WATERLOO INSTITUTE
for COMPLEXITY & INNOVATION

2010-2020

PROGRESS REPORT

SENATE GRADUATE AND RESEARCH COUNCIL

MARCH 2021

UNIVERSITY OF WATERLOO

EXECUTIVE SUMMARY

Since its inception, WICI's **vision** has been to create an interdisciplinary institute that integrates complex systems knowledge from the university's faculties, departments, centres and schools, and that draws complex systems expertise from around the world to address the most pressing problems of the 21st century. WICI's **mission** has been to facilitate and undertake rigorous, transdisciplinary, collaborative research that promotes innovation and resilience within the complex adaptive systems at the core of human well-being in the 21st century.

This document summarizes the activities and achievements that WICI has made toward advocating and advancing complex systems research at University of Waterloo and beyond:

- WICI has consistently achieved its goals and objectives of the past 5 years (and the previous 5-year term as well).

- Since our first year's initial cohort of 22 members, WICI has grown steadily each year to a current membership of **147** members, as of December 31, 2020.

- More than 41% of the over **16.1 million** dollars of successful complex systems related grants reported by WICI core members over the years were from sources other than tri-council funding agencies

- Jinelle Piereder's recent project *Mapping Canadian Complex Systems Scholarship* reveals the breadth of peer-reviewed published complex systems research at University of Waterloo (of which WICI currently represents only 6.3%), and paves the way for continued growth of WICI's Canadian Network for Complex Systems (CNCS).

- WICI has provided over **$30,000** in travel/conference funds, fellowship awards and smaller prizes for 24 graduate student members over the past eight years.

- WICI has hosted **5** conferences and/or symposia, **31** workshops and at least **89** seminars and/or talks (not including the number of talks that were delivered during our conferences and/or workshops). Talks have had **7,977** views to date, indicating that we are reaching not only a significant crowd of participants, but also a broader audience long after talks have taken place.

- **Two thirds** of the collaboration discussions WICI has engaged in over the past two years occurred as a result of WICI being discovered either from our web presence, internal referrals or through our network of researchers.

- Thirty percent **(30%)** of respondents to the 2019 Member Survey suggested that WICI should strengthen its activities in training/education opportunities. A training program proposal (Dordi, 2020) was developed for consideration in our five-year planning process.

WICI's accomplishments and activities to date have been achieved largely from member-driven support, with exemplary WICI leadership, modest administrative staffing, and an annual operating budget of between **$60-100K**.

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Acknowledgements:

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Cover image by Gerd Altmann (2020) Retrieved from https://pixabay.com/illustrations/wave-concentric-waves-circles-water-3732123/

TEN YEAR REVIEW 2010-2020

INTRODUCTION: THE VALUE OF WICI

WICI was formed eleven years ago by a core team of complex systems researchers at University of Waterloo, and with core funding support from the University of Waterloo, has grown to a team of 147 members across the globe. WICI has worked to **highlight and support complex systems research** at the University of Waterloo through various member-led and member-driven initiatives, including WICI talks, workshops and conferences, student competitions and symposia, working/reading groups, support for grant development, and the development of a national network for Complex Systems researchers.

This review document details the history and evolution of WICI over the past eleven years. Section 1 covers WICI's institutional background, the vision, mission and goals, and Section 2 reviews the growth of its membership. In Section 3 we describe the complex systems research of WICI's core members, outline various supports WICI has offered to student and affiliate members over the years, and recap the conferences, workshops and impressive list of WICI talks that have been delivered over its lifetime. We also discuss WICI's establishment of a Canadian Network for Complex Systems and the various collaboration opportunities that WICI has identified in recent years. WICI Governance is detailed in Section 4 and a copy of our financial statements is included in the final section.

We hope that in reviewing this document, the reader concludes that WICI brings unique value to researchers at the University of Waterloo and beyond, through recognition, development and advancement of Canadian contributions to complex systems research, and will agree with WICI's view that the University of Waterloo has tremendous potential to advance complex systems research, training and education in modern academia.

1. THE WATERLOO INSTITUTE FOR COMPLEXITY AND INNOVATION (WICI) BACKGROUND

In 2009/10, WICI was formed with the vision of creating an interdisciplinary institute that would integrate complex-systems knowledge from the university's faculties, departments, centres and schools, and that would draw complex-systems expertise from around the world to address the most pressing problems of the 21st century.

We continue to see a steadily higher incidence of unanticipated and sometimes catastrophic change, such as financial crises, pandemics, sharp spikes in food prices, extreme weather events, and severe social and political unrest. The traditional disciplinary-based approach to research and policymaking cannot address such complex problems effectively, because they are intrinsically systems-based and potentially transdisciplinary. Humans are embedded in a nested and interconnected hierarchy of complex socio-ecological systems encompassing the biosphere and the global economy. These systems are increasingly perturbed by powerful, simultaneous and often interacting stresses, including rapid population growth, systemic imbalances in the global economy, enormous gaps between rich and poor classes, worsening scarcity of high-quality energy, and severe damage to Earth's environment.

In this context, innovative problem solving demands a **complex-systems approach** that integrates knowledge across disciplines with a systems lens. By bringing together scholars, practitioners, and policy makers working on both theoretical and applied complex-systems problems, WICI is one of the top Institutes at the University of Waterloo for connecting researchers and students from multiple faculties. In doing so, it facilitates knowledge translation of deep disciplinary expertise in complex systems methods that resides within individual faculties and departments. WICI helps researchers and students

at the University of Waterloo create a shared understanding of complexity concepts, theories, and methods, and to connect with local stakeholders interested in these ideas. Beyond the immediate geographic scope of Southern Ontario, WICI disseminates its findings and engages vigorously with complexity researchers around Canada and the world.

By establishing the University of Waterloo as a leader in the use of complex-systems ideas to solve important problems, the Institute furthers the university's goal to "use its disciplinary and interdisciplinary strengths to solve increasingly complex, real-world problems."

1.1 WHY STUDY COMPLEX SYSTEMS?

Complex systems are all around us. They are seen in natural world, for example, the ways that migrating birds organize themselves into flocking formations and that ants communicate to successfully forage. They are also seen in the social world, for example in the ways in which humans form social networks, and in the patterns of communication, social capital, and reputation that emerge from these networks. They are seen in the emergent power-law or fractal structures of plants, snowflakes, landslides, and galaxies, as well as in similar structural patterns of wealth and income distribution, stock market fluctuations, population distributions between cities, and patterns of urban development. Complex systems, whether natural or anthropogenic, are often referred to as "wholes that are more than the sum of their parts," wholes whose behaviour cannot be understood without looking at the individual components and how they interact.

> "Complex systems research narrows the gap between fundamental research and its application to problems."
>
> *-Roger White*
> *WICI External Core Member*
> *Memorial University*

Complex behaviour arises from the interplay, in densely interconnected systems, between multiplicative causation and positive and negative feedbacks. A signature of such systems is radically disproportional causation (i.e., small causes do not always produce small effects) or what is often called "nonlinearity." Nonlinear systems can undergo sudden flips between stable states, or equilibria. A second signature is the "emergence" of structured macroscopic patterns that are the outcome of the independent microscopic interactions of the entities in the system. These macroscopic patterns—be they hurricanes in Earth's atmosphere or boom-bust cycles in global financial markets—often have enormous causal power.

Complex adaptive systems—predominantly living systems, including human social systems—exhibit all these features; in addition, they survive and reproduce within dynamic selection environments. To do so, they have sets of embedded rules that guide their action in response to their external environments. These rules evolve under selection pressure.

The formal study of complex systems began in the mid-20th century in mathematics, physics, computer science, systems engineering (including cybernetics) and meteorology. More recently, ecology, social science and cognitive science have made important contributions. Researchers now apply the insights of complexity theory to the behaviour of systems as diverse as pathogen transmission, fresh-water lakes, mammalian immune systems, financial markets, social networks, the Internet, the power grid, urban environments, and meta-cognition.

Mathematically, complex adaptive systems are multi-state variable dynamical systems characterized by a moderate degree of structured interactions and interconnections. State variables in these systems are

often characterized by heterogeneous parameter sets and updating rules. Spatial and network relationships are often non-uniform and violate mean field theory assumptions. As a result, mathematical representations of these systems often do not have analytical solutions. Further, system behaviour is characterized by path dependence, nonlinearities, bifurcations, and threshold behaviour. Higher-scale or aggregate output patterns are often characterized by power-law statistical distributions.

WICI members across the natural and physical sciences, engineering, mathematics, social sciences, and the humanities study the formal aspects of complex systems, harnessing both quantitative and qualitative approaches. We investigate questions such as: What processes and structures define complex systems and characterize their outcomes? How might theoretical or methodological insights in one application area of complexity science be transferable to another? How can complex systems be modeled and their implications understood? What real-world problems are best represented by complex systems, and what new insights are gained from a complex-systems lens? Most importantly, how can our understanding of complexity help us innovate to better address the world's most intractable problems?

1.2 VISION, MISSION AND GOALS

Since its inception, WICI's vision has striven to become an interdisciplinary institute that integrates complex systems knowledge from the university's faculties, departments, centres and schools, and that draws complex systems expertise from around the world to address the most pressing problems of the 21st century. WICI's mission has been **to facilitate and undertake rigorous, transdisciplinary, collaborative research that promotes innovation and resilience within the complex adaptive systems at the core of human well-being in the 21st century.**

In its 2010 Proposal to Establish, WICI established three initial sets of goals:

1. **The pursuit of leading-edge research**:
    a. Combine existing ideas from complex-system studies with complementary ideas from relevant fields to develop enhanced and integrated conceptual frameworks and methods for the study of complex natural and social systems; and
    b. Apply these integrated concepts and methods to stimulate rapid innovation that either:
        i. enhances the resilience of complex systems vital to human well-being that are economically viable, socially equitable, and ecologically sustainable, or
        ii. hastens the beneficial transformation of complex systems with irremediable and fundamental flaws.

2. **The creation of a university-wide research community in the field of complexity and innovation studies; and,**
    a. To encourage the synthesis of disparate knowledge on the University of Waterloo campus through collaborative research, seminars, workshops, conferences, and high-quality publications;
    b. To draw together the expertise of researchers from existing university departments, centres and institutes and associated institutions to create a community focused on using complex-systems ideas to promote innovation to solve practical problems;
    c. To develop a shared foundation in concepts and research tools;
    d. To provide university-wide training and support in the use of complex-systems research and modelling tools; and

e. To act as a hub for graduate students across campus and related institutions who are studying complexity and innovation.

3. **The strengthening of the university's reputation in the field of complexity and innovation studies:**
    a. To establish the University of Waterloo as a world leader in efforts to use complex-systems ideas to promote innovation to solve multi-scale, systems-level global problems.

Progress against those initial goals were outlined in the 2015 Five-Year Review Report. At that time, WICI established a new set of strategic goals through 2020:

1. **Strengthen core networks.**
    a. Continue to actively support current core projects and members through grant writing assistance and complementary activities such as talks, workshops, and working groups.
    b. Look for existing opportunities on campus to expand core membership in the areas of network science, human-environment interactions, expanding conventional economics, complexity and non-rational drivers of behavioural change, psychological dynamics of catastrophic dehumanization; rapid ideological change/ideological conflict; and embodied cognition.
    c. Work with faculty units and deans to identify opportunities for new hires whose research has a complex systems focus.
    d. Seek out particular opportunities to establish core WICI members in under-represented faculties (namely AHS and Science).

2. **Facilitate interdisciplinary research.**
    a. Host talks and workshops, striving to maintain a balance between bringing in global leaders in complex systems and highlighting local complex systems scholarship.
    b. Support working groups, allowing their focus and scope to evolve with the interests and needs of membership.
    c. Offer support for grant development.

3. **Enhance public engagement.**
    a. Improve WICI's web and social media presence, including the development of web pages for WICI core research projects and a set of introductory "What are complex systems?" materials.
    b. Highlight WICI work through press releases and actively engage the media when opportunities arise.
    c. Offer more public talks in the community.
    d. Continue informal receptions before talks with speakers and attendees.

4. **Enhance WICI's resource base and long-term viability.**
    a. Prioritize efforts to obtain higher-level, external support to establish and support initiatives such as a staffed resource lab; funding for a graduate fellowship program; a competitive post-doctoral scholar program; and funding for short-term (sabbatical or study leave) positions for more senior complex systems scholars.

5. **Raise WICI's profile.**

a. Focus on academic and media outreach to highlight WICI's unique contributions on a national and global scale.

1.2.1 PROGRESS TOWARDS 2015 STRATEGIC GOALS

Since 2015, WICI has made substantial progress towards its strategic goals.

1. Membership has doubled. WICI has initiated connections with Canadian Complex Systems researchers and institutions through a Canadian Network for Complex Systems (CNCS) initiative, expanded into areas of lower representation (namely Health and Science) and continued to deliver high profile WICI seminars and conferences attracting the attention of national and international scholars and prospective partners.

2. WICI **core** members have collectively developed over **75** successful complex-systems-themed grant applications in collaboration with other researchers (and countless more applied to that were not successful). WICI core members have supervised over **50** graduate students, employed at least **9** postdoctoral fellows to work specifically on WICI core research projects, and have attracted speakers from a diverse disciplinary span to UW to present their work at well attended WICI events, and to also meet with local researchers for networking discussions and opportunities.

3. WICI talks and seminars have reached **7,997** viewers, our website has been visited over **41,000** times, our email subscribers have increased from 400 to nearly **600**, we have built a following of **724** Twitter accounts, **581** Facebook users and **114** LinkedIn members.

4. Initial plans toward viability centered around the goal of running grants and contracts through the centre and receiving a portion of the research support funds or overhead. As a clearly cross-faculty, interdisciplinary centre, with a broad disciplinary scope and strong reputation, WICI anticipated application for University Centre status. However, WICI was ultimately discouraged from pursuing such status, in light of a review of University Centres and Institutes and a possible future shift in the overall structure of research centres at UW. In 2018 and 2019 WICI initiated extensive discussions with the Office of Research, Deans, other Waterloo Research Centres, and external complex systems hubs in France (Île de France) and the United States (Santa Fe Institute) regarding alternative budget models that WICI could consider. A one-year extension of the mandate was granted in 2020.

   Development plans for an alternative model continued in 2020/21, with further consultation with the Office of Research, Waterloo Institute for Social Innovation and Resilience (WISIR), Professional Development and the Problem Lab. WICI's best near-term strategies toward an alternate funding model now appear to include consolidation with existing small centres (e.g. WISIR), partnership(s) with Advancement office(s) at UW to search for donor and foundation funding, and serious consideration of professional development offerings, on topics such as leadership and problem-solving in a complex world. WICI continues consultation with the Aspen Institute, Cascade Institute, Problem Lab, WISIR and Balsillie School of International Affairs, with all parties anticipating high demand for training in a variety of potential markets including professionals, government and non-profit agencies, commercial businesses and students.

   In addition, collaborations with members of a new Canadian Network for Complex Systems, which WICI established, have led to a number of new grant applications in the past year,

including an imminent CIHR-SSHRC-NSERC training grant for $4.9 million. Our next five-year plan includes direct support for similar future applications. WICI has also consulted with Steering Committee members regarding possible fee-for-service offerings and "donation" type models for events. WICI continues to develop a business model and business plan for long-term financial viability going forward. This will be a top strategic priority for the near term.

5. WICI's "What is a Complex System?" videos have been viewed nearly **3,000** times and are even sought out and referenced by external members in their own complex systems teachings. WICI is currently sought out by prospective students asking "how can I register for a PhD in complexity at UW?" Researchers asking "can you partner with us on grants?", "how can I become a member?" and "how can you help industry partners solve their own complex problems?" Chris Bauch's modelling of pandemic spread in classrooms and Igor Grossmann's work on "World After Covid" have received national and global attention this past year alone.

In each of WICI's Annual Reports, WICI has thoroughly detailed how our yearly activities have impacted our goals. A report of our progress against strategic goals from 2010-2015 was included with our 2015 Five-Year Review and Renewal Report. A full report of the progress against our strategic goals from 2015-2020 is included in Appendix A: Progress Against WICI's Yearly Goals 2015-2020.

1.3 OVERVIEW OF ACTIVITIES AND SERVICES

WICI has offered a range of programs and activities for University of Waterloo faculty and students, as well as external researchers and the public, which have enabled us to achieve our institutional goals. These include:

1. **Direct support for cross-faculty collaborative research:**
   - Supporting the work of several distinct core research programs;
   - Committing in-kind and financial contributions for core members' grant applications, as well as grant-writing support;
   - Contributing to the training of highly qualified personnel through our core research projects;
   - Hosting research, networking, and grant development workshops.

2. **Support for development of a network of complex systems researchers on campus and beyond:**
   - Hosting a Speakers Series that brings experts in their field to the university and allows University of Waterloo scholars working in the field to share their work;
   - Organizing public workshops and symposiums;
   - Publishing an occasional paper series;
   - Creating and disseminating software tools for analysis of complex systems through core research projects and challenges;
   - Curating a list of complexity readings and complexity-related courses on our website;
   - Facilitating and hosting working/reading groups at University of Waterloo;
   - Engaging the community through talks, workshops, a WICI mailing list and social media accounts;
   - Facilitating and hosting research networking events;
   - Identifying and connecting scholars working in complementary areas.

More information about WICI's key achievements in these areas can be found in Section 2: Eleven Years of Accomplishments.

2. MEMBERSHIP AND ENGAGEMENT

Our established network of complex systems researchers has become the cornerstone of our Institution. The following section discusses membership composition, engagement with our audience and feedback through our membership survey.

2.1 MEMBERSHIP

WICI's membership is composed of University of Waterloo faculty, graduate students and undergraduate students, as well as external members who are leaders in the field of complexity science.

