WATERLOO INSTITUTE
for COMPLEXITY
& INNOVATION

URBAN
GROWTH
& CHANGE
RESEARCH
GROUP

Conference on Modelling Complex Urban Environments

June 21-22, 2018

St. Jerome's University Academic Centre – SJ2
University of Waterloo, Canada

Schedule at a Glance

Thursday June 21, 2018 - Day 1			
8:30-9:00 AM	Coffee and Opening Remarks		
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10:20-12:20 PM	Session 8 (1002)	Session 2A (2002)	Session 4 (2003)
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1:30-2:30 PM	Keynote 2: Geoffrey West (1002)		
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3:00-5:00 PM	Session 7 (2002)	Session 9 (1002)	Session 3 (2003)
5:00-6:00 PM	Poster Presentations/Reception (Atrium)		

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1:30-2:30 PM	Keynote 4: Pamela Robinson (1002)	
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Keynote Details, June 21

Keynote 1: Hedwig van Delden, Research Institute for Knowledge Systems (RIKS), Netherlands
June 21, 2018; 9:00-10:00 AM; Location: 1002

Can complex systems modelling provide support to policy?
Abstract: The world we live in is complex and ever-changing. While the academic world is trying to unravel and simulate the complexity of our society and its drivers of change, there is also the realisation that we will need to accept living in and operating on a system we only have limited understanding of. With this acceptance comes the need for adaptive planning and policy-making to deal with a changing environment. Tools and techniques to support understanding possible future developments and assessing the impact of potential policy portfolios under a range of external conditions have great potential in the planning and policy practice. Nonetheless the adoption of those systems remains a challenge. A frequently heard complaint in literature is the complexity of the models. But is it really model complexity that is the problem in this case? This presentation will focus on lessons learnt over the past decades, applying complex systems modelling in planning and policy practice. It will cover the challenges in integrating socio-economic and biophysical processes and in linking scientific model to policy-relevant information. It will furthermore discuss how models designed for exploring future developments can be used in conjunction with narrative scenarios developed in a participatory process and emphasize the importance of sensemaking in obtaining our original goal: bringing scientific knowledge, tools and techniques into the policy practise.

Keynote 2: Geoffrey West, Santa Fe Institute, United States
June 21, 2018; 1:30-2:30 PM; Location: 1002

Growth, Innovation, Economies of Scale and the Accelerating Pace of Life: Developing a Quantitative Science of Cities, Companies and Sustainability
Abstract: Why do all companies and people die whereas cities keep growing and the pace of life continues to accelerate? Why do we stop growing, sleep 8 hours a day and live of the order of 100 years? And how are these related to innovation, wealth creation, social networks, urbanisation and global sustainability? Global urbanisation has emerged as the source of the greatest challenge the planet has faced since humans became social. Cities are simultaneously the hubs of innovation, engines of wealth creation and centers of power, but are also the prime source of crime, pollution, disease, climate change and the consumption of energy and resources. Despite this dual role and the threat to global sustainability, there is no integrated, quantitative, predictive, scientific framework for understanding their dynamics, growth and organization. Ideas for developing such a theory, inspired by a network-based framework for understanding diverse properties of organisms (such as growth, metabolism, cancer, sleep, aging, death, and ecosystems) will be discussed and extended to companies. Despite their extraordinary complexity and diversity, many characteristics of cities and companies, including wages, patents, assets, sales, diversity, crime, police, disease, pollution, and infrastructure, scale systematically and predictably with size suggesting that universal principles that transcend history, geography and culture underlie their dynamics and structure. This has dramatic implications for growth, development and long-term sustainability: left unchecked, innovation and wealth creation that fuel socio-economic systems potentially sow the seeds for collapse.

Session Details: June 21 – 10:20-12:20

Session 8: Identifying the Modelling Needs of Policy Makers and Practitioners
Organizer: Dawn Parker
June 21, 2018; 10:20 AM-12:20 PM
Location: 1002
Description: This interactive session invites discussion between academic modellers and urban policy makers and practitioners. We invite policy makers and practitioners to present questions that they might wish to investigate with models, their data sources, models they have developed in-house, and their wish lists for additional modelling and analysis. Following these presentations, a moderated discussion will explore further opportunities for collaboration, data and model sharing, and co-design/development of models between academics and practitioners.

10:20-10:30
Contemporary Challenges at MPAC: Equitable data acquisition, maintenance, and application
Author: Russel Enns (MPAC); Robert Babin (MPAC)
Abstract: The Municipal Property Assessment Corporation (MPAC) represents the largest property assessment jurisdiction in North America, responsible for the classification and valuation of over five million properties across Ontario. The ability to develop well-performing valuation models is highly dependent on the quality of data that goes into them. One of the largest challenges at MPAC is maintaining existing internal data and establishing protocols for the systematic ingestion and equitable application of new data sources. MPAC maintains the most comprehensive dataset of property characteristics in the province; however, the ability to capture and validate data, especially pertaining to the interior of buildings, is limited by the increasing desire of homeowners for privacy. While the amount of open data provided at the municipal level has been increasing over time, the quality and availability of these data are not standard across the province. To ensure that valuation at MPAC is completed equitably, data must be collected in a systematic, standardized fashion with ongoing feeds of updates as the data changes.
Keywords: Property Assessment, Valuation, Data, Equity

10:30-10:40
Monitoring Change in the Central Transit Corridor (CTC)
Author: Tristan Wilkin (Region of Waterloo)
Abstract: In 2011 The Region of Waterloo committed to implement Light Rail Transit (LRT). From the beginning, the Region has recognized the importance of monitoring change in the Central Transit Corridor (CTC) over time. ION, the new rapid transit system, will do more than just increase transit access throughout the Region. It creates an opportunity to build healthy and vibrant communities along the route. The CTC monitoring program will monitor the corridor from the baseline year of 2011 until at least 2021, after ION has been constructed, opened for service, and is functioning within the community. With an objective to quantify ION's benefits in moving people and building community within the CTC, sixteen baseline indicators were selected and, where data permits, are monitored annually. Themed indicators are selected each year to provide a more comprehensive lens for monitoring CTC activity by presenting selected dimensions in a more robust way. The Region of Waterloo entered a partnership with the University of Waterloo to engage in a three-year study to quantify, monitor and measure socioeconomic, and core-area intensification impacts of ION on the CTC in order to explore and understand the causal dynamics of these changes. The research intends to link connections between indicators of economic success and social equity to socio-economic and urban infrastructure changes in the Region. The key outcome of the UW researchers' contribution to the

project will be an improvement on traditional assessments of public interventions and quantified correlations amongst conditions before and after government actions.
Keywords: monitoring change, transit corridor, intensification

10:40-10:50
Smart Cities: Addressing Community Challenges Through Collaboration and Technology
Author: Matthew Chandy (Region of Waterloo)
Abstract: The municipalities of Waterloo Region have come together to apply to the Government of Canada's Smart Cities Challenge. The Smart Cities Challenge encourages communities to leverage technology and data solutions to overcome their most pressing challenges. The Phase 1 application, submitted April 24, 2018, focuses on the identification of a community challenge area based on community engagement. Finalists will be announced in the summer of 2018, with a top prize of $50million. Waterloo Region's approach to the Smart Cities Challenge is uncommon in that potential challenge areas were identified through community generated quantitative data and extensive community input through a local initiative to further advance a more integrated, holistic approach to community wellness/wellbeing. Out of this initiative three areas of focus were identified: Affordable Housing; Healthy Children and Youth; and Social Inclusion. Using this research and input as a starting point, further public consultations, and discussions with not-for-profits and technology companies helped identify Healthy Children and Youth as the community challenge area of focus. Matthew Chandy, Manager for the Office of Economic Development and Smart Cities Team Lead for Waterloo Region's Phase 1 application, will describe the application process and how Waterloo Region is creating connected technology and data solutions to support child and youth wellbeing in the community by enhancing early childhood development, literacy, mental and emotional health, sense of belonging, bullying, and high school graduation rates.

10:50-12:20
Feedback and discussion

Session 2A: Social-Ecological Networks in the City
Organizer: Jeremy Pittman and Carrie Mitchell
June 21, 2018; 10:20 AM-12:20 PM
Location: 2002
Description: This theme focuses on conceptual and empirical models of three interrelated patterns that characterize cities as complex social-ecological systems: (1) social interactions that occur across cityscapes; (2) ecological interactions across cityscapes, and (3) social-ecological interactions, or how people relate to key features of their urban environments. These various aspects, individually and collectively, have demonstrated impacts on sustainability of a broad range of rural/non-urban systems. Our intent is to bring together diverse urban scholars working on one or all of these different components, with the hopes of fostering meaningful dialogue and integration towards understanding the role of social-ecological networks in urban sustainability.

10:20-10:40
Integrating spatial networks and agent-based modelling for representation of forest insect infestation in urban landscapes
Author: T.M. Anderson (Simon Fraser University); S. Dragicevic (Simon Fraser University)

Session Details: June 21 – 10:20-12:20

Abstract: The representation of complex ecological systems as *aspatial networks*, i.e. food webs, pest-parasitoid webs, and mutualistic webs, provides insight into their organization and function. Recently, *spatial networks* are leveraged in the form of landscape connectivity networks, composed of geolocated habitat patches that link together as a function of the maximum dispersal distance of the species of interest. Landscape connectivity networks are used to understand dispersal patterns and how these patterns respond to changes in landscape structure and connectivity. However, landscape connectivity networks are mostly limited to static representations at the larger landscape-scales and do not account for complexity in dispersal processes where the emergent structure and evolution of network structure is a function of dispersal dynamics at smaller scales. The main objective of this research study is to develop a modelling approach that integrates network theory and agent-based modelling (ABM) for the representation of a dynamic dispersal network of the emerald ash borer (EAB) forest insect infestation in an urban setting. The proposed Network-ABM (N-ABM) generates dynamic spatio-temporal patterns of EAB spread together with the spatio-temporal EAB dispersal network using geospatial datasets of the urban forest environment from the Town of Oakville, Canada as a case study. Graph theory measures are used to characterize the N-ABM simulation results to provide insight into the dynamics of the EAB dispersal and spatial network structure in the urban landscape. The proposed model can be useful for urban forest management as it is capable to identify important EAB dispersal pathways and habitat features.
Keywords: Networks; Agent-based modeling; Forest insect infestation; Urban forest management, Geographic information systems

