	46125.974	754.857	6.203	No	8
274	4.787	2.841	5.237	44590.271	593.229	9.246	42.429	13.186	4.926	2.737	5.560	44731.000	645.286	15.500	No	6
275	5.106	2.693	4.539	47560.590	503.667	8.368	31.739	8.650	4.810	2.846	5.557	43669.826	671.130	11.152	No	6

MNA2	AR_MD	AR_GI	AR_LI	AR_TD	AR_LD	AR_Inte	NH_Conn	NH_Cont	NH_MD	NH_GI	NH_LI	NH_TD	NH_LD	NH_inte	Outlier	Cluster
276	4.489	3.113	6.146	41811.192	1089.447	14.352	25.067	3.529	4.843	2.808	5.495	43975.178	662.044	8.927	No	8
277	5.441	2.424	4.694	50686.846	273.981	7.562	12.179	2.533	5.843	2.204	4.431	53054.714	234.250	5.526	No	6
278	4.558	3.035	6.413	42457.645	1024.355	14.075	13.000	4.449	5.994	2.183	3.205	54421.262	186.381	5.956	No	8
279	4.886	2.816	5.481	45509.566	747.263	9.944	21.077	3.566	5.249	2.570	4.746	47656.308	600.062	8.203	No	8
280	5.286	2.499	4.546	49241.929	274.964	5.217	7.917	2.830	5.687	2.297	3.216	51636.208	134.333	3.447	No	3
281	5.110	2.685	4.672	47601.754	618.600	8.428	27.438	5.607	5.209	2.603	4.677	47294.854	623.551	10.539	No	4
282	5.338	2.483	4.503	49727.240	294.240	6.025	16.149	2.986	5.561	2.367	4.535	50493.830	300.190	#######	No	6
283	4.693	2.952	5.580	43717.565	715.391	10.986	14.211	4.129	5.805	2.301	2.841	52713.070	249.263	6.176	No	6
284	4.498	3.106	6.241	41894.264	1098.038	18.748	26.905	3.576	4.786	2.851	5.696	43455.608	730.797	9.439	No	5
285	4.878	2.816	5.364	45436.039	794.208	5.978	28.026	4.083	4.754	2.867	6.349	43166.636	1005.896	9.777	No	6
286	5.465	2.393	3.783	50903.000	176.895	4.685	8.179	1.652	6.185	2.071	3.257	56158.321	97.679	3.949	No	6
287	5.423	2.488	4.423	50516.875	368.250	10.500	8.531	2.266	7.098	1.811	3.167	64449.094	68.969	4.711	No	6
288	5.191	2.590	4.016	48355.546	450.364	4.188	37.333	7.525	5.048	2.756	4.726	45836.917	841.500	13.547	No	5
289	4.686	2.923	5.688	43648.429	734.000	15.544	31.556	10.389	4.836	2.849	5.507	43907.667	776.667	11.077	Yes	0
290	5.179	2.635	4.698	48242.100	522.900	10.776	21.375	4.732	5.872	2.261	3.521	53317.550	334.975	9.455	No	3
291	5.869	2.215	3.300	54671.036	115.250	3.853	24.458	6.497	4.865	2.778	5.433	44174.125	665.875	8.805	No	6
292	4.689	2.951	6.123	43674.909	941.432	16.306	23.711	3.596	5.027	2.668	5.387	45646.079	613.711	8.887	No	6
293	4.714	2.928	5.585	43914.918	832.306	12.408	25.721	3.385	4.891	2.759	6.208	44410.407	860.837	9.324	No	6
294	5.679	2.378	2.851	52898.456	270.526	6.109	42.667	12.393	4.687	2.949	5.072	42558.467	820.800	14.471	No	4
295	4.603	3.011	6.309	42877.067	974.067	18.201	47.386	8.443	4.816	2.837	6.102	43729.636	906.250	16.702	No	6