Since our first year establishing 22 members, WICI has grown steadily each year to a current membership of **147** members, as of December 31, 2020. Figure 1 illustrates the growth of WICI's yearly membership over the duration of the Institute.

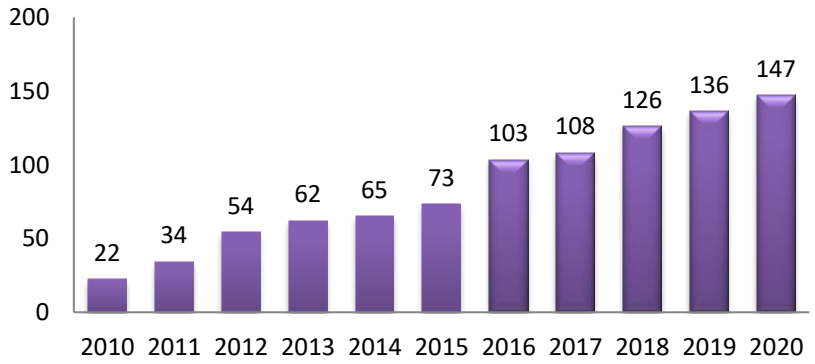


Figure 1: Yearly WICI Membership Growth

2.1.1 MEMBERSHIP BY FACULTY

WICI brings together researchers and students from all of University of Waterloo's faculties and disciplines, as well as from external organizations. Note: external members are categorized according to University of Waterloo's faculty structure for consistency. Figure 2 provides a breakdown of WICI membership by University of Waterloo Faculty.

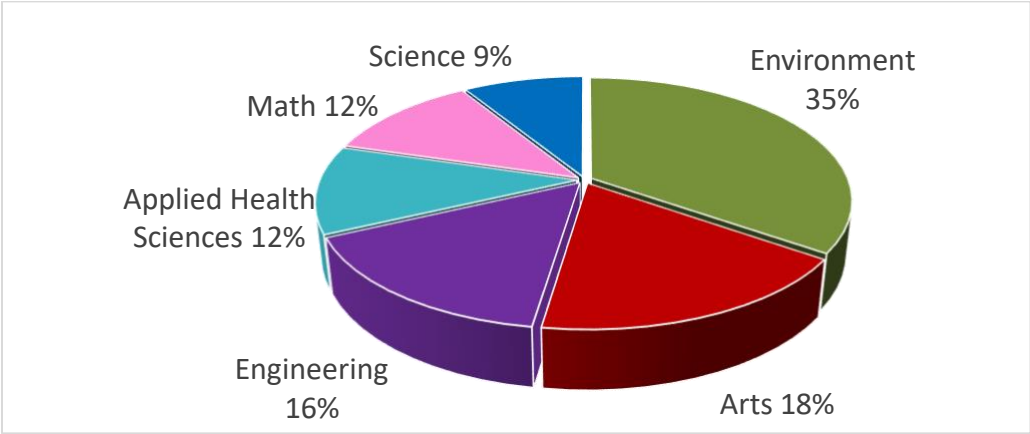


Figure 2: WICI Membership by University of Waterloo Faculty

2.1.2 CATEGORIES OF MEMBERSHIP

There are four categories of membership which reflect various levels of engagement with the Institute's activities and services.

CORE MEMBERS are regular, research, or adjunct university faculty who lead a long-horizon research program under the Institute's auspices. Membership lasts for the duration of the member's active research within WICI. Core members are expected to be active in submitted WICI-related research funding proposals, and they are eligible to request support in grant preparation and matching contribution through WICI (when applicable). When available, these grants will normally involve funding to train highly qualified personnel. Speaker and workshop proposals that closely align with core members' research agendas are prioritized for WICI funding when possible. Core research projects are listed on the WICI website and progress of these projects is reported annually. Core members are expected to actively contribute to WICI activities, such as network-building, suggesting and recruiting high-interest WICI speakers, helping to organize WICI working groups, reviewing for WICI challenges and the Occasional Paper series, and related activities. Note that in exploring development of a Canadian Network for Complex Systems, WICI has recently expanded core membership to include an external category.

AFFILIATE RESEARCHERS are regular, research, or adjunct university faculty or non-university researchers, including post-doctoral fellows, who actively participate in Institute activities, including its research projects or committees. Membership is ongoing with periodic outreach to confirm active status.

PRACTITIONER MEMBERS include people in government, the voluntary sector, and private sector interested in the Institute's research and findings and who actively participate in WICI meetings, workshops, and conferences open to a general audience. Membership is ongoing with periodic outreach to confirm active status.

STUDENT MEMBERS are students from the University of Waterloo or affiliated institutions working towards a degree on a topic of relevance to complexity science and innovation. Membership lasts until graduation, after which the members may transition to Practitioner or Affiliate Researcher status if applicable.

Figure 3 illustrates the breakdown of WICI membership by category.

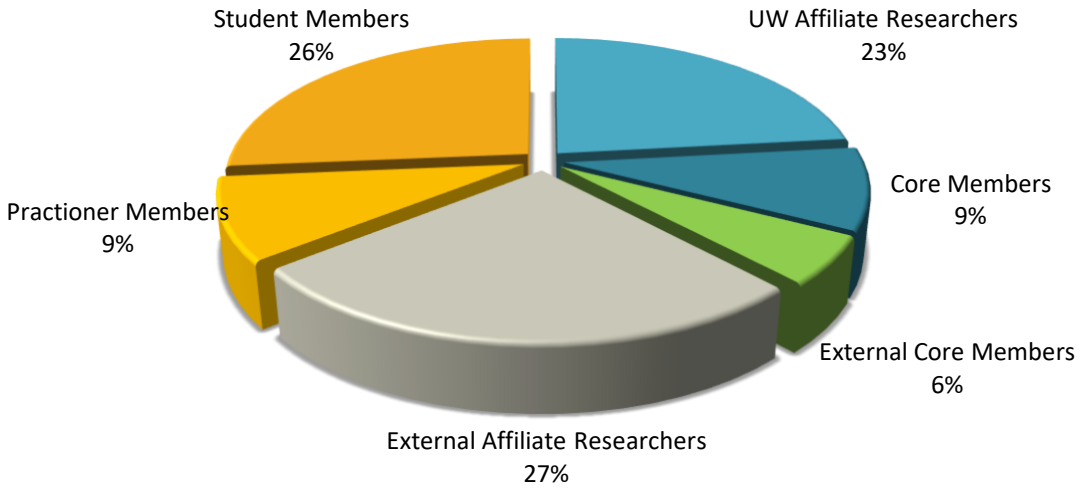


Figure 3: WICI Membership by Category

Table 1 below lists all of the current **147** members in our database, grouped by faculty and ordered by affiliation. Members marked with an asterisk are anticipated to be changing their affiliation status pending confirmation.

Table 1: WICI 2020 Membership List by Faculty and Affiliation

List of WICI Members in 2020 by Faculty and Affiliation

FACULTY OF ARTS		
Igor Grossmann	Associate Professor, Psychology	Core Member
Peter Carrington	Professor, Department of Sociology and Legal Studies	Affiliate Researcher
Owen Gallupe	Associate Professor, Department of Sociology and Legal Studies	Affiliate Researcher
Steve Mock	Fellow, Balsillie School of International Affairs	Affiliate Researcher
Sarah Tolmie	Associate Professor, English Language and Literature	Affiliate Researcher
Clayton Dasilva	Ph.D. candidate, Balsillie School of International Affairs	Student Member
Scott Janzwood	Ph.D. candidate, Balsillie School of International Affairs	Student Member
Michael Lawrence	Ph.D. candidate, Balsillie School of International Affairs	Student Member
Jinelle Piereder	Ph.D. candidate, Balsillie School of International Affairs	Student Member
FACULTY OF ENGINEERING		
Mark Crowley	Assistant Professor, Department of Electrical and Computer Engineering	Core Member
Keith Hipel	Professor, Systems Design Engineering	Core Member
Chrystopher Nehaniv	Professor, Systems Design Engineering	Core Member
Eihab Abdel-Rahman	Associate Professor, Systems Design Engineering	Affiliate Researcher
Lisa Aultman-Hall	Chair, Systems Design Engineering	Affiliate Researcher
Kerstin Dautenhahn	Professor, Electrical and Computer Engineering and Canada 150 Research Chair	Affiliate Researcher
Paul Fieguth	Professor, Systems Design Engineering	Affiliate Researcher
Mark Hancock	Associate Professor, Management Sciences	Affiliate Researcher
Ed Jernigan	Professor Emeritus, Systems Design Engineering and Knowledge Integration	Affiliate Researcher

List of WICI Members in 2020 by Faculty and Affiliation

Ponnu Kumaraswami	Professor, Systems Design Engineering	Affiliate Researcher
Rebecca Saari	Assistant Professor, Civil and Environmental Engineering	Affiliate Researcher
Mark Weber	Professor, Management and Organization and Eyton Director of Conrad School of Entrepreneurship and Business	Affiliate Researcher
Jorge Garcia	Ph.D. Candidate, Systems Design Engineering	Student Member
Simon Leroux	Ph.D. Candidate, School of Architecture	Student Member
Ajar Sharma	Ph.D. Candidate, Systems Design Engineering	Student Member
Andjela Tatarovic	Undergraduate Student, School of Architecture	Student Member
Kirsten Wright	Ph.D. Candidate, Systems Design Engineering	Student Member
FACULTY OF ENVIRONMENT		
Peter Deadman	Associate Professor, Geography and Environmental Management and Interim Associate Dean, Graduate Studies	Core Member
Thomas Homer-Dixon	Founder and Director, Cascade Institute, Royal Roads University and Faculty of Env. University Research Chair	Core Member
Dawn Parker	Professor, School of Planning	Core Member
Stephen Quilley	Associate Professor, School of Environment, Resources and Sustainability	Core Member
Vanessa Schweizer	Associate Professor and Associate Chair, Undergraduate Studies, Knowledge Integration and WICI Director	Core Member
Sarah Burch	Associate Professor, Geography & Environment Management	Affiliate Researcher
Neil Craik	Professor, School of Environment, Enterprise and Development (SEED) and Balsillie School of International Affairs	Affiliate Researcher
Sean Geobey	Assistant Professor, School of Environment, Enterprise and Development	Affiliate Researcher
Yu Huang	Postdoctoral Researcher, University of Waterloo	Affiliate Researcher
Dan McCarthy	Associate Professor, Environment, Resource & Sustainability (SERS)	Affiliate Researcher
John McLevy	Associate Professor, Knowledge Integration	Affiliate Researcher
Jeremy Pittman	Assistant Professor, School of Planning	Affiliate Researcher

List of WICI Members in 2020 by Faculty and Affiliation

Derek Robinson	Associate Professor, Geography and Environmental Management	Affiliate Researcher
Simron Singh	Associate Professor, School of Environment, Enterprise and Development	Affiliate Researcher
Hazem Ahmed	Ph.D. Candidate, School of Planning	Student Member
Joe Battikh	Ph.D. Candidate, School of Environment, Enterprise and Development	Student Member
Ileana Diaz	Ph.D. Candidate, Geography and Environment Management	Student Member
Truzaar Dordi	Ph.D. Candidate, School of Environment, Enterprise and Development	Student Member
Milton Friesen	Ph.D. Candidate, School of Planning	Student Member
Fatima Jahanmiri	Ph.D. Candidate, School of Planning	Student Member
Katherine Laycock	Ph.D. Candidate, School of Planning	Student Member
Christopher Luederitz	Ph.D. Candidate, Geography and Environment Management	Student Member
Adrienne Mason	MSc Candidate, School of Environment, Resource & Sustainability (SERS)	Student Member
Majid Mirza	Ph.D. Candidate, School of Environment, Enterprise and Development	Student Member
Nicholas Palaschuk	Ph.D. Candidate, School of Environment, Enterprise and Development	Student Member
Perin Ruttonsha	Ph.D. Candidate, School of Environment, Resource & Sustainability (SERS)	Student Member
Katharine Zywert	Ph.D. Candidate, School of Environment, Resource & Sustainability (SERS)	Student Member
FACULTY OF HEALTH		
Sharon Kirkpatrick	Associate Professor, School of Public Health and Health Systems and Associate Director, WICI	Core Member
Warren Dodd	Assistant Professor, School of Public Health and Health Systems	Affiliate Researcher
Craig Janes	Professor, School of Public Health and Health Systems	Affiliate Researcher
Christopher Perlman	Assistant Professor, School of Public Health and Health Systems	Affiliate Researcher
Lesley Andrade	PhD Candidate, School of Public Health and Health Systems	Student Member

List of WICI Members in 2020 by Faculty and Affiliation

Julia Goyal	PhD Candidate, School of Public Health and Health Systems and Department of Mechatronics	Student Member
Kirsten Lee	PhD Candidate, School of Public Health and Health Systems	Student Member
FACULTY OF MATHEMATICS		
Chris Bauch	Professor, Applied Mathematics	Core Member
Kathryn Fair	Postdoctoral Researcher, Bauch Lab	Affiliate Researcher
Hans de Sterck	Professor, Applied Mathematics	Affiliate Researcher
Thomas Bury	Ph.D. Candidate, Applied Mathematics	Student Member
Peter Jentsch	Ph.D. Candidate, Applied Mathematics	Student Member
John Lang	Ph.D. Candidate, Applied Mathematics	Student Member
FACULTY OF SCIENCE		
Trevor Charles	Professor, Biology	Core Member
Anna Klinkova	Assistant Professor, Chemistry	Affiliate Researcher
Tejal Patel	Clinical Associate Professor, School of Pharmacy	Affiliate Researcher
Luis Ricardez Sandoval	Associate Professor, Chemical Engineering	Affiliate Researcher
Christopher Greyson-Gaito	Ph.D. Candidate, Integrative Biology	Student Member
Chantal Hutchison	Ph.D. Candidate, Biology	Student Member
EXTERNAL WICI MEMBERS		
Madhur Anand	Professor, Ecology and Environmental Sciences, University of Guelph	External Core Member
Laurette Dubé	Founding Chair and Scientific Director, McGill Centre for the Convergence of Health and Economics, McGill University	External Core Member
Liane Gabora	Associate Professor, Psychology, UBC Okanagan	External Core Member
Mary O'Connor	Professor, Zoology, UBC	External Core Member
Raja Sengupta	Associate Professor, Geography, McGill University	External Core Member

List of WICI Members in 2020 by Faculty and Affiliation

James Shelley	Knowledge Mobilization Coordinator, Arthur Labatt Family School of Nursing & Research Project Coordinator, Faculty of Health, Western University	External Core Member
Roger White	Professor, Geography, Memorial University	External Core Member
W. Brian Arthur	External Professor, Santa Fe Institute	External Affiliate
Robert Axtell	George Mason University	External Affiliate
Yaneer Bar-Yam	Founder, New England Complex Systems Institute	External Affiliate
Michael Batty	Bartlett Professor of Planning, University College London and Chair, Centre for Advanced Spatial Analysis (CASA)	External Affiliate
Marisa Beck	Research Director, Institute for Science, Society and Policy (ISSP)	External Affiliate
Eric Beinhocker	Professor, Public Policy Practice, Oxford Martin School and Executive Director, Institute for New Economics Thinking, Blavatnik School of Government, Oxford University	External Affiliate
Jessica Blythe	Assistant Professor, Environmental Sustainability Research Centre, Brock University	External Affiliate
Teresa Branch-Smith	Postdoctoral Researcher, Institut Jean Nicod Epistemic Norms Lab	External Affiliate
Virginia Capmourteres	Postdoctoral Researcher, University of Guelph	External Affiliate
Monica Cojocaru	Professor, Department of Mathematics & Statistics, University of Guelph	External Affiliate
Yue Dou	Research Associate, Environmental Geography, Vrije Universiteit Amsterdam	External Affiliate
Niall Douglas	Capital Markets Platform Consultant, C++	External Affiliate
J. Doyne Farmer	External Professor, Santa Fe Institute	External Affiliate
Bill Flanik	Assistant Professor of Political Science - Colorado Mesa University	External Affiliate
Carl Folke	Science Director, Stockholm Resilience Centre	External Affiliate
Ian Goldin	Director, Oxford Martin School, Oxford University	External Affiliate
Scott Heckbert	Chief Environmental Scientist, Alberta Energy Regulator, and Adjunct Assistant Professor, University of Lethbridge	External Affiliate
Matthew Hoffmann	Associate Professor of Political Science, University of Toronto	External Affiliate
Ilias Kotsireas	Professor, Physics and Computer Science	External Affiliate
Jude Kurniawan	Researcher, Institute for Advanced Sustainability Studies	External Affiliate

List of WICI Members in 2020 by Faculty and Affiliation

Eric Lambin	Professor & Senior Fellow, Woods Institute for the Environment, Stanford University	External Affiliate
Anna Lawniczak	Professor, Mathematics & Statistics	External Affiliate
Diana Luna-Gonzalez	Research Assistant, International Institute for Applied Systems Analysis	External Affiliate
Jon Mackay	Lecturer, Management Sciences, University of Auckland	External Affiliate
Hassan Masum	Director of Data Science, Prodigy Game	External Affiliate
Anthony Masys	Associate Professor, Global Disaster Management & Homeland Security, University of South Florida	External Affiliate
Sergey Melnik	Lead Data Scientist, Cara Operations	External Affiliate
Matto Mildenberger	Assistant Professor, Political Science, University of California	External Affiliate
Manjana Milkoreit	Assistant Professor, Political Science, Purdue University	External Affiliate
Jukka-Pekka Onnela	Associate Professor, Biostatics; Director, Health Data Science Program, Harvard School of Public Health	External Affiliate
David A. Petrie	Professor and Department Head, Department of Emergency Medicine, Dalhousie University	External Affiliate
Amanda Raffoul	Postdoctoral Researcher, Harvard STRIPED	External Affiliate
Felix Reed-Tsochas	Director, Oxford Martin Programme on Complexity	External Affiliate
Rob Robson	Principal Advisor, Institute for Healthcare Communication, Healthcare System Safety & Accountability Inc.	External Affiliate
Sergio Rossi	Professor of Forest Ecology, Université du Québec	External Affiliate
Marten Scheffer	Aquatic Ecology and Water Quality Management, Wageningen University	External Affiliate
Mathias Schulze	Professor and Director, German, San Diego State University	External Affiliate
Naresh Singh	Senior VP, Global Partnerships, Global Development Solutions Canada	External Affiliate
Lee Smolin	Adjunct Professor, Physics, Perimeter Institute for Theoretical Physics	External Affiliate
Matteo Smerlak	Research Group Lead, Max Planck Institute for Mathematics in the Sciences	External Affiliate
Robert Spekkens	Theoretical Physicist, Perimeter Institute	External Affiliate
Leah Stokes	Assistant Professor, Political Science, University of California	External Affiliate