10:40-11:00
Comparing Social Capital and Spatial Use Patterns in Urban Environments
Author: Milton Friesen (University of Waterloo)
Abstract: This paper utilizes the results of a new social capital measurement instrument (Social Capital General Social Survey – SCGSS) developed for neighbourhood scale measurement of citizens social network and trust levels. Understanding and reliably quantifying social infrastructure at this scale is becoming increasingly urgent and this exploratory paper extends our knowledge of those dynamics. The survey instrument is paired with Global Positioning System (GPS) data to measure spatial behaviour of a random sample of participants (n=97) across three East Hamilton Census Tracts differentiated by income – median (Rosedale) and a standard deviation above (Delta) and below the median (McQueston) for adults aged 18-64 years. The spatial statistics of the GPS data are analyzed and summarized in ArcGIS for comparison with the SCGSS data collected from the same participants to determine the validity of the central hypothesis that greater movement in the urban environment correlates with higher levels of social capital. The comparative data are analyzed using linear regression (LM), random forest (RFM) and principal component analysis (PCA) in an R environment and the results are summarized.
Keywords: social capital, social networks, spatial statistics, social infrastructure, GPS

11:00-11:20
Modeling Avian Patch Networks in Dense Urban Settings
Author: J. Cameron Parkin (University of Waterloo)
Abstract: This research focuses on the movement and accommodation of avian and other vagile species through patch networks in dense urban fabric. The goal of this research is to analyze and visualize existing urban patch networks in order to inform the location, strategy, and composition of interventions in the urban fabric. These interventions are designed to promote urbanite-fauna interaction, which has potential to increase city dwellers' environmental stewardship, and benefit their psychological well-being. In order to manage the inherent complexity of negotiating urban and ecological systems in the dense downtown core, digital methods of modelling networks are borrowed

from landscape ecology, graph theory, and parametric architecture. Computational workflows are created to simulate two dimensional and three dimensional agent movement within patch networks, populate these networks with bird sighting data, and use this information to locate and inform a variety of intervention typologies.
Keywords: Ecology; Urban Ecology; Ecological Data; Ecological Networks; Computational Design

11:20-11:40
A Green Infrastructure Spatial Planning model for evaluating ecosystem service tradeoffs and synergies in three coastal megacities
Author: Sara Meerow (Arizona State University)
Abstract: A growing number of cities are expanding green infrastructure to foster resilience. While these nature-based solutions are often promoted on the basis of their multifunctionality, in practice, most studies and plans focus on a single benefit, such as stormwater management. This represents a missed opportunity to strategically site green infrastructure to leverage social and ecological co-benefits. To address this gap, this paper presents the Green Infrastructure Spatial Planning (GISP) model as a tool for identifying and comparing spatial tradeoffs and synergistic 'hotspots' for multiple benefits in three diverse coastal megacities: New York City, Los Angeles (United States), and Manila (Philippines). Spatial multi-criteria evaluation is used to examine how strategic areas for green infrastructure development across the cities change depending on which benefit is prioritized. Preliminary GIS layers corresponding to six planning priorities (managing stormwater, reducing social vulnerability, increasing access to green space, improving air quality, reducing the urban heat island effect, and increasing landscape connectivity) are mapped using existing datasets and spatial tradeoffs assessed. Criteria are weighted to reflect local stakeholders' priorities as determined through surveys and stakeholder meetings, and the combined results visualized. While additional model improvements are clearly needed, preliminary results empirically illustrate the complexities of planning green infrastructure and urban resilience more generally.

11:40-12:00
Community engagement with green infrastructure as a mechanism to promote urban resilience
Author: Kirsten Schwarz (Northern Kentucky University); Dustin L. Herrmann (University of Cincinnati)
Abstract: Green infrastructure is a mechanism for promoting urban resilience through its social and ecological benefits, but its potential to confer resilience may depend on the level of community engagement in the design, implementation, and maintenance of such projects. We use a case study of a community-engaged green infrastructure project in northern Kentucky as well as an emerging framework, Ecology for the Shrinking City, to examine the potential role of community engagement in building urban resilience. A central tenet of resilience is the ability to "return to desired functions in the face of disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity" (Meerow et al. 2016). Resilience, therefore, is a goal only attainable through sustained effort and investment. When green infrastructure projects are implemented with little input from the community in which they are embedded, they not only miss an opportunity to develop environmental stewardship but may impact the long-term ability of a community to respond to disturbance in a way that promotes urban resilience. Understanding the role of community engagement in building urban resilience is especially important in shrinking cities and areas of concentrated disinvestment, as vacant lands represent places of potential social-ecological transformation.

12:00-12:20
Feedback and discussion

Session Details: June 21 – 10:20-12:20

Session 4: Artificial Intelligence & Optimization Models in Urban Environments
Organizer: Jorge Garcia
June 21, 2018; 10:20 AM-12:20 PM
Location: 2003
Description: Artificial Intelligence (AI) may provide decision-makers with tools to combine, interpret, and extract rules from data generated by different information systems. Detecting lifestyle patterns, anticipating problems, identifying areas of risk, analyzing collective real-time data, and classifying populations are some of its potential benefits. These techniques can potential provide decision support for cities striving to efficiently allocate scarce resources. More and more companies opt for using AI in their operations, so it is likely we will see more AI applications for urban environments. Optimization techniques are excellent decision-making tools for well-defined linear deterministic problems; however, when we have uncertainties in parameters, nonlinear relations, multiple agents, or multiple relations we may opt for either using a more sophisticated model (or set of models) or simplifying the real problem. In the context of urban environments, there are many problems that need proper planning and efficient allocation, and here optimization may play an important role. We invite presentation of novel optimization applications for complex urban environments. This session is devoted to the application of AI or Optimization models applied to urban problems including:
- urban planning
- transportation
- healthcare
- waste management
- resource allocation
- population dynamics
- public services

10:20-10:40
Land use planning and optimal subsidies
Author: L.M. Briceno-Ariasa (Universidad Tecnica Federico Santa Maria); F. Martinez (University of Chile)
Abstract: The urban planification is a complex problem involving the choice of a social objective for a built city, from which an optimal allocation of agents should be found as a market equilibrium with the help of some policy like subsidies. In order to find the optimal allocation and subsidies, we prove a fundamental result which asserts that any feasible allocation can be achieved as a market equilibrium by applying suitable subsidies, which can be computed even in the case with location externalities. This allow us to split the problem in two independent steps. First, we find the optimal allocation for a social objective and, second, we use the fundamental result to derive subsidies that reproduce the optimal allocation as a market equilibrium. The computation of the optimal allocation is obtained from a convex optimization urban planning problem applicable to a wide class of objective functions. Optimal subsidies can be obtained even when the policy maker seeks to reduce the impact of the policy, or faces implementation constraints, e.g., some agents or zones can not be subsidized or taxed, or in some specific zones the budget for subsidies is limited. As an example, we simulate a small city which aims at improving social inclusion.
Keywords: convex optimization; land use planning problem; location subsidies; urban segregation.

Session Details: June 21 – 10:20-12:20

10:40-11:00

Sharing or sparing? Optimising a virtual urban region to foster biodiversity and climate regulation

Author: Nina Schwarz (University of Twente); Falk Hoffmann (Helmholtz Centre for Environmental Research UFZ); Michael Strauch (Helmholtz Centre for Environmental Research UFZ); Sonja Knapp (Helmholtz Centre for Environmental Research UFZ)

Abstract: Similar to the land sparing versus land sharing debate for agricultural landscapes, urban scientists discuss the pros and cons of different urban forms, i.e. the spatial layout of cities and use intensities, under the terms of "compact city" or "smart growth" and urban sprawl. While a compact urban development is often assumed as the goal to strive for, more scattered built-up and green areas in cities could be beneficial for some ecosystem services provided by urban green spaces, especially if close proximity between residents and urban green spaces is required. Thus, in this paper we optimise the spatial layout of a virtual city regarding two objectives, namely biodiversity, operationalised as species richness of vascular plants, and one ecosystem service, local climate regulation. We derived both underlying models from empirical findings and employed a multi-objective genetic algorithm. In this paper, we present preliminary results regarding the spatial arrangement of urban green spaces, low-density residential and high-density residential areas. Also, we discuss challenges we faced when choosing an appropriate spatial extent and resolution and when setting up simple models to be used during optimisation based on complex results from empirical studies.
Keywords: optimisation; biodiversity; climate regulation; virtual landscape

11:00-11:20

Comprehensive Schedule Optimization in Construction Using Constraint Programming

Author: Zinab Abuwarda (University of Waterloo)

Abstract: Delays and cost overruns are common facts in construction projects due to its increasing complexity, the day-to-day dynamic changes, the stricter execution constraints, and the general lack of efficient scheduling tools to support the optimization of construction plans. Currently, many scheduling tools and techniques are available, in addition to a large body of literature that focus on schedule optimization. Such tools and techniques, however, do not adequately represent or incorporate various practical decisions and constraints, nor provide the project manager with the ability to examine the combinations of actions in order to either plan or bring the project back within the constraints. In this paper, the schedule optimization research is enhanced by efficiently modeling real-life decisions and constraints, and develops a framework to optimize planning and corrective-action decisions; dynamically before and during construction. The development of the proposed framework starts with a basic model that suits the schedule optimization decisions at the preconstruction stage. This model is then extended to a generic model that accommodates the dynamic schedule optimization needs during construction. The enhancements and extensions are formulated in a generic mathematical formulation to optimize the schedule's decisions at any stage. This formulation integrates a wide range of scheduling options (e.g., linear crashing, activity multimodes, overlapping, and multipath networks), and incorporates the project manager's preferences about the corrective-action decisions' implementation. The formulation also considers a variety of practical constraints (e.g., variable resource availability, correlated modes, and intermediate milestones); and uses a multi-objective optimization to tradeoff among the project time, cost, resources, and permissible schedule changes during construction. Based on the mathematical formulation, the proposed framework was then coded using the advanced constraint programming tool "IBM ILOG CPLEX Optimization Studio". To validate the model, multiple experiments on four case studies were used to prove the functionality, practicality, and its better representation of real-life construction challenges. Two of these case studies are taken from the literature to prove the ability of the comprehensive model to achieve better solutions. Construction experts were also consulted at multiple stages of this work to investigate the relevance of the

framework. Introducing the proposed framework as an add-on to standard project management software is expected to change the practitioners' perception that optimization is a theoretical and complex tool. Therefore, it helps to present optimization as useful decision support and cost-benefit analysis tools for construction scheduling.

Keywords: Construction Management, Scheduling, Constraint Programming, Multi-Mode Resource-Constrained Scheduling, Constrained Resource Scheduling, Schedule Optimization

11:20-11:40
Bayesian Algorithm to Estimate Travel Times in Road Networks
Author: Jorge A. Garcia (University of Waterloo); K. Ponnambalam (University of Waterloo)
Abstract: The use of Advance Traveller Information Systems (ATIS) aim at improving the performance of a road network as well as improving drivers's decision-making in regard to route selection. Having accurate information about current travel times is essential for drivers to decide the route to follow according to their preferences and risk aversion. In this study we developed an algorithm for updating states of road segments using the information of current vehicles traveling on the road network, such algorithm includes a diffusion term to account for the deterioration of information over time. Drivers are supplied with estimates from the Bayesian algorithm and they choose the route to follow by optimizing a utility function that includes individual and social gain and a risk aversion component. We compared the results from the simulation against solutions obtained from an optimization model of the same system. We also measured the efficiency achieved in the road network by using the Bayesian algorithm. Finally, we created and tested an online learning procedure to let drivers remove any bias coming from the Bayesian algorithm.