296	4.907	2.887	4.763	45707.083	911.667	13.221	22.415	4.233	5.275	2.567	4.651	47895.939	580.815	8.734	No	3
297	4.847	2.777	4.970	45147.000	270.000	5.222	4.846	1.340	6.341	2.030	2.590	57572.308	71.308	2.388	No	1
298	6.018	2.213	3.020	56059.890	139.566	3.187	14.000	3.261	5.495	2.362	4.721	49892.500	188.500	5.928	No	4
299	5.012	2.681	4.846	46687.426	383.957	5.714	6.371	1.772	6.567	2.010	2.643	59629.032	114.919	3.169	No	8
300	4.632	2.979	5.671	43144.040	809.200	9.801	56.887	10.616	4.666	2.949	6.177	42370.830	1019.302	19.288	Yes/Reintroduced	2
301	5.488	2.460	3.567	51117.700	365.225	8.912	6.796	1.605	6.378	2.043	2.925	57913.583	120.644	3.326	No	3
302	4.959	2.774	4.705	46196.214	663.056	10.052	38.846	7.621	4.763	2.891	5.613	43249.923	913.154	13.438	No	6
303	8.012	1.584	2.059	74632.238	32.700	2.225	4.429	1.751	10.425	1.125	2.446	94661.714	31.286	3.938	Yes/Reintroduced	3
304	4.903	2.767	5.401	45666.842	629.395	8.570	38.446	5.417	5.005	2.679	6.117	45442.635	735.176	14.351	No	6
305	4.638	2.976	6.385	43201.416	1059.403	9.582	20.568	2.776	5.008	2.692	5.625	45469.338	729.432	7.640	No	8
306	5.997	2.183	2.619	55861.692	77.462	2.220	13.548	2.017	5.074	2.625	5.087	46071.143	482.167	5.160	No	3
307	4.615	3.015	6.151	42986.594	981.844	18.043	7.478	2.090	8.129	1.615	2.551	73807.609	53.826	4.630	No	6
308	4.644	3.001	5.643	43256.615	963.615	13.200	22.857	4.650	5.581	2.392	3.907	50677.929	335.357	9.555	No	8
309	5.351	2.556	4.087	49846.482	460.630	6.824	31.500	9.925	5.428	2.453	4.584	49288.150	396.000	12.840	No	5
310	4.580	3.054	5.091	42662.067	881.200	14.318	10.353	2.256	5.476	2.426	3.839	49724.284	254.588	4.267	Yes/Reintroduced	3
311	4.795	2.825	5.191	44661.619	529.714	4.973	17.500	3.956	5.525	2.453	4.018	50162.923	451.269	7.134	No	6
312	5.394	2.506	3.919	50240.643	349.429	9.322	40.656	8.566	5.044	2.680	5.035	45797.219	653.406	15.168	No	5
313	5.308	2.523	3.987	49441.475	333.220	4.689	14.609	2.764	5.329	2.476	4.716	48387.109	342.304	5.900	No	5
314	4.900	2.785	5.651	45641.378	764.216	7.444	58.000	31.896	4.256	3.245	7.222	38643.000	908.000	17.874	No	8
315	4.856	2.831	5.068	45228.875	699.406	14.695	31.333	10.081	4.935	2.721	5.484	44809.444	647.333	11.517	No	6
316	5.136	2.629	4.525	47844.868	459.604	10.501	21.318	3.595	5.171	2.593	5.131	46948.059	510.000	8.221	No	8
317	5.044	2.687	5.156	46987.235	530.682	8.047	6.800	1.145	5.115	2.601	4.561	46440.500	402.800	2.615	No	8
318	4.834	2.805	5.549	45027.444	704.111	11.843	43.667	14.554	4.851	2.788	5.795	44043.167	750.333	15.660	No	2
319	4.749	2.878	5.864	44235.167	824.167	16.158	26.125	4.063	5.583	2.387	4.415	50690.000	359.750	10.943	No	2