List of WICI Members in 2020 by Faculty and Affiliation

Shreyas Sundaram	Associate Professor, School of Electrical and Computer Engineering, Purdue University	External Affiliate
William Sutherland	Physician & Assistant Clinical Professor, McMaster University; Founder & Director, Institute for Complexity and Connection Medicine	External Affiliate
Isaac Tamblyn	Adjunct Professor, Economics, University of Ontario Institute of Technology	External Affiliate
Mohamed Tawhid	Professor, Department of Mathematics and Statistics, Thompson Rivers University	External Affiliate
Leigh Tesfatsion	Professor of Economics, Mathematics, and Electrical & Computer Engineering, Dept. of Economics, Iowa State	External Affiliate
Ola Tjornbo	Assistant Professor, Applied Human Sciences, Archipelago Constultants	External Affiliate
Mark Tovey	Adjunct Research Professor, History, University of Western	External Affiliate
Tara Vinodrai	Associate Professor and Director, Master of Urban Innovation, University of Toronto	External Affiliate
John Whalley	Chair in International Trade, Professor Emeritus of Economics, University of Western Ontario	External Affiliate
Jan Wouter Vasbinder	Founder, Para Limes Institute, Singapore	External Affiliate
Reza Yousefi-Nooraie	Postdoctoral Researcher, Institute of Health Policy, Management & Evaluation, University of Toronto	External Affiliate
Haotian Zhang	Senior Research Engineer, Samsung AI Centre	External Affiliate
Robert Babin	Data Analyst, Municipal Property Assessment Corporation	Practitioner Member
Kary Bheemaiah	Engagement Manager, Farenheit 212	Practitioner Member
Robert Cutler	Complex Organization and Decision Specialist, Canadian Energy Research Institute	Practitioner Member
Mark Damm	CEO, Fuseforward Group	Practitioner Member
Sami Houry	Senior Research Officer and Project Manager, Athabasca University	Practitioner Member
Xiongbing Jin	Senior Specialist at Canadian Mortgage and Housing Corporation	Practitioner Member
Jamie Miller	President, Environmental Engineering, Biomimicry Frontiers	Practitioner Member

List of WICI Members in 2020 by Faculty and Affiliation

Kirsten Moy	Senior Fellow, Aspen Institute	Practitioner Member
Glenn Smith	Director, Project Management, Communitech	Practitioner Member
Kevin Yeung	Transport Planning & Advisory Planner, Arup	Practitioner Member
Samuel Petrie	Masters student, Spatial Determinants of Health Lab, Carleton University	Student Member
Nicholas Damer	Master of Arts, Political Science, Carleton University	Student Member

2.1.3 APPLICATION FOR MEMBERSHIP

Interested parties can apply directly to WICI for membership through the website, by submitting a letter of inquiry and a CV, which are reviewed by WICI's administrative leadership in consultation with the steering committee, to ensure their research activities reflect an active interest in complex systems science. Particular individuals may be invited directly to become WICI members, often once they have participated in WICI events or activities or upon the recommendation of WICI steering committee or other members.

Other than core members, who are invited by the Director in consultation with the Associate Director and Steering Committee, all membership categories are designed to be open and ongoing to serve the networking goals of WICI.

2.2 ENGAGEMENT

WICI strives to maintain effective two-way communication with its membership. Our website has been actively maintained to strive for optimal navigability. A regular newsletter of events and information is circulated through the Mailchimp platform, and WICI actively maintains its Facebook, Twitter and LinkedIn accounts. All activity and event participants are openly encouraged to subscribe to the newsletter as an initial access point for more information and are invited to learn more about WICI on our webpage. Official member surveys have been conducted to evaluate the services and activities offered, and many informal collaborative discussions have taken place over the years.

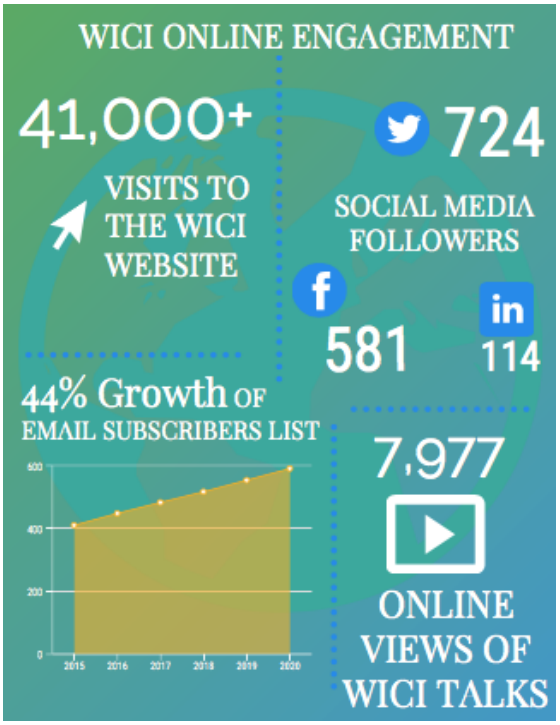


Figure 4: WICI Online Engagement

2.2.1 ONLINE ENGAGEMENT

WICI's website continues to be the primary source for information relating to the Institute. It is used to share news about upcoming events, profile WICI members, and recruit researchers and staff. Software, tools, publications, relevant career opportunities and other resources are also available on our website. As of December 31, 2020, the WICI website has had a cumulative total of **41,413** visits.

WICI has a Mailchimp email list with **591** active subscribers, which is a growth of over 44% since our first year using this platform. Members are given the opportunity to subscribe from visiting our website and/or attending our events, and are able to unsubscribe any time. Events and news are also publicized using WICI's social media channels. Our LinkedIn company page, Facebook page, and Twitter feed are now reaching an audience of **581**, **724**, and **114** followers respectively. Figure 3 highlights our key online engagement numbers.

WICI also records most of its speakers' talks and posts the [Vimeo] video links on our website, allowing viewers from all over the world to engage with the ideas presented. As of December 31, 2020, the video recordings of core members on "What is a Complex System?" that were recorded in 2018 have already been viewed a total of **2,939** times, and all of the WICI talks available on our website have been viewed a total of **7,977** times. A full list of view counts for videos on the WICI Vimeo site was listed in Table 17: WICI Seminars and Video Viewing Statistics on page 46.

The high view counts of recorded WICI talks on our Vimeo account demonstrate that in addition to capturing a significant crowd of in-person attendees, our WICI seminars are also reaching an audience long after the talks have taken place. It is important to note that while, as expected, talks by high-profile complexity scholars (Solomon, Thagard, Eliasmith, Westley) have very high view counts, many talks by junior and mid-career scholars on the University of Waterloo campus (Walker, Crowley, K. Robinson) also have very high view counts, highlighting the recognized contributions of local junior scholars to complex systems science.

2.2.2 WICI 2019 MEMBERSHIP SURVEY

In fall 2019, WICI sent a survey to all current members to gage their past interaction with the Institute and solicit their thoughts on our direction moving forward. Thirty-five people participated in the survey. This is double the number of participants who completed our 2015 member survey, which was discussed in the WICI 2015 Five-Year Review Report.

Respondents suggested that WICI's greatest value continues to lie in sharing current research through the speakers series and/or network-building for complex systems research on campus and beyond. The next two greatest values WICI has provided appear to be in direct support for cross-faculty collaborative research and in training/education opportunities through workshops, reading groups or working groups.

Thirty percent (30%) of respondents suggested that WICI should strengthen its activities in training/education opportunities. Comments relating to training/education opportunities specifically:

- "Regular trainings for students would be great"
- "Training on existing tools and methodologies: integrating approaches to complex problems"
- "More exploratory/conversational opportunities would be very interesting"
- "Best if these can include remote participation somehow"
- "Training/education opportunities could be considered that target post-docs and faculty"
- "Complex systems certificates (grad/undergrad) esp. methods classes at Waterloo"

- "Industry initiatives such as a 'Problems solved' seminar detailing how a company solved a problem through an analysis of complex systems" or a 'Hard unsolved problems' series where industry presenters seek a complex systems approach to difficult problems they face"

The full report is included as Appendix B: WICI 2019 Member Survey Report.

Overall, it was determined from this survey that WICI members recommend a clearly defined mission and scope, which includes a continued commitment to maintaining and growing a strong local (and national) network of complex systems scholars, regular delivery of activities that include talks and/or workshops, additional training and/or education initiatives, with consideration for external members and/or partners as well as students.

3. ELEVEN YEARS OF ACCOMPLISHMENTS

The following section summarizes WICI's achievements during its eleven years of operation in the areas of core research projects and funding, scholarly outputs, student involvement, and events.

3.1 CORE RESEARCH PROJECTS

Over WICI's past eleven years, there have been a wide variety of research projects led by our Core members. Many of these have developed additional related projects and research groups, and all of them have supported a number of graduate students and postdoctoral fellows in their research while attracting external funding. Progress updates for each active core research are provided in our Annual Reports each year, and are posted on our website.

ALGEBRAIC INTELLIGENCE & COMPUTATION (2018-)

In 2018, Chrystopher Nehaniv joined the University of Waterloo and founded the Waterloo Algebraic Intelligence & Computation Laboratory (WAICL), securing start-up funds of $150K and an NSERC Discovery grant ($205K). Research in the Waterloo Algebraic Intelligence and Computation Lab develops new tools and methods for STEM areas, including Neuroscience, Biochemical and Biological Networks. Research in this area carried out by U Waterloo students in Nehaniv's new course SYDE 710 in 2019 led to all students, except the one auditor, having at least one accepted refereed abstract and presentation as co-author (with Nehaniv) at an international Complex Systems conference (V AMMCS) based on course projects and assignments. Six of the accepted presentations from the conference were expanded to full papers, independently refereed and accepted for a Springer post-proceedings in 2020 (now in press). Three Waterloo undergraduates (Eric Lin, Alex C. Chen, Zixuan Gao) whom Nehaniv supervised in WAICL, contributed to publications and to a US Air Force Cognitive and Computational Neuroscience program review invited talk in 2020, and will be co-authors of the final technical report and journal papers currently in preparation. At the end of 2020, two outstanding international undergraduate students (math- and physics- Olympiad winners) have been selected for two projects in WAICL as research internships (and travel to Waterloo, if possible) funded under MITACS Global Link Undergraduate Research Assistants in Summer 2021. Two projects funded under this theme are "Automatic computational understanding and manipulation of finite discrete-event dynamical systems throughout natural sciences and engineering" and "Novel computational methods for predicting transitions in spatiotemporal neurodynamics between attention and mind-wandering".

ARTIFICIAL INTELLIGENCE-BASED TOOLS FOR FRESH PRODUCE PROCUREMENT PRICE DECISIONS IN CANADIAN DISTRIBUTION CENTERS (2020-)

Market price forecasting models for Fresh Produce (FP) are crucial to protect retailers and consumers from highly priced FP. However, utilization of the data for forecasting is obstructed by the occurrence of missing values and limited by conventional machine learning or simple deep learning models with moderate performance. Therefore, it is imperative to develop imputation models for those missing instances thereby enabling effective forecasting. Moreover, most of the current forecasting models are for yield forecasting and they are either conventional machine learning or simple deep learning models with moderate performance. These models are usually univariate, i.e. do not consider many of the factors that affect the yield, or multivariate models that rely on historical station-based data that are not readily available for many croplands around the globe. In addition, fresh produce price prediction is rare to find and the models are univariate considering previous prices as input. All available yield and price forecasting models tend to be crop dependent and most of the work consider one crop per model leaving out any framework for generalization to other crops.

Fahkri Karray's research team, which includes WICI member Dawn Parker, proposes a deep learning (DL) application to be used for decision support by procurers, which forecasts the fresh produce yield and prices for any county using extensive DL models to enhance performance. Hence station-based data, imputed by DL imputation models to avoid missing data, as well as satellite images are used to overcome the scarcity of data in some geographic areas. Compound deep learning forecasting models such as SeriesNet with Gated Recurrent Unit (GRU) and Convolutional Neural Network LSTM with Attention layer (Att-CNN-LSTM) are trained and tested with both: station-based parameters and the same parameters extracted from satellite images. An averaging ensemble of both outputs is built for better forecasting performance. Strawberry is chosen as initial FP and the microeconomics theory is used to estimate the supply curve of strawberries based on Loblaws procurement dataset. A generalization framework should be provided to transfer the learning to similar crops or retrain for dissimilar ones. The application should be tested with complete functional and usability test scenarios to ensure accuracy and user friendliness. This project is supported by Loblaws and a Natural Sciences and Engineering Research Council (NSERC) Collaborative Research and Development Grant ($600,000).

ASSESSMENT OF AGRICULTURAL BEST MANAGEMENT PRACTICES (2018-)

Peter Deadman's research group continues work on the assessment of the impact of agricultural best management practices (BMPs) on water quality, with a focus on watersheds in southwestern Ontario. The research group is using hydrological models (SWAT) to simulate the impact of the frequency and spatial distribution of BMPs on key water quality parameters (nitrogen and phosphorus) in agricultural watersheds. The work includes the use of agent-based models to simulate farmer decision making around the selection and implementation of BMPs.

AUGMENTING DECISION-MAKING IN COMPLEX AND SAFETY-CRITICAL DOMAINS (2018-)

This project, led by Assistant Professor Mark Crowley, focuses on problems of prediction and control in the areas of forest fire management, medical imaging and autonomous driving. The work on forest fires includes two main approaches. The first uses deep neural networks to learn compact models of forest fire spread directly from data such as satellite images or computationally expensive, physics based simulations. Another, more holistic approach taken uses reinforcement learning and game theory to learn a policy for wildfire spread across a landscape based on local conditions, as if the wildfire were an agent making decisions about where to move next. This approach utilizes multi-modal satellite, weather and other data to build more robust and generalizable models for prediction and decision making. These simulations are currently being applied to forest fire management but could apply to flood

management, disease modelling and urban sprawl as well. This project involves collaborations with researchers in applied fields such as sustainable forest management, ecology, automotive technology and medical imaging.

BLUE-GREEN INFRASTRUCTURE ON PRIVATE LANDS (2019-)

Building on previous work impacts of residential stormwater management on Potomac Gorge stream water quality and the SLUCE2 project examining linkages between residential landscaping and carbon sequestration, Dawn Parker's research group is beginning new research on residential land management in Kitchener-Waterloo and blue-green infrastructure. As climate change and urbanization accelerate, so does flood risk. Rapid urbanization and climate change are leading to increasing stormwater (SW) runoff due to increases in paved surfaces and extreme storm events. Traditional "grey" infrastructure on public lands is proving insufficient to manage this SW increase. Green infrastructure (GI) for stormwater management on private land (such as rain barrels, rain gardens, and permeable paving) is potentially part of a hybrid system solution, since private yards occupy more than 50% of urban areas, and such decentralized infrastructure is more adaptable to changing conditions. While GI has the potential to alleviate some flood risk, a significant knowledge gap exists regarding barriers to adoption of GI on private lands, the impact of GI adoption on flood risk, and flood impacts at the watershed scale. Working with the Cities of Kitchener and Waterloo, the non-profit REEP Green Solutions, and two consulting firms, the research team seeks to co-develop policies to facilitate further resident adoption of GI for SWM on private lands. The research group is working to develop an empirical agent-based model (ABM) of resident information, attitudes, knowledge, socio-economics, and social norms to explore the potential for policies and institutional supports to catalyze GI adoption.

COMPLEX SYSTEMS SCENARIO ANALYSIS (2016-)

Vanessa Schweizer researches complex systems methods for scenario analysis in the context of the human dimensions of climate change (HDCC). In 2016, she received an NSERC Discovery Grant to use complex systems methods for understanding difficult-to-imagine but high impact scenarios, so-called 'black swan' or 'perfect storm' scenarios. Also, in 2016, she was hosted as a Visiting Professor by the Helmholtz Alliance in Germany for the ENERGY-TRANS project, which studied the German energy transition. In 2017, she was a Visiting Scholar at the US National Centre for Atmospheric Research with the Integrated Assessment Modeling Group. In 2018, she began new research projects that interface her methods with other complex systems approaches, namely agent-based modelling (through hosting a WICI International Visiting Graduate Student (IVGS), Mr. Tristan de Wildt from TU Delft in the Netherlands) and network analysis. With Mr. de Wildt, she continues to work on the social justice dimensions of low-carbon energy transitions, and their research has been presented at two congresses of the International Environmental Modelling & Software Society. In 2018-19, she initiated new projects in complex systems methods for decision support in water management with WICI core member Keith Hipel. Also in 2018-19 with her students, she has worked on using scientometrics to perform semi-automated scientific assessment of HDCC scenario studies. In 2020 with her students, she has focused on complex systems methods for identifying strategies to achieve the Sustainable Development Goals (SDGs) both globally and at the national level. A book chapter is currently in review regarding strategies for business contributions to achieve the SDGs globally. A project focusing on achieving the SDGs in the context of Small Island States is also underway with an IVGS, Sen. Crystal Drakes from the University of West Indies at Cave Hill, Barbados. For Dr. Schweizer's work on the HDCC, she has been an invited co-collaborator on two grant applications regarding climate intervention strategies (e.g. carbon dioxide removal and solar geoengineering) prepared by investigators at the US University Corporation for Atmospheric Research. The applications are in review with the US National Science Foundation and total $4 million.