11:40-12:00
Network Accessibility, Urban Form, and Diminishing Value in the Volumetric City
Author: Christopher D. Higgins (The Hong Kong Polytechnic University); Darren Nel (The Hong Kong Polytechnic University), Gerhard Bruyns (The Hong Kong Polytechnic University
Abstract: Traditional urban economic models of the city postulate that the price and development intensity of land is a function of its accessibility. This accessibility has typically been estimated from both the topographical and topological perspectives. However, the complexity of higher-density "volumetric" cities requires new methods and techniques for estimating accessibility and its link to urban form and value. Volumetric cities feature multiple modes of movement and stacked layers of activities above and below ground with a particular emphasis on pedestrian networks. Moreover, variation in the relationship between these layers of activities and the ground presents additional complexity when considering pedestrian connectivity and the ease of movement in cities with varied terrain. In response, this work applies a new suite of hybrid network-geographic volumetric spatial analysis tools to the case of Hong Kong. In the first step, these tools are used to estimate accessibility measures that capture spatial proximity to opportunities for interaction considering the city's built and natural morphological forms. In the second step, we utilize these measures to evaluate the value of property in the Hong Kong context. Although early in this research program, preliminary analyses show that accessibility is generally positively reflected in property prices. However, the highest densities are associated with a negative price effect. In this sense, our work suggests there may be a point at which the compact, 3D city becomes overwhelming.

12:00-12:20
Feedback and discussion

Session Details: June 21 – 3:00-5:00

Session 7: Measuring, Modelling and Interpreting Scaling/Power Laws in Urban Systems

Organizer: Fatemeh Jahanmiri
June 21, 2018; 3:00-5:00 PM
Location: 2002
Description: Technological advancements in the collection and analysis of "big data" have led to the identification of scaling and power law models in urban systems, including the distribution of population, size of buildings and parcels, length and structure of infrastructure, firm size and income among many more. Interpretations of these models are dispersed coming from frameworks of multiple disciplines including physics, economics, sociology and geography. This session aims to highlight the latest findings in this area and distill to converge to a unified theory that is comprehensible and useful for generalist city scientists. Session goals include exploration of advancements in models that link patterns to processes based on the universal scaling laws. We also invite novel application ideas that use scaling concepts to advance urban planning policy and practice.
Potential topics include:
- Review, comparison and classification of power law models in urban systems;
- Latest techniques in measuring and analyzing scaling pattern in various data types and the resulting urban metrics;
- Hypotheses/ models of the origin of scaling in urban systems and their resulting theoretical frameworks;
- Challenges in interpretation of power law models and the effects of multidisciplinary contexts;
- The latest applications of power law models in urban policy and practice, including gaps and obstacles;
- The application of fractal theory in urban scholarship and planning;
- Comparison between the effects of different organizational models and the fractal structure in human agglomerations;
- Scaling process in urban systems and the effects of digital infrastructure and globalization on such processes.

3:00-3:20
Combining polycentricity and urban scaling to explain socio-economic variables
Author: Amin Khiali-Miab (PLUS Zurich); Maarten J. van Strien (PLUS Zurich); Kay W. Axhausen (PLUS Zurich); Adrienne Gret-Regamey (PLUS Zurich)
Abstract: Recent studies predict that 75 percent of people will be living in cities by 2030 (Triantakonstantis and Mountrakis 2012). This fast urbanization process and an increasing per capita utilization of resources, raises serious concerns about the resilience and future performance of socio-economic systems. In order to ensure sustainable growth of settlements, requires a good understanding of the way in which settlement patterns affect socio-economic processes. This knowledge will allow us to predict the future performance of settlement areas (Czamanski 2008, Ernstson, van der Leeuw et al. 2010, Grêt-Regamey, Celio et al. 2013). Meijers (2006) and Bertaud and Malpezzi (2003) show how studying the spatial structure of settlement networks can reveal the economic performance and transitions of these networks. In general, it is believed that settlement networks are formed by the combination of two processes. The first process is the bottom-up self-organisation of settlement systems which results in the universal scaling-law in settlement systems. The second process is the top-down regulations which are set by regulations, policies or environmental conditions of a region (Strano and Sood 2016). A large amount of research has been done to understand bottom-up self-organisation

of settlement systems (Lämmer, Gehlsen et al. 2006, Deville, Song et al. 2016). Based on these studies a unified theory of urban scaling can be suggested (Bettencourt and West 2010). However, deviations from the universal scaling-law in settlement areas have been reported (Bettencourt, Lobo et al. 2010, Strano and Sood 2016). The reason for these deviations is still an open question in this research area. Theoretical and empirical studies in the field of landscape planning showed that polycentricty, which refers to the existence of multiple centers in the organisation of settlement areas, is associated with the higher efficiency (Meijers and Burger 2010), increased territorial cohesion (González-González and Nogués 2016) and consequently the higher performance of settlement areas. Polycentricity has become a normative planning goal in many top-down spatial development plans at global, European and national scales. Recent advances in complex network science can provide indicators to assess polycentric network structures. For example, in previous research we have shown that the structural hierarchy indicators (e.g. GRC: Global reaching centrality) is a good approximate measure of polycentricity in settlement networks (Khiali-Miab, van Strien et al. 2017) Here we show that GRC can also be used to explain deviations from the scaling law. Making use of a linear regression model ($R2 = 0.77$), we show that the combination of scaling law and hierarchical structure of settlement networks can be used to predict the median income in settlement areas in Switzerland. These findings provide spatial planners with quantitative methods that can aid them to determine whether settlement development moves towards a socio-economically efficient state.

3:20-3:40
Urban scaling: A Bayesian panel data approach
Author: Carlo Bottai (University of Turin); Consuelo R. Nava (University of Aosta Valley)
Abstract: The role of cities for socio-economic development have attracted an increasing popularity in recent years, so that urban scaling is become a urgent topic of analysis. Our contribution focuses on the European OECD FUAs development [Bettencourt and Lobo, 2016]. We estimate their nonlinear agglomeration and scaling effects by comparing their population size with key aggregate variables, like urbanized area size, number of granted patents, total employment level and GDP. Indeed, several contributions have characterized cities as the emergent property of a Complex Adaptive System. Accordingly, the relationship between their size and many macroscopic variables turns out to be describable by power-law distributions [Bettencourt and West, 2010]. This suggests that general scale-free laws may govern cities agglomeration dynamics, while geographical, historical and cultural features play only a secondary role [Bettencourt et al., 2010]. Compared to the previous literature, in the paper temporal dynamics and Bayesian methods are, to our knowledge, jointly exploited for the first time in this framework, in order to obtain more robust estimates and policy implications. We assess scaling parameters consistency across nations and over time, by taking advantage of a panel data approach. In that way, we overcome small sample size drawbacks, also obtaining more accurate estimates. We suitably specify the econometric model to deal with variable endogeneity and we add time-specific random effects, modeled with a Bayesian method. Both city-specific fixed and random effects are considered as a way to estimate the under- or over-performances of each metropolitan area, relative to expectations for their size.
Keywords: Urban scaling; Panel data; Bayesian inference; European metropolitan areas

3:40-4:00
A microeconomic explanation of cities' scaling laws
Author: Francisco J Martínez (University of Chile)
Abstract: The empirical evidence of scaling laws in cities as universal regularity (Bettencourt, et al., 2007, 2008) has been followed by several models searching for a theoretical explanation of this phenomena, most them based on models from physics. In Martínez (2016) I show that this law emerges

for land rents from the microeconomic assumption of rational agents with stochastic behavior. In this result, the extreme value distribution is a key assumption, which is theoretically justified in the context of a utility maximization. In this work, this initial result is further analyzed both theoretically and on its implications for cities evolution. Moreover, a new result is the emergence of scaling laws in the production of goods & services, regarding the industry type defined by its returns to scale, and in the labor market. These theoretical results consider open cities in a system of cities (e.g. a country), where migration leads to market equilibrium in the whole system. In sum, this work uses microeconomic principles –individuals' behavior and market equilibrium- and extreme value distributions of behavior, to build a theoretical model of the cities land use consistent with the emergence of scale laws on its economic variables.

4:00-4:20

Building a polycentric city from the bottom up: An agent-based modeling approach

Author: Fatemeh Jahanmiri (University of Waterloo); Dawn Parker (University of Waterloo) --via Skype

Abstract: Despite their differences, cities share basic properties that connect their building blocks in a power law order. Mathematical frameworks have been proposed to explain the origin of these regularities. However, the underlying chain of processes that is responsible for these patterns is yet to unveil. In our previous work, we have developed an agent-based model that generates power law distributed urban blocks from very basic dynamics. The model suggested that the complexity of urban physical form emerges from very basic human interaction processes that operate locally. In the present research, I extend our previous work by modeling endogenous evolution of urban density and the behavior of the model based on aggregation and segregation parameters. The simulation results indicate that polycentric patterns emerge in model landscape with spatial and statistical fractal properties. The results contribute to the theory of urban complexity by providing a possible explanation for the polycentric structure in cities and the link between the power law social and spatial profiles.

Keywords: Urban form, power law size distribution, fractal, agent-based model, polycentricity.

4:20-4:40

Towards an autopoietic interpretation of fractal dynamics in cellular automaton

Author: Martin Pham (University of Waterloo)

Abstract: Fractals are mathematical objects that exhibit self-similarity and scale-invariant complexity. Urban land use patterns have been shown to have a high degree of fractality. There exists a number of agent-based models to simulate these dynamics. Among these are cellular automaton (CA), a class of spatial models defined on a lattice whose evolution is determined at each cell simultaneously by a rule-based transition function depending only on the local neighborhood. Multi-state CA, where each state represents a type of land use, have been shown to exhibit the same bifractal structure as observed cities. The emergent structure is strongly dependent on a small regime of stochastic and deterministic parameters. In order to better understand these simulations, a more robust theory and interpretation of CA for urban modelling is required. This talk will present the outlines and challenges of developing an autopoietic theory of urban modelling. An autopoietic system is an ateleological unity whose components act to reproduce the relationships between themselves. The basic multi-state CA for urban land use modelling will be introduced to motivate the discussion of a simpler and well-known CA (The Game of Life) from an autopoietic perspective. The distinction between structure and organization will be explored, and the notion of structural coupling will be contrasted with polycentricity. The aim of this talk is to present a language that emphasizes a process-based interpretation of fractal dynamics.