320	5.221	2.576	4.684	48633.650	443.800	13.046	24.882	8.300	5.677	2.318	3.428	51549.500	266.353	10.733	No	8
321	5.518	2.411	3.486	51395.971	301.206	11.040	21.200	6.568	5.231	2.545	5.261	47493.967	392.333	8.329	Yes/Reintroduced	5
322	5.181	2.595	4.456	48260.750	469.333	10.439	36.875	11.812	5.013	2.678	5.361	45516.000	591.125	13.771	No	6
323	5.462	2.508	3.667	50876.400	365.733	4.094	49.600	16.874	4.821	2.801	6.292	43773.600	800.000	17.706	No	5
324	4.917	2.758	5.412	45796.875	646.000	14.143	19.813	6.046	5.178	2.584	4.954	47011.750	508.938	7.667	No	2
325	6.146	2.147	2.769	57246.429	141.143	1.864	10.000	2.564	5.610	2.411	3.634	50942.467	338.133	4.148	Yes/Reintroduced	2
326	5.079	2.660	5.013	47309.438	549.625	7.847	27.404	5.333	5.262	2.540	4.510	47776.231	443.981	10.790	Yes/Reintroduced	6
327	4.955	2.714	4.576	46151.300	414.800	2.506	9.175	1.662	5.295	2.515	4.221	48075.300	323.325	3.648	No	2
328	5.644	2.369	2.935	52568.905	275.143	7.035	5.154	1.087	5.297	2.509	3.807	48094.692	313.769	2.054	No	2
329	5.138	2.625	4.250	47860.200	353.475	3.552	13.321	3.921	4.931	2.712	5.404	44774.571	588.893	4.913	No	8
330	5.168	2.598	4.688	48135.088	281.382	6.058	12.875	2.635	5.650	2.313	3.853	51304.225	79.025	5.566	No	8

MNA2	AR_MD	AR_GI	AR_LI	AR_TD	AR_LD	AR_Inte	NH_Conn	NH_Cont	NH_MD	NH_GI	NH_LI	NH_TD	NH_LD	NH_inte	Outlier	Cluster
331	5.528	2.387	3.847	51494.575	80.225	5.394	12.175	2.724	6.048	2.183	3.275	54916.246	183.895	5.576	Yes/Reintroduced	7
332	5.920	2.255	3.276	55140.965	190.140	5.446	14.895	5.016	5.205	2.560	4.225	47261.105	472.895	5.819	No	4
333	5.434	2.458	3.947	50621.600	304.350	5.086	8.000	2.081	5.524	2.402	3.338	50160.645	155.548	3.331	No	6
334	4.803	2.818	5.497	44739.893	648.929	4.994	30.000	9.826	4.913	2.731	5.768	44609.889	664.222	10.985	No	2
335	4.706	2.901	6.382	43839.600	886.200	18.273	13.650	4.641	5.175	2.568	4.484	46984.600	462.250	5.315	No	2
336	5.064	2.650	4.553	47167.200	501.000	5.473	4.684	1.335	6.529	1.944	2.621	59283.342	52.421	2.410	No	2
337	4.801	2.898	4.467	44719.000	690.923	9.769	27.737	4.456	5.073	2.673	5.458	46061.934	706.684	10.378	No	3
338	5.190	2.586	3.823	48348.923	323.308	1.993	27.692	8.967	4.927	2.789	4.452	44735.000	651.539	9.931	No	2
339	5.093	2.642	4.285	47438.211	510.632	5.976	4.000	1.088	6.247	2.093	2.764	56723.286	137.571	1.911	No	1
340	4.807	2.820	5.845	44773.111	723.889	11.310	8.298	1.777	6.149	2.108	3.842	55832.511	163.234	3.936	No	2
341	5.606	2.371	3.565	52220.980	282.000	3.477	12.350	2.452	5.561	2.377	3.937	50494.950	293.950	5.196	No	3