COMPLEXITY IN DIETARY PATTERNS, UNINTENDED CONSEQUENCES OF NUTRITION POLICIES AND PROGRAMS (2018-)

This research is led by Sharon Kirkpatrick and supported by a team of WICI graduate student members. Understanding people's eating patterns—including what they eat and drink and the contextual factors that influence diet—is essential to better elucidating how diet influences health, as well as how to support eating patterns consistent with disease prevention. The main focus of Dr. Kirkpatrick's work is on improving and disseminating strategies for appropriately collecting, analyzing, and interpreting dietary data. Current areas of focus include novel methods for characterizing the complexity of eating patterns and their associations with health, with an emphasis on the potential for deep learning to overcome the limitations of current dietary patterns research.

Dr. Kirkpatrick's work also explores the utility of systems thinking and methods to better understand the array of factors that influence major nutrition challenges and the effectiveness of interventions to address these challenges. Her graduate students are examining the implications of policies such as calorie labelling for nutrition and health, with a consideration of unintended consequences. This work involves quasi-experimental and mixed-methods research. We also consider how public health nutrition issues cluster (e.g., eating disorders and food insecurity), as well as how practices such as dieting cluster with other risk factors for poor health, such as smoking. Our work also centers equity, considering intersectionality in relation to differentials in eating patterns and other nutrition-related practices.

COUPLED HUMAN-ENVIRONMENT SYSTEMS THEORY (2016-)

This core project explores the dynamics of coupled human-environment systems and the implications of these dynamics for environmental health and sustainability. A coupled human-environment system involves a two-way interaction between human systems and our environment: what humans do influences the environment, but the resulting changes in the environment in turn influence our perceptions and behaviour. Humans and their environment together thus form a single, coupled nonlinear system.

Professors Chris Bauch and Madhur Anand have been moving this core project forward in 2020 through the initiation of new projects as well as the fruition of existing projects. This work has been spearheaded by their co-supervised graduate students. The core project was also supported by seed funding from the WICI Grant Challenges in 2017-18.

Projects with co-supervised students continued concerning COVID-19 transmission models based on complex systems principles; developing new types of early warning signals for tipping points in complex systems; spatial ecosystem mosaic dynamics; human-environment dynamics of forest pest outbreaks; human feedbacks on invasive versus native grasslands; mining social media data for clues about dynamics of climate change; the effects of globalization and interconnectedness on socio-ecological population collapse; and further development of their long-standing collaboration on forest-grassland mosaics.

DID MIRACLE PROJECT/OPEN MODELLING (2013-)

Dawn Parker received funding from the Social Sciences and Humanities Research Council (SSHRC) via the Digging into Data Challenge (DiD) from 2013-2016. The international DiD program was established to advance the use of computational methods to explore, analyze and visualize the rapidly expanding pool of crowd-sourced and remotely sensed "big data" from real-world systems. Unique among her year's awards, Parker's research team developed tools to analyze output from computerized simulation models and compare that output to real-world "big data."

MIRACLE created a prototype community platform to support complex systems research across research communities, providing access to sample output from computational models, as well as the algorithms used for analysis. Building on this project, Parker continues to collaborate with the CoMSES project at Arizona State University, hosting the current CoMSES platform on Compute Canada via a Portals and Platforms award. (This work is also supported by the US NSF BD Spokes: Spoke: West: Accelerating and Catalyzing Reproducibility in Scientific Computation and Data Synthesis (Michael Barton, ASU, PI). Expanding on the scope of MIRACLE and CoMSES, Parker and Piereder have been exploring new bibliometric tools in a recent project *Mapping Canadian Complex Systems Scholarship*, for keyword and scholar community identification, including Gargantext, an open-source tool developed and hosted through the Complex Systems Institute of Paris Ile-de-France (ISC-PIF). They have proposed to implement a Gargantext implementation through CoMSES, which could be available for WICI scholars for specific projects. CoMSES is also leading development of an international Open Modelling Foundation, and Parker is an active participant.

ECONOMICS FOR THE ANTHROPOCENE (2018-)

Through WICI, Stephen Quilley has been a partner on the *Economics for the Anthropocene* project – an international partnership between McGill, Vermont and York. Working closely with Prof. Peter Brown at McGill (including being on the committee for one of his students), Quilley has helped to create an opening for Katie Kish, who is now playing a leading role in the Canadian Society for Ecological Economics (CANSEE). In consequence, Quilley was on the scientific committee of the CANSEE 2019 conference that was held in Waterloo where he gave a keynote presentation with Paul Gregory, Director of Outreach for the Green Party (personal capacity).

FOLK THEORIES OF SOUND JUDGEMENT (2019-)

This project, led by Igor Grossmann, concerns exploration of a theoretical framework accommodating the notion of rationality advocated in neoclassic economics and political science with the Aristotelian notion of practical wisdom, as well as the notion of reasonable judgment discussed by legal philosophers such as Rawls. The core question is how lay people understand these concepts and whether their intuitive understanding corresponds to any of the distinct philosophical positions. Over many studies involving linguistic analyses of large-scale text corpora, behavioral experiments, and surveys, Grossmann's team has observed that people represent intellectual virtues by accommodating two distinct standards of judgmental competence: a standard of rationality that corresponds to economists' definition of decontextualized rational self-interest, and a standard of reasonableness that corresponds to philosophical traditions encouraging context-specific balance of self-interest with fairness. For instance, experiments show that concerns for rationality and reasonableness lead people to different conclusions about what constitutes good judgment in dilemmas that pit self-interest against fairness: Rationality is absolute and self-maximizing, whereas reasonableness pays attention to particulars and fairness (Grossmann et al., *Science Advances*, 2020). Currently, the team aims to expand this framework theoretically, providing a synthesis of ideas from distinct streams of behavioral and decision sciences, and to test implications of this framework in real life (e.g., by developing intergroup hostility reduction techniques via framing other party's actions as irrational vs. unreasonable).

NAVIGATORS OF THE ANTHROPOCENE (*RESEARCH GROUP)* (2018-)

Since 2015 Stephen Quilley has worked with Dan McCarthy to develop a broad cluster of doctoral projects under the WISIR Umbrella, working with Barb Davy, Katherine Zywert (with Jennifer Lynes) and most recently Anna Beresford. In different ways these students are developing projects that share a theoretical framework that combines a complex systems approach to social and economic change,

radical political economy and an emphasis on the significance of ontology and non-rational drivers of behaviour in process of cross-scale systems change. Specific foci include: neo-paganism and ritual, ecological conscience formation and environmental politics (Barb Davy); communitarian experiments in health care and post-capitalist, post- growth health/welfare systems (Zywert); peer-to-peer production and the reMaker society (Kish); and social capital formation and sustainable community in traditional music culture (Beresford).

Continuing over the last two years, students Perin Ruttonsha, Katie Kish, Barb Davy, Anna Beresford and Katherine Zywert have all been dealing with very theoretical problems which draw upon literatures far removed from the centre of gravity of an albeit interdisciplinary department. This work is highly intensive, often rewarding for both parties and absolutely critical, though it takes a great deal of time. This is a necessary transaction cost of interdisciplinarity. Katie Kish defended her dissertation in 2019. She is currently finishing a post-doc with the E4A project and she and Dr. Quilley are working on an Insight Grant application as well as a book for Routledge looking at the UN Sustainable Development Goals through the lens of ecological economics.

PROTOTYPING LAB PROJECT (2018-)

Stephen Quilley with Marcel O'Gorman were awarded a CFI-JELF grant to support the work of students and researchers who are investigating the social, psychological, and environmental impacts of contemporary technologies. The equipment purchased through this grant has been used to train HQP in the creation of digital interfaces, apps, and small electronics that serve as "objects-to-think-with." More specifically, in the past year 15 graduate students have been trained in 3D modelling and printing, physical computing, Internet of Things design, big data analysis, and visualization. The training has paid off in the form of research papers presented, hardware projects showcased in design exhibitions, and Mitacs funded positions for students at Deloitte and North (formerly Thalmic Labs). This project builds on the ongoing work in relation to Stephen Quilley's (Metcalf Funded) reMaker Society and represents quite a unique interdisciplinary collaboration.

RAPID IDEOLOGICAL CHANGE (RIC) PROJECT (2018-)

Tad Homer-Dixon was awarded a 3-year SSHRC Insight Grant for *Ideological Conflict Project (ICP), Methods field testing* in the spring of 2018. In 2019, the research team continued the development of its methods for modeling the emotional content of ideologies as complex systems into practical tools for data gathering and conflict resolution. Pilot exercises simulating conflict resolution negotiations were conducted with volunteers in the Waterloo region as well as with student volunteers at Bilkent University in Ankara, Turkey, under the supervision of Prof. Esra Cuhadar. Consultations were also held at a workshop in at the Potsdam University of Applied Sciences with German researchers using ICP methods as data gathering tools in psychology research, to further the development of standardized research materials. Drawing from these consultations, a beta version of new software for drawing Cognitive-Affective Maps called Valence is now available online for testing and public use. Plans for methods field testing were suspended in the spring of 2020 due to the pandemic; a partial test was conducted online in October of 2020. Full testing will resume when meetings can again be conducted in person.

REMAKER *(RESEARCH GROUP)* (2016-2017)

Working with colleagues across several departments and three faculties, Stephen Quilley led a series of research initiatives and funding applications, centred on the possibilities of a reMaker society. Initial research involved a series of Maker workshops (working with local Maker spaces, KWARTZLab, DIYODE

and the Maker Club for Kids) as well as developing links with social psychologists at Wilfrid Laurier University. A CFI-funded Critical Media Prototyping Suite was developed.

In relation to the Metcalf grant (www.remakersociety.com) this group was exploring issues of meaning and ontology in relation to art, fabrication, making and DIY and maintenance activity. This work was framed in terms of 'terror management theory' and linked to WICI's wider projects on the dynamics of ideological change and 'alternatives to conventional economic growth'. It built also on a relation with Prof. Sheldon Solomon established in the wake of his WICI talk 'Afraid of the Dark: Humanity at the Crossroads' (http://wici.ca/new/event/sheldon-solomon/); and connected with Sarah Wolfe's agenda around water-related governance and behaviour. The intersection of the reMaker Society project with the issue of non-rational drivers also attracted some interest outside academia. Following Steve Quilley's keynote presentation to the Canadian Society for Ecological Economics (Nov 2013), CANSEE President (and senior OMNR Economist) Andreas Link connected with his Ph.D. student Katie Kish with a view to involving her in the organization in an official capacity and she now serves on the Executive Committee. Link's rationale was that CANSEE needed to engage with our work on participatory fabrication and meaning frameworks. In 2017 this activity resulted in a special issue of Alternatives on the reMaker society and a workshop and presentations for the CANSEE 2017 conference in Montreal. The focus of this work was the application of complexity systems perspectives to linked issues of: (i.) rapid and non-linear environmental-political change; (ii.) ontological transformation; (iii.) a state-space model of alternative political economies defined by the domains of market, state and livelihood/reciprocity; and (iv.) material-energy throughput.

RETROSPECTIVE PHOTOGRAMMETRY AND VIRTUAL REALITY (2018-)

Peter Deadman is working on the use of historical photographs and survey data to construct 3D models of archeological sites for visualization using virtual reality technologies.

SOCIAL & INTELLIGENT ROBOTICS (2018-)

Chrystopher Nehaniv is co-Director and co-founder with Prof. Kerstin Dautenhahn, of the Social and Intelligent Robotics Research Laboratory (SIRRL), for which substantial infrastructure funding was secured ($939K), and which has established a growing research group with approximately 20 postdoctoral, research prof, graduate and undergraduate members. A steady and growing stream of research results and publications of U Waterloo MASc and PhD researchers working in Cognitive Robotics, Artificial Life, and Human-Robot Interaction (HRI) has been successfully initiated during 2019 and 2020. This builds directly on their expertise, and links with ongoing and previous work in the U.K. culminating in several ACM/IEEE/other journal and conference papers accepted and published in 2018-2020 in AI Robotics / HRI with former postdocs and students, and new students and researchers in SIRRL.

Nehaviv and Dautenhahn's research is situated in the fields of social robotics, human-robot interaction, cognitive and developmental robotics and Embodied Artificial Intelligence. They aim to discover fundamental principles and mechanisms that can make robots more socially intelligent, as well as enabling them to interact with people in a trustworthy and efficient but also "natural" and socially acceptable manner, e.g. in roles of co-workers, assistants or companions. The goal of this research is to advance knowledge in social and intelligent robotics and to develop robots that can make a positive contribution to human society.

URBAN GROWTH AND CHANGE *(RESEARCH GROUP) (*2012-)

Dawn Parker's research group is conducting long-term, highly empirical research to explore interactions between residential location and transportation decisions, using Kitchener-Waterloo and the natural experiment of its light rail implementation as a living laboratory case study.

The outward growth of cities after the Second World War and associated urban sprawl has created extensively documented negative impacts. As a result, contemporary planning policy and investments promote intensification–concentration of activities in vibrant urban cores and nodes and corridors that support accessibility and more efficient municipal expenditures. Rapid transit (RT) has potential to catalyze intensification, assuming that it causes intensification and economic vitality. However, while numerous studies have demonstrated correlation between these factors, due to data and methodological limitations, causality has not been established. Establishing causality is challenging, as some relationships may be direct–new RT investments may make adjacent lands more desirable–producing direct changes in property values. Yet, some impacts may be indirect, as RT investment might increase the density of complementary land uses, creating positive agglomerative feedbacks. Confounding the identification challenge, such feedbacks can occur independent of, and may themselves induce, RT investments. Further, RT investments often occur with complementary physical investments, higher land values, or policy changes to achieve planning goals.

The team's research responds to a natural experiment to explore the causal dynamics between the just-implemented Ion light rail transit (LRT), core-area intensification, residential land use and markets, and transportation behavior in Kitchener-Waterloo, Ontario, working with local government and industry partners. Research in the UGC research group has two streams: data gathering/analysis and modeling. Working in partnership with the Region of Waterloo, they are gathering and analyzing qualitative and quantitative information from the pre-build stage through completion of the LRT construction. To date they have surveyed residential land owners, renters, and developers, buyers, sellers, and real estate agents, with results reported in four completed student theses. A just-approved PhD thesis combines survey, land transaction, and assessment data for an in-depth, multi-method statistical examination of space-time price trends and their relationship to demographic buyer cohorts. A new paper in the Journal of Transportation Geography demonstrates that many buyer seek, but can't afford, transit-oriented development areas, and therefore locate in more car-dependent areas. In-progress research is chronicling retail changes along the LRT corridor to assess any retail gentrification trends. An additional study for the Region and cities examines property value impacts of cycling infrastructure, finding that it is associated with positive condo sales prices, and that street trees and tree canopy are associated with higher condo and home prices. The team will be using these data to build a series of agent-based models that model the joint evolution of residential land-use change and transportation behaviour. In addition to the partnership with Municipal Property Assessment Corporation and Teranet that facilitated their most recent research, the research team is exploring new collaborative partnerships with the Canadian Mortgage and Housing Corporation and the Bank of Canada.

WISDOM OF KNOWING THE DIFFERENCE: UNPACKING KNOWLEDGE OF STRATEGY-SITUATION FIT AND ITS RELATIONSHIP TO CONTEXT-SENSITIVE META-COGNITION (2019-)

At least since Aristotle, the notion of practical wisdom has focused on the ability to discern the best action for the different situations people encounter in their lives. For Aristotle and many scholars after him, practical wisdom concerned both knowledge of which strategies fit which situations and application of such knowledge in daily life. In contrast, current psychological wisdom research has largely focused on individual characteristics attributed to wise persons. Igor Grossmann proposes to

bring together these two approaches in a process model linking characteristics attributed to wise persons with knowledge of Strategy-Situation Fit (SSF) and its application in meaningful daily life situations. He hypothesizes that a "wise" meta-cognitive ability to discern the features of a situation, often attributed to wise people, affords greater SSF knowledge and facilitates its application in daily life. His goal is to provide a unified SSF framework encompassing an ecologically-derived set of cognitive, emotional, motivational and behavioural strategies, to assess their applicability across typical daily life situations, and to test the role of wisdom-related meta-cognitive processes for SSF development. Specifically, in this ongoing research he:

1. Develops tools to assess knowledge of Strategy-Situation Fit, with a focus on cognitive, emotional, motivational and behavioural strategies across different situations;
2. Explores the utility of Strategy-Situation Fit knowledge for performance in daily life;
3. Examines how wise meta-cognition and SSF influence each other over time.

WORLD AFTER COVID (2020-)

What will the post-pandemic "new normal" look like? There has been a great deal of speculation about how different societies may change as a result of the COVID-19 pandemic. Yet, so far, these speculations have largely focused on the economy and facets of daily life related to disease prevention and health. The voices of experts from the behavioral and social sciences have been largely missing from this conversation. This is noteworthy given that psychological and social changes may be intimately bound up with economic and health issues, and may be just as consequential. Opinions on possible outcomes of the pandemic appear to vary dramatically, be it among journalists, political commentators, pundits or the general public, but it is unclear how global experts in social, behavioral and political sciences view the post-pandemic future. What might the consequences be for mental health, intergroup relations, social norms, or political polarization? To address these questions, Igor Grossmann founded WorldafterCovid.info—a multimedia outreach project that involves gathering and sharing perspectives from the world's leading behavioral and social scientists regarding the potential societal and psychological changes stemming from the pandemic. Grossmann asked 57 of the world's leading experts (among them 11 fellows of national academies and 20 presidents of major scientific societies in behavioral and social sciences) to share their wisdom regarding how we might sustain positive changes and prevent or reverse negative changes resulting from the pandemic. The database of video interviews with a diverse set of leading behavioral and social science experts from around the world is a time capsule of scientists' hopes and worries over the course of the first wave of the COVID-19 pandemic in 2020. The project also involves use of innovate discourse analyses, natural language processing, and interactive visualization (https://www.IgorGrossmann.com/wac) to identify and illustrate core themes from reflections on the possible outcomes of the pandemic and wisdom needed to master it to the general public, policymakers, and diverse communities of academics.