4:40-5:00

Feedback and discussion

Session Details: June 21 – 3:00-5:00

Session 9: Learning Session - Data Visualization

Exploring Frontiers of High Resolution Dynamic Spatial Modeling to Support Decision Making in Complex Urban Systems
June 21, 2018; 3:00-5:00; Location: 1002
Presenter: Timon McPhearson (The New School); Daniel Sauter (The New School); Carson Farmer (University of Colorado Boulder); Rocio Carrero (The New School); Jaskirat Randhawa (The New School)
Description: In this Learning Session we aim to ignite a constructive and engaging discussion on the current frontiers and challenges on developing usable and transferable High Resolution Dynamic Spatial Models to support decision making in cities. Working on the interface of geo-computation, spatial modeling, machine learning and data visualization, our team has developed a flexible model that can be applied to different urban contexts and different purposes (e.g. green infrastructure analysis, vulnerability to extreme events, scenarios simulations). We have applied our model to cities such as New York (USA), San Juan, Puerto Rico, Valdivia (Chile) and Hermosillo (Mexico) and co-developed scenarios through local collaboration with practitioners and stakeholders. In the process we have confronted and (to some extent) solved multiple challenges from developing stakeholder engagement processes for scenario development, data limitations, need for flexible modeling options that we propose to share with peers in this Learning Session. Specifically, we propose to cover topics such as: data-driven models on data-scarce cities, pros and cons of machine-learning approaches, pseudo-customizable modeling environments online, integrating real planning into models, and approaches to visualizing indicator interactions and uncertainty. We will facilitate an interactive session were we will invite participants to explore the aforementioned topics while generating a discussion on how methods can be shared towards advancing understanding of complex urban systems. Insights will be captured via smart-phones surveys so the session collective 'knowledge outputs' can be shared with the conference attendants. We plan a collaborative publication as result from the learning in this session.

Session 3: Modelling and the Planning Process

Organizer: Jeremy Pittman
June 21, 2018; 3:00-5:00 PM
Location: 2003
Description: We solicit presentations that demonstrate the application of modelling within planning processes, including (but not limited to): (1) the use of simulation models to inform decision-making under uncertainty and (2) participatory modelling to guide public engagement and planning efforts. Presentations may cover a diversity of topics or applications (e.g., transportation, energy, sustainability), but must align with the general theme of demonstrating model application in real-world planning processes.

3:00-3:20

Institutional Emergence and the Persistence of Inequality in Hamilton, ON 1851-1861
Author: Milton Friesen (University of Waterloo); Srikanth Mudigonda (St. Louis University)
Abstract: Economic inequality in urban settings is a readily observable phenomena in contemporary cities but historical research reflects that the problem is not new. In this paper we argue that there are citizen level interactions and arrangements that contribute to the stability of a small group of wealthy citizens alongside a high degree of transience in the poor and populous part of the city. We develop an R coded agent based model that draws on citizen agency and economic dynamics revealed in a study of Hamilton, Ontario (1851-1861) by Michael Katz (1975). The Katz study drew on tax assessment, census

Session Details: June 21 – 3:00-5:00

and related formal documentation to establish economic, institutional and mobility citizen patterns across a ten year span. Our central hypothesis is that the wealthy citizens developed and had access to institutional resources that buffered negative externalities whereas the poor did not. In our Axtell and Esptein based model, a probability function leads to proto-institutions that emerge from agent interactions and thereafter produce greater stability, higher levels of wealth (sugar) and longer lifespans for their participating agents. The inverse is true for the agents who do not have institutional access.
Keywords: agent-based modeling, insitutional emergence, citizen agency, social evolution, inequality, urban policy, citizen transience

3:20-3:40
Application of System Dynamic modeling tool in sustainability assessment of water and wastewater asset management plans

Author: H. Mohammadifardi (University of Waterloo); M. A. Knight (University of Waterloo); A. J. A. Unger (University of Waterloo)

Abstract: The public infrastructures, specifically underground water and wastewater pipe network systems, are reaching their end of service life, and their replacement will need significant capital work. The government of Canada announced the $53-billion New Building Plan for rejuvenation of Canadian public infrastructure, the largest infrastructure investment in country's history. However, the accelerated rehabilitation and reconstruction of infrastructures will not happen without consequences on social, ecological, and economic systems through the choices taken in their asset management plans. The complexity of planning decisions is more compounded when planners realize that different economic, social, and environmental dimensions of the challenge are inherently interrelated. In fact, technological systems are noted to have the highest level of complexities, in which they interact with all social, natural, and economic systems (Halliday & Glaser, 2011). Complying with existing and changing regulatory policies and requirements, and development of socially acceptable, environmentally friendly and financially viable asset management plans calls for a comprehensive sustainability assessment. This paper, demonstrate the application of System Dynamic (SD) modeling and Life-Cycle Assessment (LCA) tool for sustainability assessment of municipal water and wastewater asset management plan scenarios.
Keywords: System dynamic modeling, Sustainability assessment, Life cycle assessment, Water and wastewater, asset management planning

3:40-4:00
Equitable Modes of Planning Practise for Urban Climate Resilience: A Case Study in Charlottetown, PEI

Author: Luna Khirfan (University of Waterloo); Hadi El-Shayeb (University of Toronto)

Abstract: The unpredictability of climate change impacts on urban areas cannot be ignored in order to avoid significant losses in the built environment, economy, and human health. Climate vulnerable cities require context-specific resilience plans, where natural and constructed systems are able to return to an original state (persist), respond (adapt), and reorganize (transform) in the wake of disturbance. Yet, the discussion on urban resilience cannot be given due process without the tethering of the ecological dimension, where blue and green natural elements are preserved and valued for their services. Furthermore, the singular emphasis on the expert at the expense of community knowledge of biotic and abiotic functions can render the design process void of context-specific and community value essential for creating climate resilience. In this paper, we underscore the socio-ecological elements of urban climate resilience by developing a theoretical framework that adapts the charrette, as a participatory design tool, to capitalize on local ecological knowledge (LEK) and attribute a local value system for blue-green design interventions. Thus, the framework is grounded in an interdependent triad of values including the design of the built form, blue-green interventions, and local knowledge transfer to action, to succeed transformative resilience. We apply this theoretical framework to Charlottetown, Prince

Session Details: June 21 – 3:00-5:00

Edward Island (P.E.I.), a city that is increasingly subjected to intense storm surges and sea level rise in Atlantic Canada, where a series of design charrettes integrated the LEK into urban climate resilience proposals.
Keywords: Urban Climate Resilience; Local Ecological Knowledge; Blue-Green Infrastructure; Transformation

4:00-4:20

Exploring Issues of fairness in the smart electricity grid using agent-based modelling

Author: Tristan de Wildt (Delft University of Technology)

Abstract: The smart electricity grid is key to the energy transition. By supporting the optimal alignment between power supply and demand, a wider range of new (green) technologies can be integrated into the electricity supply chain. While new opportunities for citizens are created, for example by allowing them to become 'prosumers', it may not be the case for all. Participating in electricity production indeed requires a minimum level of financial resources, education and a suitable living environment (among others space). Hence it may well be that the smart electricity grid will only increase existing socio-economic disparities between groups of citizens, thereby leading to justice and fairness issues. If not addressed during planning, public protests and political discussions may emerge that may hamper the deployment of these critical technologies. Our work concentrates on the identification of (future) injustices that the smart electricity may cause. We use the capability approach of Sen (1992) and Nussbaum (2001) as a normative framework to guide the assessment of the smart electricity grids' impact on individual well-being. As populations are heterogenous and connected through multiple social networks, we use agent-based modelling to take account of the multiplicity of (dynamic) ways in which individuals are positively and negatively affected by these technologies. Innovative elements of our work include the consideration of injustices in the smart electricity grid, which are still relatively unexplored, as well as a first conceptualization of the capability approach into an agent-based model. During the WICI Conference of Modelling Complex Urban Environments, the model will be introduced, and identified injustices, potential policies and implication for planning will be discussed.
Keywords: agent-based modelling, capability approach, scenario discovery, urban planning

4:20-4:40

A Systems-Oriented Vulnerability Approach to Flooding in Cave, Westmoreland

Author: Tracy-Ann Nicole Hyman (University of the West Indies); David Smith (University of the West Indies); Leonard Nurse (University of the West Indies)

Abstract: The Community of Cave is approximately 4.8 km² and lies just off the southeast coast of Westmoreland, Jamaica. It is approximately 12 km from the parish capital, Savanna-la-Mar, with major economic activities namely farming and fishing. Like many island eco-systems, Cave is prone to tropical cyclones that give rise to flooding. Of special note is the 1979 flood event, which caused significant damage to terrain, disruption to transportation systems and devastation to lives and property in Western Jamaica. The parish of Westmoreland experienced 31 of the 41 deaths, and many persons were trapped in their communities, unable to evacuate. Still today, there are limited rainfall gauges and no flood gauges, early warning systems nor an official evacuation shelter. With a 50-year return period, any recurrence of this type of flood in 2016, could be worse than in 1979. The overall aim of this research was thus to construct a basic simulation of a 1979 flood-like event assessing the vulnerability of stakeholders to flooding in 2016. This based on geographical considerations, flood characteristics and the movement patterns of residents – analyzed through the use of Agent-Based Models, Geographic Information Systems, and implemented with Netlogo software. Preliminary results reveal that possible loss of life takes place on each of the three days sampled, [1] with most fatalities on a Friday. The expected results from this research should guide local government in the appropriate citing for

Session Details: June 21 – 3:00-5:00

evacuation shelters, safe zones, along with implications for early warning and land use planning in South-East Westmoreland.
Keywords: Cave, flooding, agent-based model, evacuation

4:40-5:00
Feedback and discussion

Session Details: June 21 – 5:00-6:00

Poster Presentations

A Systems-Oriented Vulnerability Approach to Flooding in Cave, Westmoreland

Author: Tracy-Ann Nicole Hyman (University of the West Indies); David Smith (University of the West Indies); Leonard Nurse (University of the West Indies)

Abstract: The Community of Cave is approximately 4.8 km² and lies just off the southeast coast of Westmoreland, Jamaica. It is approximately 12 km from the parish capital, Savanna-la-Mar, with major economic activities namely farming and fishing. Like many island eco-systems, Cave is prone to tropical cyclones that give rise to flooding. Of special note is the 1979 flood event, which caused significant damage to terrain, disruption to transportation systems and devastation to lives and property in Western Jamaica. The parish of Westmoreland experienced 31 of the 41 deaths, and many persons were trapped in their communities, unable to evacuate. Still today, there are limited rainfall gauges and no flood gauges, early warning systems nor an official evacuation shelter. With a 50-year return period, any recurrence of this type of flood in 2016, could be worse than in 1979. The overall aim of this research was thus to construct a basic simulation of a 1979 flood-like event assessing the vulnerability of stakeholders to flooding in 2016. This based on geographical considerations, flood characteristics and the movement patterns of residents – analyzed through the use of Agent-Based Models, Geographic Information Systems, and implemented with Netlogo software. Preliminary results reveal that possible loss of life takes place on each of the three days sampled,[1]with most fatalities on a Friday. The expected results from this research should guide local government in the appropriate citing for evacuation shelters, safe zones, along with implications for early warning and land use planning in South-East Westmoreland.