3.2 RESEARCH FUNDING SUCCESS

Historically, all WICI related grants have been submitted by member Principal Investigators through their home units. WICI has supported these applications by providing direct administrative support to assist with grant preparation, offering in-kind and financial matching contributions, and facilitating connections between researchers working in complex systems, through its various events over the years.

As illustrated in Figures 5 and 6, WICI core member research projects have demonstrated increasing success in obtaining complex-systems related external research funding, both from Tri-Council Funding

Agencies and from other funding sources. More than 40% of the over $16.9 million dollars of funding that have been obtained, were from sources other than Tri-Council Funding Agencies.

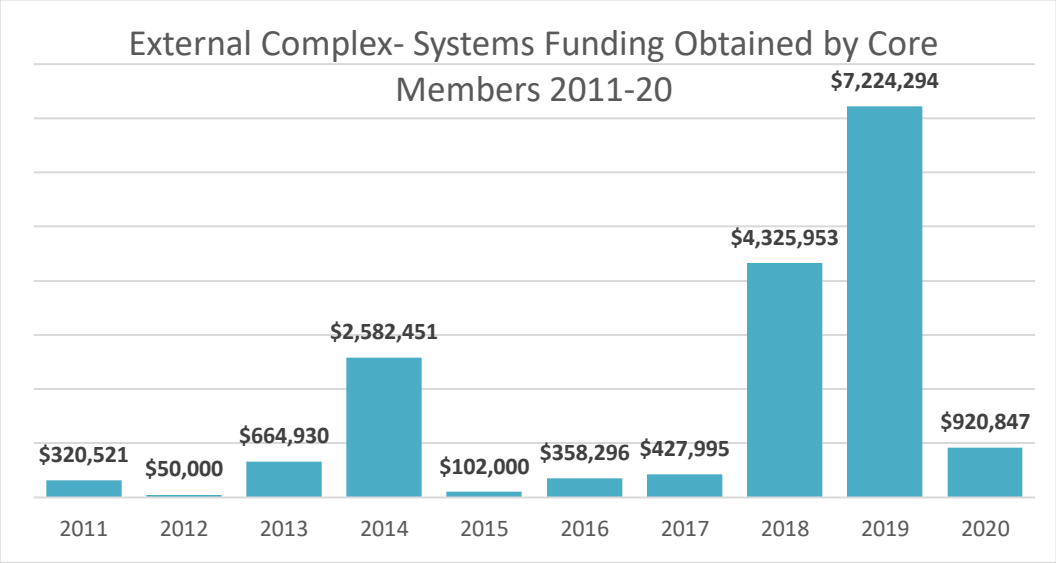


Figure 5: WICI-Related External Funding

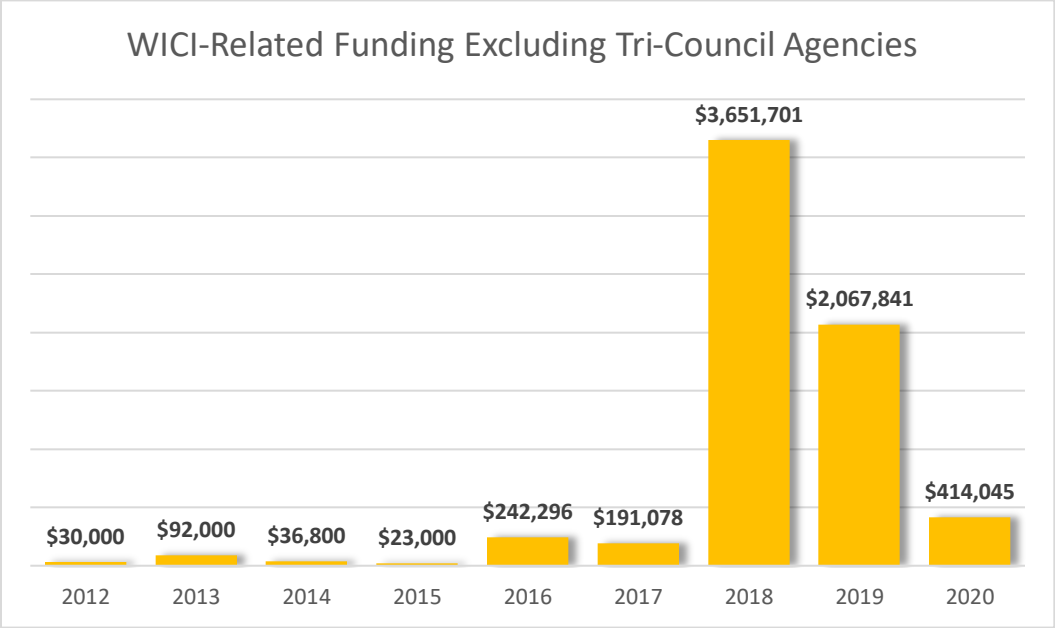


Figure 6: Non Tri-Council WICI-Related Funding

The funding successes WICI's core members have obtained demonstrate broader national and international collaborations, and success in network and capacity building over the years. Table 2 below features a list of the successful complex-systems related grants reported by WICI core members over the years. Some of these successes are directly attributed to partnerships formed through WICI-sponsored seminars, conferences or networking events, others through mentorship of more senior WICI members, and some through small matching funds provided by WICI.

Table 2: WICI Core Member Grants Obtaining Funding

COMPLEX-SYSTEMS GRANTS OBTAINING FUNDING BY WICI CORE MEMBERS 2011-2020

2011

- *Human-Environment Systems, Urban Growth and Change* - $320,521 from SSHRC for "*Urban intensification vs. suburban flight*" (Parker)

2012

- *Ideology:* $30,000 from CIGI CRA Research Initiative (Homer-Dixon)
- *Alternatives to Growth:* $20,000 from SSHRC Partnership Grant (Quilley)

2013

- *Ideology:* $90,000 from CIGI (Homer-Dixon)
- *Human-Environment Systems:* $125,000 from SSHRC, part of $567,000 (USD) from Digging into Data (Parker)
- *Human-Environment Systems, Urban Growth and Change:* $199,930 from SSHRC Partnership Development Grant for project "LIGHT RAIL TRANSIT AND CORE-AREA INTENSIFICATION: Unpacking Causal Relationships" (Parker)
- *Human-Environment Systems:* $198,000, Partnership Development Grant for project "Hedgelaying in Ontario's Greenbelt: A multicriteria assessment of social-ecological innovation and novel ecosystems" (Quilley)
- ***Open Modelling:*** Consulting on simulation model description protocols, Statistics Canada $2,000 (Parker)
- *Coupled Human-Environment Systems - Mathematical modelling of human-environment interactions:* $50,000 (yearly to a total of $250,000 over 5 years) from NSERC Individual Discovery Grant for "Dynamics of coupled human-environment systems" (Bauch)

2014

- *Alternatives to Growth:* $36,800 from Metcalf Grant (Green Prosperity Program) for "Green prosperity and the (re) Maker Society" (Quilley)
- *Economics for the Anthropocene:* $2,495,651 from SSHRC Partnership Grant (Lead institution McGill with York University and Vermont where students will be trained; WICI contribution $3,370) (Quilley)
- *Coupled Human-Environment Systems - Mathematical modelling of human-environment interactions:* $50,000 (yearly to a total of $250,000 over 5 years) from NSERC Individual Discovery Grant for "Dynamics of coupled human-environment systems" (Bauch)

2015

- *Urban Growth and Change:* Partnership Grant $230,000 (Parker)
- NSERC Discovery Grant – Schweizer $25,000 (yearly to a total of $125,000 over 5 years) for *"Uncovering 'perfect storms' among possible events affecting complex systems"* (Schweizer)
- *Coupled Human-Environment Systems - Mathematical modelling of human-environment interactions:* $50,000 (yearly to a total of $250,000 over 5 years) from NSERC Individual Discovery Grant for "*Dynamics of coupled human-environment systems"* (Bauch)

2016

- *Funding for Resilience Conference*: $4,000 from Fields Institute
- UW Seed Grant for SSHRC Insight Development Grant: $4,000 (50% of grant) for *"Revisiting Nature Conservation in Canada for the 'Human Age'* (Schweizer)
- *Coupled Human-Environment Systems - Mathematical modelling of human-environment interactions:* $50,000 (yearly to a total of $250,000 over 5 years) from NSERC Individual Discovery Grant for "*Dynamics of coupled human-environment systems*" (Bauch)
- *Coupled Human-Environment Systems* Canadian Foundation for Innovation-John R. Evans Leaders Fund (CFI-JELF) $234,296 for '*Coupled human-and-natural systems laboratory*.' (Bauch)
- NSERC Discovery Grant - $37,000 for *"Transitions and thresholds in global ecological changes of forest ecosystems"* (Anand)
- NSERC Discovery Grant – $25,000 (yearly to a total of $125,000 over 5 years) for *"Uncovering 'perfect storms' among possible events affecting complex systems"* (Schweizer)

2017

- *Urban Growth and Change* -UW IPRG Grant: $20,000 for "*Modelling Urban Complexity*" (Parker)

COMPLEX-SYSTEMS GRANTS OBTAINING FUNDING BY WICI CORE MEMBERS 2011-2020

- Canadian Foundation for Innovation-John R. Evans Leaders Fund (CFI-JELF): $40,000 for "*Critical Media Prototyping Suite"* (Quilley)
- Balsillie Seed Grant: $2,230 (Schweizer)
- UW/SSHRC Seed Grant: $7,000 (Schweizer)
- Global Water Futures Program: $120,000 for *"Agricultural Water Futures in Canada: Stressors and Solutions"* (Deadman)
- University of Guelph: $848 for *WICI Conference*
- Canadian Institutes of Health Research: $20,000 for *"Improving population health in an era of social-ecological instability and economic contraction"*(Quilley)
- *MIRACLE (DiD)* – Resource allocation from Compute Canada for the CoMSES Net Community Web Portal $8,000 (Parker)
- *Coupled Human-Environment Systems - Mathematical modelling of human-environment interactions:* $50,000 (yearly to a total of $250,000 over 5 years) from NSERC Individual Discovery Grant for "*Dynamics of coupled human-environment systems*" (Bauch)
- NSERC Discovery Grant - $37,000 for *"Transitions and thresholds in global ecological changes of forest ecosystems"* (Anand)
- NSERC Discovery Grant: $29,000 (yearly to a new total of $145,000 over 5 years) for *"Uncovering 'perfect storms' among possible events affecting complex systems"* (Schweizer)
- CIHR Planning and Dissemination Grant, Institute of Population & Public Health: $19,917 for *"Improving population health in an era of social-ecological instability and economic contraction"* (Quilley)
- SSHRC Postdoctoral Fellowships Program: $81,000 for Mark Hathaway *& Transformative Ecological Learning in Permaculture* (Quilley)

2018

- NSERC Discovery Grant - $37,000 for *"Transitions and thresholds in global ecological changes of forest ecosystems"* (Anand)
- *Urban Growth and Change*: Municipal Property Assessment Corporation - $300,000 in-kind for *"Interpreting housing market dynamics in Kitchener-Waterloo, and investigating relationships between housing demand and demographics from housing survey*" (Parker)
- *Urban Growth and Change:* Teranet - $74,700 in-kind for *"Interpreting housing market dynamics in Kitchener-Waterloo, and investigating relationships between housing demand and demographics from housing survey"* (Parker)
- *Urban Growth and Change:* Cities of Kitchener, Waterloo, Cambridge and Region of Waterloo - $7,051 for *"Residential Property Values and Active Transportation Infrastructure"* (Parker)
- Ontario Research Funds – Research Excellence (ORF-RE): $465,000 for *"Computational Peer Review through Identification and Captioning of Gigapizel Digital Pathology Scans"* (2018-2024) (Crowley)
- NSERC Collaborative Research and Development (CRD) matched with funds from industry partner Magna International: $265,000 for "*Driver Behaviour Learning*" (2018-2021) (Crowley)
- MITACS Accelerate Cluster Fund with Industry Partner Accerta Analytics Solutions: $240,000 for *"End-of-line Testing for Safety and Quality with Machine Learning*" (2018-2021) (Crowley)
- NSERC Discovery Grant: $140,000 for "*Towards Fully Integrated Deep Learning and Reinforcement Learning for General Spatial Domains*" (2018-2023) (Crowley)
- UW Research Incentive Fund: $10,000 for "*Embracing complexity: Advancing our understanding of dietary patterns to inform chronic disease prevention"* (Kirkpatrick)
- Canadian Foundation for Diabetic Research Grant: $20,000 for *"Impact of numeric and traffic light calorie labels on label use, purchasing, and intake among young adults"* (Kirkpatrick)
- Ontario Early Research Award: $150,000 for *"Building capacity in dietary assessment"* (Kirkpatrick)
- UW Water Institute Seed Grant: $18,500 for "*Integrated Assessment of Agricultural Best Management Practices and Phosphorus Runoff"* (Deadman)
- Global Water Futures Program: $2,761,700 for *"Agricultural Water Futures in Canada: Stressors and Solutions"* (Deadman)
- SSHRC Partnership GRF Extension Plan fund: $41,000 for "*Hedgelaying in the Ontario Landscape [UNIT 4 50658 10006]*" (Quilley)

COMPLEX-SYSTEMS GRANTS OBTAINING FUNDING BY WICI CORE MEMBERS 2011-2020

- SSHRC IDG Fund: $62,752 for "*A Pattern Language for Traditional Music and Sustainable Communities"* (Quilley)
- NSERC Discovery Grant: $29,000 (yearly to a total of $145,000 over 5 years) for *"Uncovering 'perfect storms' among possible events affecting complex systems"* (Schweizer)
- SSHRC Insight Grant: $232,000 for *"Ideological Conflict Project (ICP)" as a component of the "Rapid Ideological Change (RIC) Project"* (Homer-Dixon)

2019

- NSERC Discovery Grant - $37,000 for *"Transitions and thresholds in global ecological changes of forest ecosystems"* (Anand)
- Ontario Research Funds – Research Excellence (ORF-RE): $93,000 (Total award of $620,000 over 2018-2024) for *"Computational Peer Review through Identification and Captioning of Gigapizel Digital Pathology Scans"* (Crowley)
- NSERC Collaborative Research and Development (CRD): $82,000 for "*Driver Behaviour Learning"* (Total award of $164,000 over 2018-2021) (Crowley)
- Mitacs Globalinks Research Travel Award: $6,000 for "*Integration of Scientific Workflows in Geoscience"* (Crowley)
- NSERC Collaborative Research and Development (CRD): $39,600 for *"Trace Analysis for Safety Assurance of Critical Software Systems"* (33% of total 120,000 award) (Crowley)
- National Research Council – UW Collaboration Centre for AI/Cybersecurity/IoT: $90,000 for "*Automated Material Synthesis Using Deep Reinforcement Learning*" (Crowley)
- Waterloo Artificial Intelligence Institute, Microsoft, AI for Social Good $25,000 for "Artificial Intelligence and Wildland Fire Management" (50% of total award of $50,000) (Crowley)
- Canada Foundation for Innovation & Ontario Research Fund (CFI-ORF): $212,659 for "*GIS based virtual and augmented reality tools" (Deadman)*
- Global Innovations in Character Development Grant from Templeton World Charity Foundation: $299,919 for *"Measuring and developing the character strengths of wisdom in low-security contexts: Testing new approaches in Sri Lanka and the Philippines*" (Grossmann)
- SSHRC Insight Grant: $239,703 for "Wisdom to know the difference: Unpacking knowledge of strategy-situation fit and its relationship to context-sensitive cognition" (Grossmann)
- Canadian Institutes of Health Research (CIHR): $15,000 for "*Accelerating methods for characterizing dietary patterns"* (Kirkpatrick)
- Canadian Institutes of Health Research (CIHR): $914,175 for "*Measuring cardio-vascular Outcomes in Depression in referred Youth (MODIFY)"* (Kirkpatrick)
- Canadian Institutes of Health Research (CIHR): $2,994,975 for *"International food policy study: Evaluating the impact of food labelling, marketing, and fiscal nutrition policies*"(Kirkpatrick)
- Australian Research Council Discovery Grants $254,200 for "*Accuracy and cost-effectiveness of technology-assisted dietary assessment"* (Kirkpatrick)
- US National Cancer Institute (contract): $13,351 for *"Measurement error in self-report dietary intake data"* (Kirkpatrick)
- NSERC Discovery Grant: $205,000 for *"Automatic Computational Understanding and Manipulation of Finite Discrete-Event Dynamical Systems throughout Natural Sciences and Engineering"* (Nehaniv)
- Canada Foundation For Innovation - John R. Evans Leaders Fund (CFI-JELF) and Ontario Research Fund (ORF) (with other funding source(s)): $930,812 for "*Infrastructure for Social & Intelligent Robotics"* (Nehaniv)
- US Air Force Office of Scientific Research (awarded via University of Hertfordshire): $108,150 for *"Novel Computational Methods for Predicting Transitions in Spatiotemporal Neurodynamics between Attention and Mind-wandering"* (Nehaniv)
- Natural Sciences and Engineering Research Council of Canada (NSERC) CRD: $600,000 for "*Artificial Intelligence-based Tools for Fresh Produce Procurement Price Decisions as Applied to Canadian Distribution Centers"* (Parker)
- Cities of Kitchener: $18,750 for *"Residential Property Values and Active Transportation Infrastructure"* (Parker)

COMPLEX-SYSTEMS GRANTS OBTAINING FUNDING BY WICI CORE MEMBERS 2011-2020

- Global MITACS: $6,000 for "*A Pattern Language for Traditional Music and Sustainable Communities"* (Quilley)
- UW/SSHRC RIF: $10,000 for "*Scientometric tools and complex systems modelling for solution-oriented assessment"* (Schweizer)
- NSERC Discovery Grant: $29,000 (yearly to a total of $145,000 over 5 years) for *"Uncovering 'perfect storms' among possible events affecting complex systems"* (Schweizer)

2020

- COVID-19 Rapid Research Fund, Ontario Ministry of Colleges and Universities: $148,624 for *"How to re-open Ontario's economy without causing a resurgence of COVID-19"* (Anand/Bauch)
- NSERC Alliance COVID-19 Grant: $50,000 for "*Public Health Interventions in the COVID-19 Endgame: Insights from Percolation Theory" (*Anand/Bauch)
- New Frontiers in Research Fund (NFRF) Exploration Stream: $125,000 for "*Navigating the Climate Emergency with Coupled Human-Environment Models"* (Anand/Bauch)
- Templeton World Charity Foundation: $32,833 for *"Post-pandemic kaleidoscope: Documenting social scientists' wisdom on how to navigate the new normal"* (Grossmann)
- SSHRC Connection Grant - $15,926 for "*Behavioural and Social Scientists' Wisdom for Navigating the New Normal"* (Grossmann)
- Health Canada: $40,000 for *"Developing and Validating a Screener to Assess Alignment of Intakes with Canada's Food Guide"* (Kirkpatrick)
- Public Health Ontario Locally Developed Collaborative Projects $15,692 for *"Validation of a food literacy measure for use in public health practice"* (Kirkpatrick)
- US National Institutes of Health $143,896 for "*Machine Learning to Inform Dietary patterns to Promote Healthy Pregnancy Outcomes"* (Kirkpatrick)
- Canadian Institutes of Health Research (CIHR): $286,876 for "*Monitoring ultra-processed food intake in Canada"* (Kirkpatrick)
- AI For Good: $25,000 for "*Using deep learning to understand dietary patterns"* (Kirkpatrick)
- NSERC Discovery Grant: $29,000 for "*Uncovering 'perfect storms' among possible events affecting complex systems"* (Schweizer) (supplemental award of 1 additional year for Early Career Researchers)
- Interdisciplinary Centre on Climate Change (IC3) Seed Grant: $8,000 for *"Understanding the need and role of climate intervention strategies in Canadian climate policy"* (Schweizer)

3.3 SCHOLARLY PUBLICATIONS AND OUTPUTS

The outputs listed in Table 3 are all **self-reported** by core members as being complex systems works related to their WICI core projects. It is important to note that when reporting this information annually, core members consider the intangible contributions of WICI, such as partnerships made through WICI events, and many of their self-reported outputs were developed as a result of work that originated through involvement with WICI.

Table 3: Core Member Scholarly Publications/Output

CORE MEMBER OUTPUT TYPE*	2012	2013	2014	2015	2016	2017	2018	2019	2020
PUBLICATIONS	12	14	24	13	51	45	62	72	65
PUBLICATIONS IN PRESS	6	6	7	2	7	10	20	18	12
INVITED/KEYNOTE PRESENTATIONS	17	26	18	8	13	14	11	5	10
OTHER PRESENTATIONS	14	13	20	3	14	19	40	64	40
WORKSHOPS/CONFERENCES ORGANIZED	1	5	3	1	5	4	10	9	7
OP-EDS/MAGAZINE ARTICLES	3	3	11	5	2	1	2	2	25
OUTREACH: RADIO/PRINT INTERVIEWS	2	3	9	3	10	4	19	18	40+
HONOURS, DISTINCTIONS AND AWARDS							5	9	10

**Notes: WICI began formally gathering outputs from our core membership in 2011-12 and summarized these accomplishments in each year's Annual Report. Data for 2011-2014 covers outputs from July 1-June 30. Data for 2014-15 covers July 1, 2014 to December 31, 2014. Data for 2015 onward covers data from January 1 to December 31 each year. Data for Honours, Distinctions and Awards was not collected prior to 2018.*

A full list of self-reported WICI core member publications is included in Appendix C: Core Member Publications.

It should be noted here that core members make up only about 8% of our total membership at this time. In a recent project, Graduate Research Assistant Jinelle Piereder, *Mapping Canadian Complex Systems Scholarship,* determined that our self-reported core member publications represent only about **6.3%** of actual complex systems research at University of Waterloo (2020). Table 4 summarizes the number of publications that Piereder analyzed in the project's bibliometric analysis.

Table 4: Scholarly Complex Systems Publications in Scopus up to 2019

Scholarly Publications Captured in Scopus by Complex Systems Query (up to 2019)

MEMBER STATUS	CAPTURED	NOT CAPTURED	TOTAL
Core and External Core Members, self-reported	31	202	233
Core Members, all publications	102	583	685
Core and External Core Members, all publications	150	739	889
All WICI Members (non-student) publications	356	1806	2162
University of Waterloo researchers, Complex Systems Query	3671	n/a	3671

WICI recognizes that tracking outputs of its membership is challenging and may not fully reflect the true scope and impact of WICI or of Complex Systems research as a whole. However, this information has been collected and reported annually over the past ten years and thus warrants inclusion in this progress report. Piereder's report provides compelling insight toward improved reporting and analysis in the future that is a significant opportunity for WICI and will play a key role in defining future metrics for success.

3.3.1 WICI OCCASIONAL PAPERS AND BRIEFS

In order to provide a venue for dissemination of research findings for core projects and other local complex systems scholars, WICI established an "occasional paper series" in 2012. Papers are reviewed by WICI Core Members, undergo copyediting, and are posted for public download. Table 5 lists the

papers published to date. In 2015, WICI reported over 10,000 views of the first five Occasional Papers. This very high readership demonstrates that junior scholars associated with WICI are producing high-impact complex systems research. While view counts are no longer available due to migrating to a different website and changing our subscriptions, it can be noted that the web page address from where these papers are accessed continues to record average traffic of around 1,000 visits per year.

Table 5: WICI Occasional Papers

DATE	WICI OCCASIONAL PAPER TITLE AND AUTHOR	VIEWS*
January 2012	**"**A Complex Systems Approach to the Drug War in Mexico: Resources, Violence and Order" -Michael Lawrence (Student Member)	2293
February 2012	**"**Green Complexity Economics: Modeling Global-Scale Environmental, Resource and Ecological Challenges" -Dawn Parker and Thomas Homer-Dixon (Core Members)	1847
August 2012	"Why the Mind Matters: A Cognitive Agenda for World Politics" -Manjana Milkoreit (former Student Member, Affiliate Researcher)	2072
January 2013	"Twenty-First Century Snake Oil: Why the United States Should Reject Biofuels as Part of a Rational National Security Energy Strategy" -Captain T.A. "Ike" Kiefer	2994
June 2013	"Exploring the State Space of Ideological Possibility" -Matto Mildenberger (former Student Member, Affiliate Researcher)	1779
January 2015	"Exergonic Innovations: The History of Britain's Coal Exploitation" -Clayton J. M. Dasilva (Student Member)	N/A
January 2021	"Mapping Canadian Complex Systems Scholarship" -Jinelle Piereder (Student Member)	N/A

**Note: View count statistics from Issuu were tracked until December 31, 2014, after which WICI's Issuu membership was downgraded and the view counts are no longer available.*

In addition, in 2013-2014, former PhD WICI Student Member Manjana Milkoreit (now WICI Affiliate member) prepared a series of briefs titled Negotiator Briefs on Cognition and Climate Change, which were published on the WICI website.

- CCC Brief No. 1: "A Different Take on the Problem"
- CCC Brief No. 2: "Rationality, Risk Perceptions and Risk Hierarchies
- CCC Brief No. 3: "Rationality and Ethics – Are you a consequentialist?"
- CCC Brief No.4: "Global Power Structures – (How) Do They Matter?"
- CCC Brief No.5: "What is Power in the Global Climate Negotiations?"

The series was intended to build on research on the role of cognition in the global climate change negotiations, and offer insights specifically targeted to the needs and challenges of participants in the global climate change negotiations – diplomats, climate policy experts, members of the United Nations Framework Convention on Climate Change (UNFCCC) secretariat, representatives of non-governmental organizations and stakeholders, climate scientists and domestic policy-makers, about the working of the mind and international relations. The briefs were intended to be conversation starters that give rise to questions, ideas and new kinds of conversations, while supporting political actors in their efforts to understand and effectively navigate their complex political and negotiation environment.

3.3.2 SOFTWARE TOOLS

In the past, WICI has prioritized the internal creation and dissemination of software tools for analysis of complex systems. Software tools, such as Empathica and LUXE, have been developed through WICI core research projects. Other tools were developed for the WICI-sponsored Data Challenge competition in 2013, from which the winner and runners-up were awarded a $10,000 prize for tools and methods to improve the exploration, analysis and visualization of complex-systems data, and a data symposium to disseminate the tools was organized.

Table 6 lists two software tools developed through WICI core research projects, including the winning and runner-up entries from WICI's 2013 Data Challenge.

Table 6: Software and Tools

WICI SOFTWARE/TOOL	DESCRIPTION
EMPATHICA	This software program is designed to help people understand and resolve conflicts. It is based on the hope that increasing empathy (mutual understanding of values and emotions) between people can help to overcome impasses in disputes in many domains: organizations, politics, personal relationships, and so on. EMPATHICA uses the idea of Cognitive-Affective Maps (CAMs) developed by Paul Thagard in collaboration with Thomas Homer-Dixon, Scott Findlay, and others.
LUXE (LAND USE IN AN EXURBAN ENVIRONMENT)	LUXE is an agent-based model of land-market interactions, which allows the user to explore the effects of land market elements (preferences, budget constraints, and competitive bidding) on patterns of land-use and land-value in an abstract urban setting.
FAST VISUALIZATION OF RELEVANT PORTIONS OF LARGE DYNAMIC NETWORKS*	The winners of the WICI Data Challenge, Przemyslaw Grabowicz, Luca Aiello and Fil Menczer, developed a fast algorithm that selects subsets of nodes and edges that best represent an evolving graph and visualize it by either creating a movie, or by streaming it to an interactive network visualization tool.
EARLY WARNING SIGNALS TOOLBOX: A NOVEL APPROACH FOR DETECTING CRITICAL TRANSITIONS*	An Early Warning Signal Toolbox designed for the WICI Data Challenge by Vasilis Dakos and Leo Lahti for estimating and visualizing fingerprints of upcoming critical transitions based on time series data. The toolbox is easy to use through a user-friendly interface developed in R, an increasingly popular open-access statistical language for scientific computing.
JUST: A NETWORK SIMULATION TOOLKIT FOR COMPLEX SYSTEMS RESEARCHERS*	JUST – a software framework designed by Jon Mackay for the Data Challenge to help researchers rapidly develop custom simulation models of networks. JUST is not just a framework to develop and run simulations, but a complete package that gives users the ability to visualize their models, share them with others and export the data they generate to other packages for analysis.

WICI SOFTWARE/TOOL	DESCRIPTION
VISUALIZING ARGENTINE ANTS: THE USE OF DANCE TO VISUALIZE COMPLEX DATA*	Complex systems data, regardless of their dimensions, are usually communicated on two-dimensional surfaces, such as in texts, statistics, equations, graphs, flowcharts and feedback diagrams. These classical means of data communication, though explicit and unambiguous, can often be difficult to interpret because of the dense formal language conventions of science and math. Dance and movement, as a means of 'embodied cognition' to personify complex data, facilitates audience investment in the issues presented, as well as room for creative interpretation of them. Sarah Hogland and Elliott Miller suggested movement simulations of complex systems can also be an accessible educational tool to teach complex systems concepts.
VALENCE	Valence was developed under the auspices of the Ideological Conflict Project (ICP). ICP researchers who contributed to the design of the software include: Thomas Homer-Dixon, Scott Janzwood, Jordan Mansell, Steven Mock, Jinelle Piereder, Carter Rhea, Tobias Schröder, and Paul Thagard.
MIRACLE DATA STORAGE AND ANALYSIS TOOL	Dawn Parker's MIRACLE research team developed a cloud-based community platform that presents prototype examples of output and analysis methods for agent-based models of coupled human-natural systems (ABM-CHANS). The platform was intended to facilitate improved communication within research groups, increased access and transparency for external research communities.

*Note: Software/Tools marked with *asterisk were Data Visualization and Analysis Tools submitted to WICI's 2013 Data Challenge.*

In addition, WICI core member Dawn Parker is an active participant in CoMSES Network's hosting of a global archive for software code and development of an international Open Modelling Foundation, in collaboration with Arizona State University (ASU). Models for managing data related to complex systems are continually evolving and are a large part of complex systems research. As described in our strategic plans for the next five years, WICI aims to focus on the application of modelling frameworks and tools to real-world problems and decision making.

3.4 SEED AND PARTNERSHIP GRANTS

WICI has funded **$37,150** to University of Waterloo complex systems researchers, through two grant challenges run in 2016 and in 2019.

In 2016, WICI invited applications for small grants to support development and submission of funding proposals to support complex systems research at the University of Waterloo ($5,000 - $10,000, commensurate with the scope of the developed proposal). Applications were to have a substantive complex systems focus, but could be from any academic domain, and had to clearly indicate how the work would lead to a novel direction. These funds contributed to hiring of coop students, research associates, application to larger grant opportunities (NSERC Discovery, AI for Social Good, SSHRC Insight), and successful grant awards from the Centre for Aging and Brain Health Innovation (Patel), and Global Water Futures (Deadman).

"Funding from WICI was used to support a part-time postdoctoral fellow and led to a successful Trailblazer fund and further research funding proposals."

-Anna Klinkova
Assistant Professor, Chemistry
2019 WICI Seed Grant Recipient

In April 2019, WICI offered another seed grant to be competitively awarded. Anna Klinkova, University of Waterloo Assistant Professor in Chemistry, was awarded a SEED grant for her project, *Assessment-guided development of electroorganic CO_2 fixation to value-added chemicals,* $8,000. This funding was used to support a part-time postdoctoral fellow, Rachelle Choueiri, and led to a successful Trailblazer fund that allowed the team to hire a life cycle analysis postdoc. A publication from this project is in progress and further research funding proposals are also in development.

The successful applicants for all of these awards are listed in Table 7 below.

Table 7: WICI Seed and Partnership Grants

WICI Seed and Partnership Grants

YEAR	RECIPIENT	PROJECT TITLE	AMOUNT
2016	Patel, Tejal	Complexity in Medication Use: Older Adults and Capacity to Manage Medications	$9,950
2016	Bauch, Chris	Using Digital Social Data to Detect Early Warning Signals of Regime Shifts in Coupled Human-Environment Systems	$10,000
2016	Deadman, Peter	Impact of Tank Rehabilitation on the Resilience of Rainwater Harvesting Institutions in South India	$9,200
2019	Klinkova, Anna	Assessment-guided development of electroorganic CO2 fixation to value-added chemicals	$8,000

3.5 STUDENT INVOLVEMENT

WICI is passionate about supporting their students throughout their research careers. WICI core members supervise, co-supervise and graduate highly qualified personnel to the workforce with a toolbox of systems thinking competencies, as well as employ postdoctoral researchers for WICI core research projects. Many former WICI student members become practitioner and affiliate members who continue to collaborate with the wider WICI network.

The following section summarizes some of the support that has been distributed to students over the duration of WICI and some of the ways in which our student membership actively engage in WICI's events, activities and services.

"WICI has benefited me in many aspects, from providing cutting-edge knowledge on complex systems studies to offering me the chance to meet my post-doc supervisor and connect with many great professors and colleagues."

-Yu Huang
Postdoctoral Fellow and former WICI Student Member

3.5.1 STUDENT MEMBERSHIP

WICI student members currently make up 23% of overall membership. Table 8 below lists our **34** current student members, many of whom are directly supervised by WICI core and affiliate members.

Table 8: WICI 2020 Student Members

WICI STUDENT MEMBER	DEGREE IN PROGRESS	DEPARTMENT
Ahmed, Hazem	PhD	School of Planning
Andrade, Lesley	PhD	School of Public Health & Health Systems
Battikh, Joe	PhD	School of Environment, Enterprise & Development
Bury, Thomas	PhD	Applied Mathematics
Damer, Nick	Master of Arts	Political Science *
Dasilva, Clayton	PhD	Balsillie School of International Affairs
Diaz, Ileana	PhD	Geography & Environment Management
Dordi, Truzaar	PhD	School of Environment, Enterprise & Development
Friesen, Milton	PhD	School of Planning
Garcia, Jorge	PhD	Systems Design Engineering
Goyal, Julia	PhD	School of Public Health & Health Systems and Mechatronics & Mechanical Engineering
Greyson-Gaito, Christopher	PhD	Integrative Biology
Hutchison, Chantal	PhD	Biology
Jahanmiri, Fatima	PhD	School of Planning
Janzwood, Scott	PhD	Balsillie School of International Affairs
Jentsch, Peter	PhD	Applied Mathematics
Lang, John	PhD	Applied Mathematics
Lawrence, Michael	PhD	Balsillie School of International Affairs
Laycock, Katherine	PhD	School of Planning
Lee, Kirsten	PhD	School of Public Health & Health Systems
Leroux, Simon	PhD	School of Architecture
Luederitz, Christopher	PhD	Geography & Environment Management
Mason, Adrienne	MSc	School of Environment, Resources & Sustainability
Mirza, Majid	PhD	School of Environment, Enterprise & Development
Palaschuk, Nicholas	PhD	School of Environment, Enterprise & Development
Petrie, Sam	MSc	Spatial Determinants of Health*
Piereder, Jinelle	PhD	Balsillie School of International Affairs
Ruttonsha, Perin	PhD	School of Environment, Resources & Sustainability
Sharma, Ajar	PhD	Systems Design Engineering & Knowledge Integration
Tatarovic, Andjela	Undergraduate	School of Architecture
Wright, Kirsten	PhD	Systems Design Engineering
Zywert, Katharine	PhD	School of Environment, Resources & Sustainability

Figure 7 illustrates that while students representing all six University of Waterloo faculties are members of WICI, the majority of our student members come from Environment, Arts and Engineering faculties.