Keywords: Cave, flooding, agent-based model, evacuation

Estimating Vehicle Emissions using Big Traffic Data

Author: Anjie Liu (University of Waterloo); Liping Fu (University of Waterloo); Mathew Muresan (University of Waterloo)

Abstract: As climate change and urban air quality become growing concerns around the world, there is greater need to quantify vehicle emissions. Vehicle emissions generate a significant portion of greenhouse gases. Since these emissions are influenced by traffic flow conditions, it is beneficial for traffic management professionals to have methods to estimate emissions in real time. Unfortunately, direct measurement of emissions from all road vehicles is both costly and impractical. However, emissions can be estimated through the relationships between emission generation and traffic flow. This poster will present a method to estimate emissions in real time using big traffic data. Traffic data from video cameras, Wifi detectors, and loop detectors at intersections are used to model the traffic flow along a road corridor. An emission model is developed to use the traffic flow as input to estimate the emissions generated. New sources of traffic data, such as vehicle tracking through video cameras using image processing, provide opportunities for improved traffic flow modelling and, subsequently, emission estimation. To calibrate and validate the emission estimation methods, a pre-validated simulation approach is taken. The traffic network is simulated in Vissim, a microscopic traffic flow simulator, and calibrated according to the traffic data. Outputs of the simulation are input into MOVES, an emission simulator developed by the Environmental Protection Agency US, to generate emission

estimates. These results serve as the ground truth used to evaluate the real-time emission estimation method.

Keywords: emission modelling; traffic data; traffic simulation; traffic flow modelling

A second order cybernetic perspective on urban modelling via fractal dynamics in cellular automata

Author: Martin Pham (University of Waterloo)

Abstract: Cybernetics is the science of describing goal-oriented systems and their feedback processes. Second order cybernetics, cybernetics applied to itself, is concerned with the description of observing systems; the observer is incorporated as an agent in the system. Fractals are mathematical objects that exhibit a high degree of self-similarity and scale-free complexity. Cellular automata are a class of discrete spatial models used to consider evolutionary phenomenon based on simple rules determining the state of each cell. Presented is a computational model to investigate the growth of urban forms and arising land use patterns. A multi-state cellular automaton coupled to logistic population growth is developed to simulate the spatial structure of urban land use. The simulated cities exhibit a bifractal dynamic that distinguishes the urban centre from the urban fringe. In parallel is a discussion of the system formed by model and model-maker with an emphasis on the parameters representing stochasticity and determinism as necessary for capturing urban dynamicism. The modelling process is viewed as an observing system. This raises political and epistemological questions regarding the use of computational models in governance.

Keywords: cybernetics, urban land use, cellular automata, fractals

Application of System Dynamic modeling tool in sustainability assessment of water and wastewater asset management plans

Author: H. Mohammadifardi (University of Waterloo); M. A. Knight (University of Waterloo); A. J. A. Unger (University of Waterloo)

Abstract: The public infrastructures, specifically underground water and wastewater pipe network systems, are reaching their end of service life, and their replacement will need significant capital work. The government of Canada announced the $53-billion New Building Plan for rejuvenation of Canadian public infrastructure, the largest infrastructure investment in country's history. However, the accelerated rehabilitation and reconstruction of infrastructures will not happen without consequences on social, ecological, and economic systems through the choices taken in their asset management plans. The complexity of planning decisions is more compounded when planners realize that different economic, social, and environmental dimensions of the challenge are inherently interrelated. In fact, technological systems are noted to have the highest level of complexities, in which they interact with all social, natural, and economic systems (Halliday & Glaser, 2011). Complying with existing and changing regulatory policies and requirements, and development of socially acceptable, environmentally friendly and financially viable asset management plans calls for a comprehensive sustainability assessment. This paper, demonstrate the application of System Dynamic (SD) modeling and Life-Cycle Assessment (LCA) tool for sustainability assessment of municipal water and wastewater asset management plan scenarios.

Keywords: System dynamic modeling, Sustainability assessment, Life cycle assessment, Water and wastewater, asset management planning

Keynote Details, June 22

Keynote 3: Alex Anas, University of Buffalo, United States
June 22, 2018; 9:00-10:00 AM; Location: 1002

Urban logistics: how delivery services, transportation network companies and autonomous vehicles add complexity to urban modeling
Abstract: We are seeing a rapid increase in delivery services and in the adoption of transportation network companies like Uber and Lyft, with autonomous vehicles lurking on the horizon. The address focuses on how these developments are and will be affecting the economy of cities and how the nature of personal travel, traffic congestion, labor and housing markets and land use and many other aspects of the urban economy will evolve in response. We will also address how these developments will impact the way we model cities and the techniques that should be used.

Keynote 4: Pamela Robinson, Ryerson University, Canada
June 22, 2018; 1:30-2:30 PM; Location: 1002

Canadian Smart Cities: What an innovation challenge tells us about our near future
Abstract: In the 2017 Federal budget the Government of Canada declared its intent to spark urban innovation with an eleven year, $300 million investment in the new Smart Cities Challenge (SCC– Government of Canada, 2017) with the short-listed cities recently announced. With over 130 Canadian communities entering, the submissions provide an intriguing hint at what roles our local governments imagine technology playing. In innovation challenges like the federal government's Smart City Challenge, most of the attention will be paid to the winners. However, there is value in examining the wider range of submissions to gain theoretical and practical insight into the full range of smart city activities (Robinson and Gore, 2015). This talk will consider the full set of submissions and focus on the following questions: how is the smart city imagined by communities in Canada? what roles might emerging technology play? and, what challenges and opportunities do we anticipate these projects might present? Drawing from examples in the Smart City Challenge submissions, this talk will conclude with a discussion of next steps to prepare for the near future in Canadian communities.

Session Details: June 22 – 10:20-12:20

Session 5A: Agent-Based Models of Housing
Organizer: Yu Huang
June 22, 2018; 10:20 AM-12:20 PM
Location: 2002
Description: This session will highlight cutting-edge research in the field of agent-based modelling of urban markets. It will also provide a forum for discussion and reflection on potential implications of model findings for current urban issues, such as housing market dynamics, labour market transitions, and urban growth and change. A special journal issue will be organized around the session, comprising contributions of leading agent-based modelling scholars in the field of urban economics, urban and regional planning and development, and geography. Suitable topics for the session presentations include any theoretical or empirical agent-based modelling on
> • land/housing markets (land development; housing market mechanisms and policies);
> • residential mobility, home search and location choices;
> • labour markets and wages (job search and mobility);
> • rental markets (rent control policies);
> • land-use/transport interaction;
> • and other markets nested in complex land-use change models

10:20-10:40
The impact of transport infrastructure on housing markets: An agent-based modelling approach
Author: A. Carro (University of Oxford); D. Farmer (University of Oxford)
Abstract: In this contribution, we study some of the main channels and mechanisms by which infrastructure has an impact on the economy. In particular, we focus on its effect on housing markets, housing being the largest asset class in the economy as well as one of its main drivers. To this end, we develop a spatial agent-based model of the housing market, based on a discrete set of districts or locations, each of them containing a non-spatial housing market model. This non-spatial model simulates a large pool of households with realistic demographic characteristics, life-cycles, and housing decisions. Among other aspects, the dynamics of both the ownership and the rental market are modelled in detail, including the buy-to-let sector. Furthermore, households are allowed to move between these different local markets in order to accommodate their different budget constraints while trying to stay close to their job locations, thus embedding the non-spatial models into a spatially distributed commuting network. As a case study, the model is calibrated against a large set of UK microdata from household surveys and housing market data sources such as the Financial Conduct Authority's (FCA) loan-level Product Sales Data (PSD) and the WhenFresh/Zoopla data on rental listings, as well as confidential data from the Bank of England. Once these microdata sources have been used to fine-tune household's individual characteristics and behaviours, a macro-calibration is performed to ensure consistency with different economic aggregates and housing market core indicators.
Keywords: agent-based modelling, spatial economics, housing markets, transport infrastructure, commuting

10:40-11:00
Agent-based housing markets in face of natural hazards
Author: Tatiana Filatova (University of Twente; University of Technology Sydney); Koen de Koning (University of Twente); Okmyung Bin (East Carolina University) *--via Skype*
Abstract: About 80% of population is to live in cities by 2050 according to the UN projections. Many of these cities are within coastal zone or within river floodplains, driven by agglomeration forces close to

historic locations. Yet, with climate change projections these developments become more prone to natural hazards, which are getting more severe and frequent. Combined with rapid urbanization, this leads to increasing risks for such a long-term asset as housing. Notably, flood zones are usually spatially correlated with rich environmental and urban amenities. Individual preferences for locations play a crucial role in the formation of spatial patterns and prices in urban land markets, and consequently potential damages. We apply an empirical agent-based housing market model, RHEA, to study how flood risks capitalize in housing prices. In particular, we model a bilateral trade between individual heterogeneous buyers and sellers of residential properties. Building upon previous research on agent-based modeling of urban land markets, we make a step forward towards empirical modeling by using actual hedonic analysis and spatial data for flood-prone areas in North Carolina, USA. Our agents differ in incomes and behavioral assumptions regarding risk perceptions. We explicitly model adaptive price expectations within a spatial agent-based model using actual housing transactions data. In this talk discuss a number of methodological steps required to move from stylized to empirical agent model of a housing market.
Keywords: hedonic analysis, agent-based market, risk perception