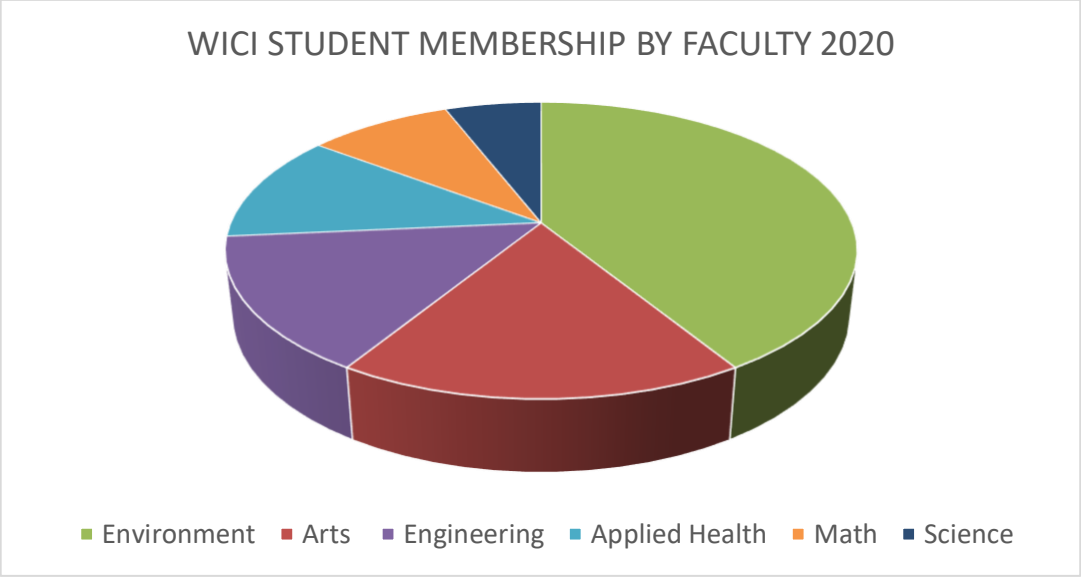


Figure 7: WICI Student Membership by Faculty

The affiliate and practitioner members listed in Table 9, are former University of Waterloo students and WICI student members who have graduated but are still actively engaged with WICI research.

Table 9: Students Graduated and Still Engaged as WICI Members

Students Graduated and Still Engaged as Affiliate or Practitioner Members

NAME	DEGREE AWARDED	YEAR
Mackay, Jon	PhD in Management Sciences	2012
Milkoreit, Manjana	PhD in Global Governance	2013
Tjornbo, Ola	PhD in Global Governance	2013
Yeung, Kevin	MSc in Civil (Transportation) Engineering and Planning	2015
Jin, Xiongbing	Postdoctoral Fellowship in Planning	2015
Capmourteres, Virginia	PhD in Environmental Sciences (UofG)	2016
Dou, Yue	PhD in Geomatics	2016
Babin, Robert	MA in Planning	2016
Miller, Jamie	PhD in Environmental Engineering (UofG)	2016
Zhang, Haotian	PhD in Electrical and Computer Engineering	2016
Beck, Marisa	PhD in Global Governance	2017
Gonzalez, Diana-Luna	PhD in Social and Ecological Sustainability	2017
Huang, Yu	PhD in Urban Planning	2018
Branch-Smith, Teresa	PhD in Philosophy	2019
Fair, Kathryn	PhD in Applied Mathematics	2020
Kurniawan, Jude	PhD in Geography	2020
Raffoul, Amanda	PhD in Public Health and Health Systems	2020

3.5.2 STUDENTS AND POSTDOCTORAL FELLOWS EMPLOYED BY WICI

WICI has employed several Graduate Research Assistants to assist with conference organization and lead institutional development projects (the students hired in the past three years are listed in Table 10). These projects have yielded exceptional results with a positive impact for both the institution and its members.

Table 10: Graduate Students Employed for WICI Institutional Projects

Graduate Students Employed for WICI Institutional Projects

NAME	EMPLOYMENT TERM	WICI PROJECT
Ruttonsha, Perin	Spring 2018	Urban Growth and Change Conference
Diaz, Ileana	Summer 2018	Urban Growth and Change Conference
Wright, Kirsten	Winter 2019	Student Engagement Initiative
Piereder, Jinelle	Fall 2019	Mapping Canadian Complex Systems
Dordi, Truzaar	Summer 2020	Education Initiative

Over the years, WICI has also employed a number of post-doctoral fellows (Table 11) to work on WICI core research projects. In recent years, WICI continues to receive several inquiries from early-career scientists seeking to join WICI as post-doctoral fellows or research scientists. The qualifications of these candidates are very strong, and this interest indicates that WICI is able to attract a very strong cohort of early-career complex systems scholars.

Table 11: Postdoctoral Fellows Employed to Work on WICI Research Projects

Postdoctoral Fellows Employed to Work on WICI Research Projects

NAME	YEARS EMPLOYED	WICI RESEARCH GROUP AFFILIATION
Mock, Steven	2010-2015, 2018-present	CAM/Ideological Conflict
Sun, Shipeng	2010-2012	Urban Growth and Change
Gostolli, Umberto	2012-2013	Urban Growth and Change
Jin, Xiongbing	2012-2015	Urban Growth and Change
Nowack, Shane	2014-2015	Human-Environment Systems
Marcinow, Michelle	2016-2017	Dietary Assessment
Karatayev, Vadim	2019-present	Human-Environment Systems
Fair, Katharine	2020-present	Human-Environment Systems
Huang, Yu	2020-present	Urban Growth and Change

3.5.3 STUDENT FUNDING

WICI provides full-time University of Waterloo students with the opportunity to seek funding from the Institute to pursue complexity related activities that will further their own research. To date, WICI has funded nearly **$30,000** in travel/conference funds, fellowship awards and smaller prizes for 24 graduate student members over the past eight years. Tables 12 through 14 list the awards funded over the duration of WICI.

Table 12: WICI Student Travel Awards

WICI Student Travel Awards

YEAR	NAME	PROJECT	AWARD
2013	Manjana Milkoreit	Attendance at POLNET workshop in Germany	$750
2013	Fatima Jahanmiri	Attendance at an agent-based modeling workshop	$1000
2014	Maren Pauly	Fieldwork in the Great Barrier Reef, Australia	$500
2016	Perin Ruttonsha	Attendance at the Global Sustainability Summer School on Urban Sustainability at Santa Fe Institute, New Mexico	$1500
2016	Amanda Raffoul	Attendance at the Complex Systems Modeling for Public Health Research course at University of Michigan	$1000
2016	Teresa Branch-Smith	On-site work in Zenith's research labs in Montpellier, France	$150
2016	Virginia Capmourteres	Attendance at M. Sackler Colloquium in Washington, DC	$500
2016	Corey Pembleton	Presentation at the Esri Geodesign Summit in Redlands, California	$500
2017	Yu Huang	Attendance at the North American Meetings of the Regional Science in Vancouver	$800
2017	Scott Janzwood	Presentation at the Decision Making under Deep Uncertainty annual workshop at Oxford Martin School, Oxford University	$1,000
2017	Katherine Laycock	Attendance at the Association of Collegiate Schools of Planning's Annual Conference in Denver	$675
2018	Scott Janzwood	Joining the Future of Humanity Institute at the University of Oxford as a visiting fellow	$500
2018	Katherine Laycock	Presentation at the Urban Affairs Conference, Toronto	$800
2018	Thomas Bury	Presentation at the Dynamics Days conference in Denver Colorado	$1,000
2018	Thomas Bury	Workshop on Human-Environment Systems hosted at the Fields Institute, Toronto	$200
2018	Thomas Bury	Attendance at the Ecological Society of America's Conference in New Orleans	$1,000
2018	Kathryn Fair	Attendance at the Ecological Society of America's Conference in New Orleans	$1,000
2018	Julia Goyal	Presentation at Qualitative Analysis Conference in Fredericton, NB	$1,000
2018	Diana Luna Gonzalez	Attendance at the Workshop on Human-Environment Systems hosted at the Fields Institute, Toronto	$75
2018	Jude Herijadi Kurniawan	Presentation at PyCon Canada in Toronto	$320
2019	Kevin Church	Presentation at SIAM Conference on Applications of Dynamical Systems in Snowbird, Utah	$500
2019	Yu Huang	Attendance & presentation at Canadian PhD and Early Career Workshop in Environmental and Resource Economics in Calgary, AB	$500
2019	Thomas Bury	Presentation at CAIMS Annual Meeting in Whistler BC	$500
2019	Kristen Lee	Presentation at Canadian Student Health Research Forum, Winnipeg, MB	$500
2019	Kirsten Wright	Attendance and workshop at CANSEE	$120

2019	Jonathan Hui	Attendance and workshop at CANSEE	$150
2019	Katharine Zywert	Attendance and workshop at CANSEE	$100
2019	Mark Tovey	Attendance and workshop at CANSEE	$200

"Without WICI's funding, I would not have been able to attend the SIAM DS19 conference in Snowbird, Utah without significant out-of-pocket expense."

-Kevin Church, NSERC Postdoctoral Fellow, McGill University and former WICI Student Member

In 2017, three PhD student graduate research assistantships were awarded competitively. On Tuesday, February 26, 2018, these three scholars were featured in a WICI talk to showcase their work. Table 13 summarizes these awards.

Table 13: WICI 2017 Student Fellowship Awards

WICI 2017 Student Fellowship Awards

NAME	PROJECT	AWARD
Amanda Raffoul Public Health & Health Systems	Are we (unintentionally) doing more harm than good? Systems approaches to the prevention of eating- and weight-related disorders	$4,000
Kevin Church Applied Mathematics	The hidden geometry of complex dynamics and how to exploit it	$4,000
Katharine Zywert Social & Ecological Sustainability	Social-Ecological Systems Change and the Future of Human Health	$4,000

"As a student member and recipient of the 2018 WICI Fellowship Award, I had the opportunity to seek training in complex systems concepts that served as the foundation for my dissertation research and eventual postdoctoral fellowship."

-Amanda Raffoul, WICI Affiliate Member and Postdoctoral Fellow at Harvard STRIPED

In April 2019, Kirsten Wright, WICI GRA, took a leadership role in organizing the WICI Complex Systems Student Project Symposium, which had over 20 participants and 10 judges from across multiple faculties. Prizes were awarded in both Graduate and Undergraduate categories (Table 14).

Table 14: WICI 2019 Complex Systems Student Project Symposium Awards

WICI 2019 Complex Systems Student Project Symposium Awards

	NAME & PROJECT	AWARD
Graduate Session		
1st	Kathryn Fair *(PhD Candidate, Applied Mathematics)* Climate change & the future of forest-grassland mosaics	$250
2nd	Hazem Ahmed *(PhD Candidate, School of Planning)* Addressing barriers to adoption of source-control stormwater management practices on private residential yards in Kitchener/Waterloo	$150
3rd (tie)	Ajar Sharma *(PhD Candidate, Systems Design Engineering & Knowledge Integration)* Cauvery River: Path dependencies and feedbacks in water sharing conflicts	$100
3rd (tie)	Julia Goyal *(PhD Candidate, Public Health and Health Systems & MME)* Navigating health and safety in Airbnb's self-regulating system	$100
Undergraduate Session		
1st	Erica J. McDonald *(School of Public Health and Health Systems)* Examining the association between marginalization and emergency room wait times in Ontario	$250
2nd	Amanda Pereira *(School of Public Health and Health Systems)* Quality of care for persons with concurrent substance use and mental health	$150
3rd	Mona Qutub *(School of Public Health and Health Systems)* Potential unintended consequences of co-operative education: Food insecurity among undergraduate students at University of Waterloo	$100

3.5.4 WORKING/READING GROUPS

WICI has facilitated faculty and student research and discussion through several reading/working groups held over the years at University of Waterloo:

AGENT-BASED MODELING WORKING GROUP: The ABM working group was formed by WICI members Xionbing Jin and Kirsten Robinson in Fall 2013 in response to interest from University of Waterloo students. Activities included weekly group meetings that featured general discussions and presentations from members on their recent modelling work and ideas, and ABM tutorials (held in Summer 2014 and Winter 2015), which taught the development of agent-based models using a popular ABM platform. One of the early participants and regular attendees of this group, also a Student Member of WICI, Fatemeh Jahanmiri, went on to defend her ABM-based thesis, for a Master of Arts in Planning, in 2015. A formal ABM course has since been developed and is taught by Dawn Parker in the School of Planning.

> "I got to know many graduates across the campus researching different complex systems through well-organized bi-weekly meetings."
>
> *-Yu Huang, WICI Affiliate Member and Postdoctoral Fellow*

COMPLEX HEALTH INNOVATION UNDER RESOURCE CONSTRAINTS WORKING GROUP: In response to Rob Robson of the Healthcare System Safety and Accountability group reaching out to WICI and asking for help in creating a space to discuss complexity and healthcare issues, this working group was formed in Spring of 2013 and provided a useful bridge for WICI into Applied Health Sciences.

COMPLEXITY, NETWORKS AND ORGANIZATIONS WORKING GROUP: WICI Member Jon Mackay contacted WICI to establish a working group as a forum to bring graduate students and interested faculty together to share knowledge and experience around complex systems scholarship and methods. Interests of participants included ecology, sustainability, network science, new approaches to business, and economics. Meetings were organized around research presentations, journal paper discussions, and workshops around new methodologies. The group gathered to discuss how a complex systems reading/learning group might be organized and what the goals might be. Student member Jonathan Hui presented his work titled "Return of the Empires: China and the US as world ecologies" to this group on November 18, 2019.

NETWORK SCIENCE READING GROUP: Following J.P. Onnela's presentation in January 2010, as part of WICI's seminar series, this reading group was developed on campus, led by former PhD student (Management Sciences Faculty) Jon McKay, in collaboration with PhD Student and Cardus (external research think tank) Research Fellow Milton Friessen and Professor Shreyas Sundaram (WICI Affiliate Researcher & Assistant Professor in Electrical and Computer Engineering at UW).

"TOWARDS A SCIENCE OF CITIES" READING AND WRITING GROUP: The WICI 2018 reading and writing series, Navigating the Complexity of Urban Systems, was designed to lead into its spring conference on Modelling Complex Urban Environments and spanned four key topics: (1) cities as complex adaptive socio-ecological systems; (2) qualitative, quantitative, and design-based urban analyses; (3) networks, scale and emergence; and, (4) planning for transition. Participants reviewed, discussed and reflected on 27 readings related to the themes, and compared, critiqued and charted complexity approaches as applied to urban systems. The group also held two workshops as part of the WICI 2018 spring conference and is preparing a journal article, "A Science of Cities for Sustainable Development" (Ruttonsha, Milne, Wright et al, in preparation).

WICI DESIGN CHAPTER: In 2019-2020, WICI student member Simon Leroux organized a group of students at the University of Waterloo School of Architecture in Cambridge, Ontario. This group was able to engage both undergraduate and graduate students of the School of Architecture in complexity theory and connect them with members of WICI to organize a cross-disciplinary colloquium on design. The colloquium event was held in November, 2019 and featured graduate students from a diverse range of academic backgrounds presenting their thesis work, with moderated discussion panels, and an informal poster showcase of both undergraduate and graduate projects grounded in complexity theory and design.

3.6 WICI SPONSORED EVENTS

A regular program of WICI Conferences, workshops and seminars allow us the opportunity to support, develop, and disseminate research from WICI's core projects, as well as highlight and share other current research developments related to complex systems.

WICI averages between eight and twelve events per year, including two to four talks each semester and at least one workshop every year, with a major conference or symposium every two to four years. The majority of our events have been very well attended, and represent a mix of faculty, students and community members from all faculties. To date, WICI has hosted **5** conferences and/or symposia, **31** workshops and **89** seminars and/or talks (not including the number of talks that were delivered during our conferences and/or workshops).

3.6.1 CONFERENCES/SYMPOSIA AND WORKSHOPS

> "Conference participation allowed our research team to enter into a large consortium…to make substantial progress toward our research goals…and to the application for two large international research calls."
>
> *-Dominique Prunetti, University of Corsica from 2018 WICI Conference on Modelling Complex Urban Environments*

WICI core members and student members have coordinated five major conference/symposia events and 31 workshops over its years of operation. As summarized in our annual reports, a diverse audience of student, academic, and community members have attended and participated in these events. Feedback collected from these activities indicate that participants enjoyed the activities, workgroups and seminars, learned relevant information related to complex systems, and even connected with other researchers from different disciplines and/or geographic locations. Student involvement was extensive and many of those who have attended WICI conferences and/or workshops listed in Tables 15 and 16, typically indicate they would like to continue seeing similar future events through WICI.