11:00-11:20
Exploring distributional influences on and effects of dynamic adaptive policy pathways for repeated coastal hazards
Author: Nicholas Magliocca (University of Alabama); Margaret Walls (Resources for the Future)
Abstract: The economic costs of coastal hazards have been increasing for decades, and future projections are only exacerbated by continued coastal economic growth and frequency and/or severity of coastal hazards. Policy interventions in the United States to discourage coastal development, preserve or reclaim coastal habitat, and/or decrease regional vulnerability to subsequent hazards have been largely ineffective. The urgent need for more effective adaptation policy has shifted the question from "what is the best policy" to "what is the best combination and sequence of policies" – a shift captured by the increasingly popular concept of adaptive policy pathways. However, accounting for the dynamic values and behaviors of heterogeneous coastal residents that affect, and are in turn affected by, coastal adaptation policies remains a challenge for the design and analysis of adaptive policy pathways. We present an agent-based model (ABM) of a stylized coastal region experiencing uncertain increases in storm frequency and severity, exogenous population growth, and endogenous socio-economic change. The ABM is used to investigate how the socio-economic characteristics and risk perceptions of a coastal population change over time in response to coastal hazards and alternative adaptation policies. The relative costs and benefits, effectiveness, and unintended consequences of a set of plausible adaptive policy pathways that focus on land use in coastal areas are evaluated and compared. While this model implementation is strictly exploratory, we illustrative its usefulness for isolating and identifying key trade-offs and specific pathways among policy options by accounting for the inherently dynamic and heterogeneous behaviors of coastal residents.
Keywords: Land-use change, housing markets, land markets, computational economics, computational social science

11:20-11:40
Modeling Buy-Seller in Housing Market—A Bidding Network Perspective to Understand Market Mechanism
Author: Ziye Zhang (Cornell University)
Abstract: This paper proposes an agent-based model (ABM) for housing markets including a new type of households who are both buyer and seller at the same time. Traditionally, economic models treat buyers and sellers in a dichotomic manner. However, housing markets witness many households buy

and sell at the same time (called "buy-seller"). According to my housing buyer survey in Beijing 2016, 45% are "exchange buyers", who are selling a housing unit while purchasing a new one. The essential feature of the buy-sellers is the interdependence between buying and selling decisions. As a buyer, a new purchase depends on a successful sale due to budget and policy restrictions; as a seller, a sale may rely on a success in bidding to avoid renting for living. This interdependence generates a bidding and transaction network, through which one household's success or failure in bidding or selling will trigger a ripple effect and influence all other connected households. This paper, for the first time, proposes an ABM to model buy-seller agents and the bidding network mechanism of urban housing markets. One challenge is to identify the loop pattern—one of the two potential transaction patterns in the network—in ABM. This paper provides a new algorithm for this identification and make it possible to run ABM with buy-sellers. Purchase restriction policies are interpreted as a shock converting some pure buyers into buy-sellers, and direct and indirect influences are examined in the ABM.
Keywords: Buy-Seller; Market Mechanism; Bidding Network; Housing Purchase Restriction; Agent-based Model

11:40-12:00
Unfolding housing market complexity: empirical housing market analysis and spatial agent-based modeling
Author: Yu Huang (University of Waterloo); Dawn Parker (University of Waterloo)
Abstract: The housing market in Kitchener-Waterloo (KW) has taken a surprising turn, with a 20.7% average sales price increase from 2016 to 2017. What has led to the housing price volatility and pre-LRT speculation in the region? How have changing demographics and location choice preferences influenced the market in this region? This study aims to interpret the recent market dynamics, unpack, if possible, the dominant factors, and build an empirical geo-computational housing market model. In contrast to conventional aggregated market analysis, this study takes individual preferences for housing and residential choice behaviour into account, so as to explain the market from bottom up. Accordingly, two approaches are proposed in our research, 1) a comprehensive housing survey and analysis; and 2) agent-based housing market modelling. The home buyer and seller survey has been distributed to home movers in KW and received 506 responses from 06/2015 to 04/2017. Taking advantage of our detailed micro-data from the survey, we propose to estimate the heterogeneous preferences among different households and their associated willingness to pay (WTP) for the houses by a demand analysis, adapted from Bajari and Kahn (2005). We then present simulations that highlight the added-value of an agent-based modeling approach, in terms of strong theoretical and empirical micro foundations for the behavioral rules of actions, interactions and learning of heterogeneous agents. Growing housing markets from the bottom up enhances our understanding of their complex dynamics and offers tools for the design of sustainable urban development strategies.
Keywords: housing market; agent-based modelling; computational economics; complexity

12:00-12:20
Feedback and discussion

Session 2B: Social-Ecological Networks in the City
Organizer: Jeremy Pittman and Carrie Mitchell
June 22, 2018; 10:20 AM-12:20 PM
Location: 1002
Description: This theme focuses on conceptual and empirical models of three interrelated patterns that characterize cities as complex social-ecological systems: (1) social interactions that occur across

cityscapes; (2) ecological interactions across cityscapes, and (3) social-ecological interactions, or how people relate to key features of their urban environments. These various aspects, individually and collectively, have demonstrated impacts on sustainability of a broad range of rural/non-urban systems. Our intent is to bring together diverse urban scholars working on one or all of these different components, with the hopes of fostering meaningful dialogue and integration towards understanding the role of social-ecological networks in urban sustainability.

10:20-10:40
Exploring Perceptions of the Western Cape Water Crisis through Social Network Analysis
Author: Kristi Maciejewski (Stellenbosch University); Paul K Currie (Stellenbosch University); Josephine Kaviti Musango (Stellenbosch University) --via Skype
Abstract: The Western Cape Province of South Africa is currently experiencing the worst drought in its recorded history. Like many cities in recent years, Cape Town is facing an existential threat to its economy and the wellbeing of its residents due the rapid reduction in water availability. Numerous demand-side-management and off-grid water supply interventions have resulted in an unprecedented reduction in daily water consumption, from 1.1 billion litres to near 450 litres, over just 24 months. The fundamental direct causes of the crisis, and of changes in water consumption levels, are as yet unclear. However, it is apparent that residents hold varied perceptions of: (i) the causes of the crisis; (ii) the contributions of different economic sectors towards water saving or over-consumption; (iii) how the crisis has been managed by the City and other stakeholders; (iv) the key institutions involved in communications or interventions; and (v) the efficacy of residents' own contributions to water saving at household and community level. Thus, the objective of this paper was to draw links between residents' perceptions of the crisis and their associated behavioural changes. This was achieved using Social Network Analysis, which was developed through a wide, convenient survey of key stakeholders, and which identified key events, campaigns, institutions and community members that initiated change and influenced human behaviour. The paper provides useful information for understanding how residents' perceptions could be influenced should future crises emerge.
Keywords: social-ecological system, drought, institutions, human behaviour change

10:40-11:00
Understanding environmental stewardship outcomes through the lens of social network analysis: towards a social-ecological network analysis
Author: Michelle Johnson (USDA Forest Service, Northern Research Station); Erika Svendsen (USDA Forest Service, Northern Research Station); Lindsay Campbell (USDA Forest Service, Northern Research Station); Lorien Jasny (University of Exeter)
Abstract: Social-ecological networks have emerged as a field of research to understand how social connectivity and ecological connectivity may interface and interact, but finding alignment of social-ecological connectivity for such analysis can be challenging in complex urban systems. However, governance social networks still have the potential to affect ecological conditions at multiple scales, regardless of ecological connectivity. The large number of individuals and organizations in cities result in complex networks; how these organizations together can affect ecological conditions has been theorized but have been empirically measured infrequently. In 2017, the New York City Stewardship Mapping and Assessment Project (STEW-MAP) collected survey-based data on environmental stewardship organizational networks, individual organizations' perceived outcomes, and other organizational-level characteristics of environmental stewardship groups. Here, we apply this social network dataset of urban environmental stewardship organizations to investigate how a social network can influence cumulative environmental outcomes in New York City. Beginning with perceived outcomes, we also consider available plot-level data on forest and wetland conditions and remotely-

sensed land use/land cover data, to gain an understanding of overall system changes. From this empirical analysis, we identify how perceived environmental outcomes relate to network structure and position, as well as overall ecological condition. We also identify the potential for future social-ecological network analysis in cities like New York, by identifying aspects of the larger urban social-ecological system where connectivity can influence both stewardship outcomes and ecological condition in a social-ecological manner.

11:00-11:20
Is climate change adaptation a public good?
Author: Sierra C Woodruff (Texas A&M University); Megan Mullin (Duke University)
Abstract: As the impacts of climate change begin to be felt across the globe – including more intense hurricanes and extreme wildfires - it is clear that adaptation is essential. The question remains, however, who is responsible? Insufficient attention has been dedicated to the identification of the providers and beneficiaries of climate adaptation. Specifically, we examine when adaptation is a public good. This information is critical to identify actors, design accurate models of adaptation, and create effective policy instruments. Climate change mitigation – reducing greenhouse gas emissions – is a classic public goods problem with implications for who engages in mitigation efforts and how. Many aspects of adaptation also have public good characteristics. The widespread, trans-boundary consequences of climate change pushes adaptation towards the public goods end of the conceptual continuum. However, there are significant "impurities" in adaptation since climate change impacts are not equally distributed. The fact that some communities and some individuals will be more heavily affected narrows the "public" nature of climate impacts. The unequal distribution of impacts, means that the benefits of adaptation are also unequal with potential implications for who takes action, policy and financing decisions. In this paper we consider where sea level rise strategies, such as elevation of buildings and construction of sea walls, fall on the continuum from private to public goods. We draw on these thought experiments to consider the financial instruments available to mobilize public and private resources to advance adaptation.
Keywords: Climate adaptation; public goods; sea level rise

11:20-11:40
Principles of justice in urban resilience
Author: Jo Fitzgibbons (University of Waterloo); Carrie Mitchell (University of Waterloo)
Abstract: As cities globally deal with increasingly complex and interrelated problems such as climate change, the idea of building general "resilience" in urban systems is outpacing other policy frameworks in popularity. Yet, many scholars have cautioned that resilience is an inherently conservative (rather than transformative) concept which obscures issues of power and justice (Meerow, Newell & Stults, 2016; Joseph, 2013; Ziervogel et al., 2017). To date, there has been little by way of in-situ or empirical findings to test these claims. The Rockefeller Foundation's 100 Resilient Cities (100RC) is one major initiative that attempts to mainstream resilience thinking into city planning. We have taken this ongoing program as an opportunity generate empirical findings on how planners confront issues of justice and inequity in resilience planning, focusing on the global South. To support our analysis, we have drawn on Anguelovski et al.'s (2016) concepts of "acts of commission" and "acts of omission" to consider both procedural and distributive justice. Procedural justice processes such as negotiation and redistribution of power are necessary to generate the transformative systems changes that resilience narratives promise (Harris, Chu & Ziervogel, 2017). These procedural considerations also influence distributive justice by affecting spatial and infrastructure planning which, in turn, affect economic and resource inequities. Using key informant interviews and directed content analysis of 13 Resilience Strategies, we examine whether and how the 100RC Chief Resilience Officers have understood and implemented

principles of justice in the development of their city's Resilience Strategy. Our findings confirm that resilience planning has not sought to radically transform power relations within cities, nor focused explicitly on justice. These findings will help guide future planners and policymakers to reflect on justice not only as an outcome for resilience, but also as a part of the planning process.
Keywords: resilience, environmental justice, critical planning, climate change, procedural justice

11:40-12:00
The social-ecological networks of cancer prevention in urban Environments
Author: Alexander Wray (University of Waterloo); Leia Minnaker (University of Waterloo)
Abstract: This paper explores the network of dependencies between social structures, ecological systems, and cancer outcomes. The global burden of cancer is substantial and growing, of which half are preventable through changes to lifestyle and/or environmental factors. Primary forms of cancer prevention often revolve around altering behavioural or environmental conditions to reduce exposure risk, while secondary forms of prevention aim to understand existing contributions of socioecological conditions to cancer epidemiology. Therefore, given the majority of the human population now resides in urban areas, the city becomes the dominant place to explore the complex system-level relationships between health and environment. We present results of a scoping review of 308 peer-reviewed journal articles published between January 1990 and April 2017, across 14 subject databases. The review of the evidence published to date reveals a trend towards accounting for complex social and environmental contributions to cancer risk. Researchers have explored the role of socioeconomic factors, as well as anthropogenic environmental exposures in alleviating or aggravating the risk of all types of cancer. The spatial patterning and access to housing, transportation, greenspace, and public services all contribute to a real or perceived risk of cancer for people. Furthermore, the evidence suggests that urban and health related disciplines operate in relative isolation, often not sharing research across each other's primary literature networks.

12:00-12:20
Feedback and discussion

Session Details: June 22 – 3:00-5:00

Session 1: Integrating "Big Data" and "Smart Cities" Data with Urban Modelling

Organizer: Alison Heppenstall

June 22, 2018; 3:00-5:20 PM

Location: 1002

Description: New forms of data about people and cities, often termed 'Big', are disrupting many traditional fields of research. This is true in geography, and especially in those more technical branches of the discipline such as computational geography / geocomputation, spatial analytics and statistics, geographical data science, etc. These new forms of micro-level data have fostered new methodological approaches in order to better understand how urban systems behave, giving rise to a new research area termed urban analytics. Increasingly, these approaches and data are being used to ask questions about how cities can be made more sustainable and efficient in the future. This session will bring together the latest methodological research focused on urban analytics, with the goal of production of a special journal issue. We are particularly interested in papers that engage with the following domains:

- Integrating urban analytics and agent/individual-based modelling;
- Machine learning for urban analytics;
- Innovations in consumer data analytics for understanding urban systems;
- Real-time model calibration and data assimilation;
- Spatio-temporal data analysis;
- New data, case studies, demonstrators, and tools for urban analytics;
- Geographic data mining and visualisation;
- Frequentist and Bayesian approaches to modelling cities.

3:00-3:20

From spectral values to three dimensional estimation of urban form: Assessing quantitative relationships between Technomass and radiometric indexes

Author: Richard Lemoine Rodriguez (Ruhr Universität Bochum); Luis Inostroza (Ruhr Universität Bochum; Universidad Autónoma de Chile)

Abstract: The representation of complex ecological systems as *aspatial networks*, i.e. food webs, pest-parasitoid webs, and mutualistic webs, provides insight into their organization and function. Recently, *spatial networks* are leveraged in the form of landscape connectivity networks, composed of geolocated habitat patches that link together as a function of the maximum dispersal distance of the species of interest. Landscape connectivity networks are used to understand dispersal patterns and how these patterns respond to changes in landscape structure and connectivity. However, landscape connectivity networks are mostly limited to static representations at the larger landscape-scales and do not account for complexity in dispersal processes where the emergent structure and evolution of network structure is a function of dispersal dynamics at smaller scales. The main objective of this research study is to develop a modelling approach that integrates network theory and agent-based modelling (ABM) for the representation of a dynamic dispersal network of the emerald ash borer (EAB) forest insect infestation in an urban setting. The proposed Network-ABM (N-ABM) generates dynamic spatio-temporal patterns of EAB spread together with the spatio-temporal EAB dispersal network using geospatial datasets of the urban forest environment from the Town of Oakville, Canada as a case study. Graph theory measures are used to characterize the N-ABM simulation results to provide insight into the dynamics of the EAB dispersal and spatial network structure in the urban landscape. The proposed model can be useful for urban forest management as it is capable to identify important EAB dispersal pathways and habitat features.

Keywords: urban morphology, remote sensing, urban indicators, land surface temperature

Session Details: June 22 – 3:00-5:00

3:20-3:40

Estimating vehicle emissions using big traffic data

Author: Anjie Liu (University of Waterloo); Liping Fu (University of Waterloo); Mathew Muresan (University of Waterloo)

Abstract: As climate change and urban air quality become growing concerns around the world, there is greater need to quantify vehicle emissions. Vehicle emissions generate a significant portion of greenhouse gases. Since these emissions are influenced by traffic flow conditions, it is beneficial for traffic management professionals to have methods to estimate emissions in real time. Unfortunately, direct measurement of emissions from all road vehicles is both costly and impractical. However, emissions can be estimated through the relationships between emission generation and traffic flow. This poster will present a method to estimate emissions in real time using big traffic data. Traffic data from video cameras, Wifi detectors, and loop detectors at intersections are used to model the traffic flow along a road corridor. An emission model is developed to use the traffic flow as input to estimate the emissions generated. New sources of traffic data, such as vehicle tracking through video cameras using image processing, provide opportunities for improved traffic flow modelling and, subsequently, emission estimation. To calibrate and validate the emission estimation methods, a pre-validated simulation approach is taken. The traffic network is simulated in Vissim, a microscopic traffic flow simulator, and calibrated according to the traffic data. Outputs of the simulation are input into MOVES, an emission simulator developed by the Environmental Protection Agency US, to generate emission estimates. These results serve as the ground truth used to evaluate the real-time emission estimation method.

Keywords: emission modelling; traffic data; traffic simulation; traffic flow modelling

3:40-4:00

Combining Big Data and Traditional Data in an Agent-Based Model of the Ambient Population

Author: Tomas Crols (University of Leeds); Nick Malleson (University of Leeds)

Abstract: Modelling the ambient population in urban areas can have applications in fields that need population estimations with highly detailed spatial and temporal resolutions. These fields include crime science, modelling exposure to air pollution, or transport studies. 'Big' data allow us to track human movements at the desired resolution, but still have a number of issues that make them sometimes difficult to apply or to get access to. The best datasets, like mobile phone data, can be unavailable because of commercial or privacy-related reasons. Geolocated data from social media platforms are not always fully representative of the entire population. Footfall data are limited to specific locations and are better suitable for model validation than for calibration. Hence, big data and more traditional spatial data could be combined for model calibration and validation. In this presentation, we discuss the development of an agent-based model of the ambient population at an individual level in an urban environment. Ultimately, the goal is to calibrate the model with different big data streams in real time by using dynamic data assimilation techniques. Currently, we have developed an application for the town centre of Otley, West Yorkshire, UK. We model daily routines of individual commuters (working, shopping, leisure, etc.) that we calibrated with census data of commuting flows and a recent British time-use survey. For validation, we use hourly Wi-Fi sensor footfall data of mobile phones passing by at different points in town.

Keywords: agent-based modelling, ambient population, big data, traditional data

Session Details: June 22 – 3:00-5:00

4:00-4:20

Leveraging Open Data for Urban Agent-based Models: Examples and Challenges

Author: Andrew Crooks (George Mason University); Sarah Wise (University College London)

Abstract: Today we are awash with new sources of open data, from CCTV to crowdsourced data. New forms of data range in their characteristics and purpose. One example is Volunteered Geographical Information (VGI), were users purposely contribute Geographic Information (GI) as in the case of OpenStreetMap; another is Ambient Geographic Information (AGI), where the intention of contributors is not necessarily to provide GI, but GI can be derived, as from Twitter. While much progress has been made in utilizing these new sources of data in GIScience, they have only recently begun to be integrated into agent-based models (ABMs). This talk will discuss the opportunities that open data provides for ABMs, specifically focusing on how such information gives us a new lens to study the micro interactions of individuals or to validate emergent patterns from ABMs. Through a series of examples, we will demonstrate how such data can be integrated into geographically explicit ABMs. By building on these examples we will showcase how the spatial environment and agent populations can be built using open data and highlight how agent behaviors can be informed along with how aggregated outcomes can be validated by such information. We will further discuss the challenges associated with this program of research: using such data is not without its difficulties, including gathering or accessing the data, storing the data, analyzing the collected data, and assessing its validity. Together, this work provides a brief overview of the current state of open data-informed ABM.

Keywords: agent-based modeling, open data, volunteered geographical information, social media, crowdsourcing, urban systems

4:20-4:40

Autonomous Condition Monitoring and Control of Infrastructure and Industrial Systems

Author: Jinane Harmouche (University of Waterloo); Sriram Narasimhan (University of Waterloo); Nicholas Charron (University of Waterloo)

Abstract: The autonomous monitoring and control of critical infrastructure and industrial systems through sensor measurements is one of the most important applications of smart cities. The objective is to develop low-cost, accurate and real-time event monitoring solutions for urban infrastructure and industrial systems, which is challenged by the increased system complexity and scale. Innovative solutions are centered around two main axes: smart automated inspection methods and efficient unsupervised data processing and modelling. Smart inspection is fostered by embedded microprocessing units bringing computation closer to the site of the sensor network. Integrating data from different sources/sensors is necessary for an accurate and a comprehensive assessment of infrastructure condition. For this purpose and given the increased scale of the urban systems, mobile sensor platforms offer widespread and cheap data collection methods compared to fixed sensor networks. Mobile sensor platform can benefit from robotic technologies assisting in different tasks such as damage detection and localization, construction progress and quality control monitoring, as well as structure decommissioning and demolition. The collected sensor data are quite complex, noisy, multi-dimensional and multi-components. The modelling is the bridge between sensor measurements and decision, and it relies on effective preprocessing and machine learning model. For this purpose, domain knowledge coupled with problem understanding and data science expertise is essential. An efficient preprocessing is able to filter out the stochastic noise and extract informational features. Transforming time-domain data into appropriate domains, such as time-frequency domain, can highlight the damage pattern and increase the detection accuracy. Data with non-linearly coupled components need to be decomposed in order to isolate the impact of a possible event (e.g. leak, crack,) and increase feature sensitivity.

Session Details: June 22 – 3:00-5:00

4:40-5:00
Right to the Smart City: modeling data, modeling trust
Author: Beth Coleman (University of Waterloo)

Abstract: Data is at the heart of the Smart Cities discussion, as data are the unit of information that makes the technology "smart." Data, for better and for worse, provide the computational values about the world that a smart technology calculates and acts on in real-time. In this talk I frame the relationship between data and smart technologies such as Internet of Things (IoT) and artificial intelligence (AI) systems in their ability to enact a radical automation of the built environment. Based on the profound role of data in information communication technologies (ICTs) and the managerial work of running a city, I argue that data policies and protocols must be reimagined toward a civic framework. I discuss examples of data publics and counter publics that model civic data engagement toward principles of access, equity, and inclusion. My argument addresses key concepts such as the civic imaginary and civic trust.

Session 5B: Agent-Based Models of Retail, Office and Industrial Markets, and Integrated Models

Organizer: Yu Huang
June 22, 2018; 3:00-5:00 PM
Location: 2002
Description: This session will highlight cutting-edge research in the field of agent-based modelling of urban markets. It will also provide a forum for discussion and reflection on potential implications of model findings for current urban issues, such as housing market dynamics, labour market transitions, and urban growth and change. A special journal issue will be organized around the session, comprising contributions of leading agent-based modelling scholars in the field of urban economics, urban and regional planning and development, and geography. Suitable topics for the session presentations include any theoretical or empirical agent-based modelling on
   • land/housing markets (land development; housing market mechanisms and policies);
   • residential mobility, home search and location choices;
   • labour markets and wages (job search and mobility);
   • rental markets (rent control policies);
   • land-use/transport interaction;
   •and other markets nested in complex land-use change models

3:00-3:20
From oil wealth to green growth - An empirical agent-based model of recession, migration and sustainable urban transition
Author: Jiaqi Ge (The James Hutton Institute); Gary Polhill (The James Hutton Institute); Tony Craig (The James Hutton Institute); Nan Liu (The James Hutton Institute)

Abstract: This paper develops an empirical, multi-layered and spatially-explicit agent-based model that explores sustainable pathways for Aberdeen City and surrounding area to transition from an oil-based economy to green growth. The model takes an integrated, complex system approach to urban systems and incorporates the interconnectedness between individuals, households, businesses, industries and neighbourhoods. We find that the oil price collapse could potentially lead to enduring regional decline and recession. With green growth, however, the crisis could be used as an opportunity to restructure the regional economy, reshape its neighbourhoods, and redefine its identity in the global economy. We

Session Details: June 22 – 3:00-5:00

find that the type of the green growth and the location of the new businesses will have profound ramifications for development outcomes, not only by directly creating businesses and employment opportunities in strategic areas, but also by redirecting households and service businesses to these areas. New residential and business centres emerge as a result of this process. Finally, we argue that industries, businesses and the labour market are essential components of a deeply integrated urban system. To understand urban transition, models should consider both household and industrial aspects.
Keywords: spatial agent-based model; recession, migration; urban transition; oil crises; sustainability

3:20-3:40
Modelling fuel poverty and market failures
Author: Gary Polhill (The James Hutton Institute); Jiaqi Ge (The James Hutton Institute); Tony Craig (The James Hutton Institute); Doug Salt (The James Hutton Institute); Kathryn Colley (The James Hutton Institute)

Abstract: Fuel poverty has been defined in Scotland as a situation in which more than 10% of household income needs to be spent on all fuel use to keep the house 'acceptably' warm (based on Boardman 1991). Building fabric is a major contributing factor to maintaining a comfortable temperature in the home. The housing and home improvement markets thus play an important role in ameliorating fuel poverty. Houses in Scotland have an Energy Performance Certificate, giving them a rating using seven bands from A, the most energy efficient, to G, the least. In work currently under review, Liu et al. have shown that in Aberdeenshire, more efficient homes do attract a premium on the rental price. Grants and interest-free loans are available for home improvements through government-funded schemes. Though aimed primarily at homeowners (some of whom are fuel poor), some private landlords are eligible; there are also schemes that tenants can apply for. Further, energy companies have obligations to provide free insulation and heating improvements to qualifying households. Many such schemes are not taken up by households, however, and this is a cause for concern. Another major market is domestic energy supply. Here, low-income families are at a disadvantage as many are on prepayment meters. Tariffs for these are typically higher than on credit meters, so low-income households generally pay more per unit of energy consumed than better-off households. Understanding fuel poverty requires modelling that does justice to the complexities of interacting markets and multidimensional priorities of the actors in them.
Keywords: Fuel poverty, complexity, agent-based modelling

3:40-4:00
Drawing on analogies from ecology to model retail competition using ABM
Author: Derek Robinson (University of Waterloo)

Abstract: Agent-based models (ABM) have been used to represent and formalize our knowledge of the drivers of land-use and land-cover change over the past two decades. Most of these models represent residential or farm households, which is likely due to the availability of survey data or the potential to survey households about how they make settlement or crop choice and land management decisions. Fewer models exist that represent actors that develop land. Among those that exist, the focus has been on developing residential lands and involved statistical models (e.g., survival analysis), with a couple cases where surveys of developer actors have been used to inform agent behaviours. Another uniquely developed ABM has been used to investigate petrol pricing competition among petrol service stations. Despite these latter examples, the creation of ABMs to represent commercial and retail development have been under represented given their influence on urban-to-exurban morphologies as employment lands and a destination for commerce. We present the results of empirical research on consumer spending and retail location site selection as the foundation for the development of an ABM of retail competition. We use these insights in combination with ecology theory about competition to create a

conceptual model of the processes and behaviours of retail agents competing for store sales. The overarching goal of the presented research is to evaluate if real-world patterns of store locations can be generated using an ABM approach so that we can enrich future land-use and land-cover change models by better representing commercial development.

4:00-4:20
Towards an Agent Based Model of Downtown Office Market Supply-Demand Dynamics
Author: A. Volz (University of Illinois at Chicago); M. Zellner (University of Illinois at Chicago); R. Weber (University of Illinois at Chicago); J. Kim (University of Illinois at Chicago)

Abstract: Agent-based models (ABM) of real estate predominantly analyze the residential market, with the 2008 recession stimulating significant interest in the area. Less attention has been paid to the commercial office market, as the busts of the late 80's predate ABM as an analytic tool. However, the changing structure of office-using firms, the resurgence of central cities, and the continuing growth of the service industry present future uncertainty in the market and demand new attention. In this paper, we present an ABM of a metropolitan area's office market: OMITD (Office Market Internal Transition Dynamics). The model posits mechanisms underlying search behaviors of commercial tenants for new space (adapting to availability and rent) and the responses from building managers to their observations of the market (adjusting rent to individual and market vacancy, developing or demolishing buildings). The market is driven by an exogenously generated labor force. The interaction between tenants and building managers over relatively short durations (64-80 quarters) results in outcomes resembling a metropolitan area's office market rent cycles, distributions of establishments by size, and distributions of buildings by class. With confidence that our model reproduces the market's macro-level structure from these micro-level interactions, we use the model to examine phenomena that have received little attention, including filtering, where smaller firms move up the office quality ladder. We find that OMITD provides a suitable test bed for exploring the market and policy implications of behavioral assumptions about agents, and generates reasonable simulated data of the internal dynamics of an office market.
Keywords: office markets, agent based models, filtering, price adjustment processes, firm life cycles

4:20-4:40
Exploring the effects of policy instruments on urban sprawl and income segregation
Author: Cheng Guo (Helmholtz Centre for Environmental Research, UFZ); Nina Schwarz (University of Twente)

Abstract: Different policies have been implemented in different cities for controlling urban sprawl. These policies have been classified into three categories: 1. regulation, 2. economic intervention, 3. institutional change, management and advocacy. While it has been shown that they can control urban sprawl, few studies so far have investigated their effects onto income segregation. For this paper, we implemented several policy instruments per category in a stylized urban agent-based model (ABM) with individual behaviors building on Alonso's bid rent theory. For each policy instrument, we ran simulations with different income distributions. We measured the overall emergent patterns with and without policies using indicators for urban sprawl and income segregation and compared these patterns qualitatively and quantitatively. Simulation results confirmed positive effects of these policies onto urban sprawl, but also revealed their – in some cases counterproductive - effects onto income segregation. Of all tested policies, homogenous density control is the one that most effectively controls both urban sprawl and income segregation. While giving practical suggestions to practitioners about urban policies, this study also demonstrates the potential of ABMs for policy design
Keywords: agent-based model; urban sprawl; segregation; policy, residential mobility

Session Details: June 22 – 3:00-5:00

4:40-5:00

Urban, agricultural and touristical land use patterns: combining spatial econometrics and ABM/LUCC

Author: Claudio Detotto (Université de Cors); Corinne Idda (Université de Cors); Eric Innocenti (Université de Cors); Dominique Prunetti (Université de Cors)

Abstract: This work deals with computer simulation of complex spatiotemporal systems based on Agent-Based Models of Land Use Cover Change (ABM/LUCC). We propose a modeling framework and its modular and scalable implementation in order to simulate and evaluate territorial planning policies. The setting of this study is a collection of tourist areas that have faced -and still face- an intense residential development leading to a huge pressure on land prices as well as to land-use conflicts (local residential market, tourist rental investment, agricultural production). The aim is to identify new management practices, able to combine economic development and land competition in a strongly constrained environment. By means of computer models, we intend to represent the behavior of heterogeneous economic agents in both time and space. Existing spatial territory management models are mostly analytically intractable. Discrete-event simulation modeling offers practicable solving techniques. In particular, it allows to process ABM/LUCC models and to deal with heterogeneous behaviour shaped by many interacting components. In this work we show how to combine spatial econometrics with ABM/LUCC computer simulation. Furthermore we explain how to obtain parameters estimation about: their distribution over space and according spatial economic activities; price determinants of land and real estate; The predictive parameters are computed from real data as well as our data simulations.

Keywords: ABM/LUCC, spatial econometrics, cellular models, complex spatial systems

Session Details: June 22 – 5:00-6:00

Session 10: Workshop - A Science of Cities for Sustainable Development

Organizer: Perin Ruttonsha (University of Waterloo)
June 22, 2018; 5:00-6:00 PM
Location: 1002
Description: Cities are increasingly garnering attention on the international political stage, in light of the challenges and opportunities urbanization engenders for sustainability and resilience. Meanwhile, science of cities discourse is mobilizing on the premise that it could offer coherent strategies for transition (West, 2017). Finally, with a city-centric category incorporated into the United Nations' 2015 Sustainable Development Goals (SDGs), a unification of purpose between sustainable development and urban planning is nascent. In this collaborative session, we will review how we are framing and building a contemporary science of cities (for example, through work in the areas of urban ecology, urban sociology, urban science and land-change science), oriented around the following questions:

- How can qualitative, quantitative and design-based approaches to urban analyses be integrated to inform a comprehensive science of cities?
- What key findings have emerged from recent work in this area?
- What are the implications for urban planning?
- What are the implications for sustainability transition?

Results will be documented and synthesized for publication.