Table 15: WICI Conferences/Symposia

DATE	WICI CONFERENCE/SYMPOSIA EVENT	ATTENDEES
Nov 2016	Waterloo Urban Growth & Change Research Group Symposium	n/a
May 2017	Living on the Precipice: Interdisciplinary Conference on Resilience in Complex Natural and Human Systems	125+
Jun 2018	Conference on Modelling Complex Urban Environments	100+
Apr 2019	WICI Complex Systems Student Project Symposium	50+
Nov 2019	Synergies Cross-Disciplinary Design Colloquium at School of Architecture	60+

Table 16: WICI Member Workshops

DATE	WICI MEMBER WORKSHOP TITLE *(*WICI sponsored and/or hosted event)*
2010-2011	Think with your Feet
2010-2011	Science and Technology Innovation Workshop, Health Canada
2011-2012	BSIA Ideational Conflict Project Workshop*
2011-2012	Mapping the Transition from the Growth Model to the Steady-State Model in the International Political Economy
2011-2012	The Way Ahead: Global Governance, Complex Adaptive Systems and Societal Transformations
2012-2013	WICI Ideology Workshop*
2012-2013	WICI Ideology Workshop: Integrating Complexity Theory*
2012-2013	Alternatives to Economic Growth Part 1*
2012-2013	Alternatives to Economic Growth: 2nd Meeting*
2012-2013	International Congress on Environmental Modelling and Software, Workshop H6: Human decisions in agent-based models (ABM) for natural resource use need for protocols
2012-2013	National Center for Atmospheric Research Agent-Based Modeling of Land Use Change Workshop on Climate Change Impacts and Integrated Assessment
2012-2013	Collaborative Democracy Camp*
2012-2013	Genome Canada Disruptive Technologies Workshop
2012-2013	Banff Workshop on Asymptotics of Large Scale Networks

DATE	WICI MEMBER WORKSHOP TITLE *(*WICI sponsored and/or hosted event)*
2012-2013	Bellairs Workshop on Distributed Signal Processing
2013-2014	WICI Ideology Workshop: Ideological Conflict Project*
2013-2014	Data Visualization and Analysis Symposium*
2014-2015	Economics for the Anthropocene SSHRC Partnership Grant Workshop
2014-2015	The Knowledge: Curriculum Development Workshop
2016-2017	Web-based Reproducible Data Analysis: MIRACLE
2016-2017	Field's Institute on Human-Environment Sustainability*
2017-2018	Complex Institutional Systems and Urban Sustainability Outcomes*
2017-2018	Leveraging Systems Approaches to Improve Human and Planetary Health
2017-2018	Development of a Code Kernel for Agent-Based Land Market Models, Part 1
2017-2018	Health in the Anthropocene
2017-2018	Enhancing Capacity to Apply Systems Approaches to Improve Human and Planetary Health
2017-2018	Deconstructing the Ideological Complexity of Right-Wing Populism Across Borders*
2017-2018	Qualitative Methods as Tools for Enacting a Systems Approach
2018-2019	Research Faculty Networking Event*
2018-2019	(The) State(s) of Complexity Workshop (CANSEE)*
2018-2019	Open Format Conversations on Complexity*
2018-2019	Research Networking Lunch for New Frontiers and NSERC Alliance*
2019-2020	Socio-Hydrology: Opportunities and Challenges

3.6.3 WICI TALKS/SPEAKER SERIES SEMINARS

The WICI Speaker Series brings experts in their field to University of Waterloo to speak on topics of their choice relevant to complexity science and offers local scholars a chance to showcase their work. Attendance at our events is generally made up of faculty and students from various departments, but also often includes members of the local community and in the case of our conferences, international scholars as well.

As mentioned above, WICI has hosted **89** seminars in its lifetime, with at least three more planned for the Winter and Spring 2021 terms. Table 19 includes a full list of WICI seminars over the duration of the centre, with a hyperlink to their video(s) and the Vimeo view count for each as of December 31, 2020.

> "I have attended several Speaker Series organized by WICI and have always learned a great deal about complex problem solving from diverse perspectives."
>
> *-Adrienne Mason*
> *WICI Student Member*
> *2019 WICI Member Survey*

Table 17: WICI Seminars and Video Viewing Statistics

DATE	WICI SEMINAR TITLE AND SPEAKER	VIEWS*
OCTOBER 2008	The Evolution of Economic Wealth and Innovation Stuart A. Kauffman	339
NOVEMBER 2008	Changing Minds About Climate Change Paul Thagard	1927
DECEMBER 2008	Applications of Complexity Science to Healthcare Brenda Zimmerman	602
JANUARY 2009	Ingenuity Theory: Adaptation Failure and Societal Crisis Thomas Homer-Dixon	327

DATE	WICI SEMINAR TITLE AND SPEAKER	VIEWS*
JANUARY 2009	Trade Versus the Environment: Strategic Settlement from a Systems Engineering Perspective Keith Hipel	87
FEBRUARY 2009	Complexity Approach to Change and Transformation Frances Westley	996
FEBRUARY 2009	Governance Avalanches: A Self-Organized Criticality Perspective on Innovation in Global Governance Matthew Hoffman	451
MARCH 2009	Symmetries in Economic Models and Their Consequences Lee Smolin	366
APRIL 2009	World and Other Systems: A Challenge to WICI George Francis	64
OCTOBER 2009	Market Activity, Landscaping Behavior, and Carbon Sequestration in Ex-Urban Landscapes Dawn Parker	85
OCTOBER 2009	Is our Concept of Moral Responsibility Newtonian? Karen Houle	767
NOVEMBER 2009	Revitalizing Central Place Theory: Cities as Experiments on a Dynamic Fitness Landscape Brad Bass	209
NOVEMBER 2009	Responsive Environments: Transitional Fields Philip Beesley	141
DECEMBER 2009	Laws of Technological Progress J. Doyne Farmer	420
JANUARY 2010	Will Ecology Dominate the 21st Century? Thomas Homer-Dixon, Stephen Bocking and Robert Gibson	N/A
JANUARY 2010	Revitalizing the Georgian Bay Fisheries: Complicated, Complex, Contested and Confused David Robinson, Ivan Filion, and Kirsten Robinson	N/A
JANUARY 2010	Harnessing Network Science to Reveal our Digital Footprints Jukka-Petta Onnela, Harvard Medical School	36
FEBRUARY 2010	Open Source Democracy (Part 1) Mark Tovey, Michael Nielsen, and Hassan Masum	78
FEBRUARY 2010	Open Source Democracy (Part 2) Mark Tovey, Michael Nielsen, and Hassan Masum	41
MARCH 2010	Can Information Technology Really Help Save the Planet? Victor Galaz	200
MARCH 2010	A Wildfire Case Study in the Canadian Rocky Mountains Mike Stone	N/A
MARCH 2010	Testing Institutional Arrangements Via Agent-Based Modeling: A U.S. Electricity Market (Part 1) Leigh Tesfatsion	552
MARCH 2010	Testing Institutional Arrangements Via Agent-Based Modeling: A U.S. Electricity Market (Part 2) Leigh Tesfatsion	75
OCTOBER 2010	Simulation-based Engineering of Complex Systems John R. Clymer	169
OCTOBER 2010	On Ranking Merit: Applying the Page-Rank Algorithm to the Electoral Process Robert Spekkens	N/A

DATE	WICI SEMINAR TITLE AND SPEAKER	VIEWS*
NOVEMBER 2010	From DNA To Complex Cognition: How We Learn, Discover, And Create The World Kevin Dunbar	766
FEBRUARY 2011	How Does Technological Innovation Happen? W. Brian Arthur, Lee Smolin, Frances Westley and Thomas Homer-Dixon	N/A**
FEBRUARY 2011	Implementation of a Companion Modeling (ComMod) Process to Mediate Land Use Conflicts in Nan, Thailand *Land Change Science Seminar* Christophe Le Page	24
FEBRUARY 2011	Examining Household and Lot Effects on Land Use Change in the Brazilian Amazon *Land Change Science Seminar* Peter Deadman	34
FEBRUARY 2011	How do Assumptions of Decision-Making Methods Affect Agent-Based Models of Land Use Change? *Land Change Science Seminar* Raymond Cabrera	28
FEBRUARY 2011	Land Use Change in the Globalization Era *Land Change Science Seminar* Eric Lambin	184
MARCH 2011	Early Warning Signs for Critical Transitions Marten Scheffer	366
MARCH 2011	Steady State Economics Steve Purdey	149
MARCH 2011	Complexity, Scaling and Cities Mark Batty	173
SEPTEMBER 2011	Diffusing Information and Reaching Agreement in Networks: Convergence and Resilience Shreyas Sundaram	86
OCTOBER 2011	Objective and Subjective Factors: Modelling Consumer Behaviour From Individual to Population Scale Monica Cojocaru	128
NOVEMBER 2011	Leveraging Physical Actions to Interact with Digital Surfaces Mark Hancock	24
NOVEMBER 2011	Crime and Terror: Mathematical Exploration and Modelling of Dark Networ *Applied Mathematics Colloquium* Sasha Gutfraind	162
DECEMBER 2011	Social Distance Games Katherine Larson	298
JANUARY 2012	Modeling Complex Healthcare Environments Using Discrete-Event Simulation: A Case Study of Mass Immunization Clinics Michael Beeler	76
FEBRUARY 2012	Clearing the Fog of Geriatrics: Applying Complex Systems Thinking to the Health and Care of Older Adults Joshua Armstrong	58
FEBRUARY 2012	The End of Economic Growth: Social Regression or New Beginning? Steve Mock	162
MARCH 2012	Computational Sustainability *Computer Science Colloquium on Computational Sustainability* Carla Gomes	39

DATE	WICI SEMINAR TITLE AND SPEAKER	VIEWS*
MARCH 2012	Reaching Agreement in Complex Networks: Avoiding the Influence of Extreme Agents Shreyas Sundaram	191
MARCH 2012	Exploring the Possibility Space of Ideological Change Matto Mildenberger	49
APRIL 2012	The Interdependence of Forest Transition Pathways at the Household Level in Yunnan, China Darla Munroe	35
NOVEMBER 2012	Human-Environment Sustainability and Alternative Stable States in Mosaic Ecosystems Madhur Anand	N/A
JANUARY 2013	Possible Futures: Complexity in Sequential Decision-Making Dan Lizotte	69
FEBRUARY 2013	How Mathematics Can Help Explain Vaccine Scares and Associated Disease Dynamics Chris Bauch	142
FEBRUARY 2013	Changing Minds About Cars: Modeling the Adoption of Innovations in Transportation Tobias Schröder	40
APRIL 2013	Leadership: It's Pretty Simple… By Itself Marc Hurwitz	53
OCTOBER 2013	Traps and Transformations of Social-Ecological Systems: Commentary from the Caribbean Brian Neff	87
OCTOBER 2013	Afraid of the Dark: Humanity at the Crossroads Sheldon Solomon	2,276
OCTOBER 2013	Handling the Complexities of Large-Scale Brain Models Chris Eliasmith	1,378
NOVEMBER 2013	Validating Models of Cognition *Data Visualization and Analysis Symposium* Terry Stewart	51
NOVEMBER 2013	Local and Global Sensitivity Analysis Connect Model Parameters to System Behaviour in a Model of Beta-Cell Metabolism *Data Visualization and Analysis Symposium* Brian Ingalls	17
NOVEMBER 2013	Tracing the Impacts of Land-Market Structure on Urban Growth *Data Visualization and Analysis Symposium* Dawn Parker	16
NOVEMBER 2013	Problems in Cosmology and the Upcoming Data Avalanche *Data Visualization and Analysis Symposium* Mike Hudson	6
NOVEMBER 2013	Fast Visualization of Relevant Portions of Large Dynamic Networks *Data Visualization and Analysis Symposium* Przemyslaw Grabowicz	38
NOVEMBER 2013	A Framework for Decision Making in Social Innovation Lab Processes *Data Visualization and Analysis Symposium* Steve Williams	30
NOVEMBER 2013	Using Models in Social Innovation Labs: Prototype Models of Agro-Economic Systems in Southern Ontario to Support Innovation in Food System Policy *Data Visualization and Analysis Symposium*	70

DATE	WICI SEMINAR TITLE AND SPEAKER	VIEWS*
	Kirsten Robinson	
NOVEMBER 2013	Visualizing a Complex System: The Use of Dance as a Data Visualization Tool *Data Visualization and Analysis Symposium* Elliott Miller & Sarah Hogland	23
NOVEMBER 2013	Interactive Visualization *Data Visualization and Analysis Symposium* Sheelagh Carpendale	17
DECEMBER 2013	Creative Cognition in Social Innovation Paul Thagard	203
MARCH 2014	Reach Control Problem Mireille E. Broucke	782
APRIL 2014	A Framework for Structural Input/Output and Control Configuration Selection of Large-Scale Systems Sérgio Pequito	N/A
MAY 2014	Open Source Ecology: Towards the Open Source Economy Marcin Jakubowski	455
MAY 2014	Agent-Based Modelling and GIS: Applications to Land Use Change and Environmental Modelling Scott Heckbert	393
DECEMBER 2014	Collaborating On-Line: An Analysis of Communication Networks for Linux Kernel Developers John McLevey	85
JANUARY 2015	Invention and Innovation: The Long Term Sander van der Leeuw	248
JANUARY 2015	Mathematical Modelling of Social Spreading Processes Hans De Sterck	203
FEBRUARY 2015	Discovering the Themes of Complexity Science in Land Use Modelling Derek Robinson	72
MARCH 2015	The Knowledge: How To Rebuild Our World From Scratch Lewis Dartnell	389
MARCH 2015	Bridges Lecture – Dancing the Math of Complex Systems Dawn Parker and Sarah Tolmie	990**
MARCH 2015	Democracy and Development: Getting Away from Linear Thinking to True Understanding Jack Goldstone	88
October 2015	Dynamics and Control of Flexible Solar Towers Vakhtang Putkaradze	56
November 2015	Transformative Sustainability Governance: Triggering Change on an Urban Planet Sarah Burch	66
January 2016	Multi-Scale Modelling of Infectious Diseases Jane Heffernan	91
February 2016	A Dangerous Master: How to Keep Technology from Slipping Beyond our Control Wendell Wallach	95
February 2016	Why Information Grows Cesar Hidalgo	117
April 2016	Comparing Climate Change Policy Networks Tuomas Yiä-Anttila	35
May 2016	Using Analogy to Recognize Visual Situations	64

DATE	WICI SEMINAR TITLE AND SPEAKER	VIEWS*
	Melanie Mitchell	
October 2016	Math on the Frontlines: Applications of Complex Systems Methods in Conflict Research Alexander "Sasha" Gutfraind	N/A
October 2016	Infighting Among House Republicans: Leaders, Factions and Complex Networks of Interest Jon MacKay	22
November 2016	Urban Growth and Change Research Group Symposium Dawn Parker	94
November 2016	Nature in a Bottle: Incorporating Real-World Complexity into Designer Ecosystems Matt Hammond	55
January 2017	Self-Generating Economic Forecast Heterogeneity Blake LeBaron	73
February 2017	Deep Learning with Darwin: Evolutionary Synthesis of Operational Deep Intelligence Alexander Wong	69
March 2017	Bio from Bit: Quantifying the Origins of Life Sara Imari Walker	343
May 2017	Extending Resilience Beyond Small-Scale Natural Resource Systems: A Help or a Hindrance for Human Well Being? *WICI Spring Conference* Ann Kinzig	21
May 2017	Investigating Resilience and Transformability in Human Systems *WICI Spring Conference* Vanessa Schweizer	57
May 2017	Resilience and the Measurement of Recovery in Development Settings *WICI Spring Conference* Mark Constas	20
May 2017	New Sentient Architecture *WICI Spring Conference* Philip Beesley	42
May 2017	System Collapse, Tipping Points and Complex Disasters: Nicobar Islands in the Aftermath of the 2004 Tsunami *WICI Spring Conference* Simron Singh	39
May 2017	Ecology of Poverty, Disease, and Health Care Delivery: A New Model District in Madagascar *WICI Spring Conference* Mathew Bonds	41
October 2017	Analysing Covert Networks from Unstructured Sources Johan Koskinen	42
October 2017	Understanding, Modeling, and Managing Complex Systems of Systems Yacov Haimes	N/A
October 2017	Using Deep Learning and Reinforcement Learning to Tame Spatially Spreading Processes Mark Crowley	88
February 2018	From Sandpiles to Real Mountains - Complex Dynamics of Tropical Mountainscapes Carla Restrepo	26

DATE	WICI SEMINAR TITLE AND SPEAKER	VIEWS*
March 2018	Poetry and Complexity – Readings and Discussions Madhur Anand, Roald Hoffmann and Rae Armantrout	39
April 2018	Synthetic Evolutionary Transitions: From Cells to Brains and Ecosystems Ricard Solé	33
June 2018	Urban Logistics: How Delivery Services, Transportation Network Companies and Autonomous Vehicles Add Complexity to Urban Modeling *WICI Conference on Modelling Complex Urban Environments* Alex Anas	44
June 2018	Can Complex Systems Modelling Provide Support to Policy? *WICI Conference on Modelling Complex Urban Environments* Hedwig van Delden	55
June 2018	Canadian Smart Cities: What an Innovation Challenge Tells Us About Our Near Future *WICI Conference on Modelling Complex Urban Environments* Pamela Robinson	18
November 2018	Wisdom in a Complex World: Measurement, Utility and Interventions Igor Grossmann	66
January 2019	Demystifying Language and Breaking Down Barriers in Complexity Science and Methods Sharon Kirkpatrick, William Sutherland, and James Shelley	54
February 2019	Graduate Fellowship Awardees: Research Symposium Amanda Raffoul: Are we (unintentionally) doing more harm than good? Systems Approaches to the Prevention of Eating-and-Weight-Related Disorders Kevin Church: The Hidden Geometry of Complex Dynamics and How to Exploit It Katharine Zywert: Social-Ecological Systems Change and the Future of Human Health	10
March 2019	Systems Approaches to Sustainability: Climate, Air Pollution and Toxic Substances Noelle E. Selin	7
August 2019	Introduction and First Two Case Studies: "Global Water Balance" and "Lumped Models and Stochastic Ordinary Differential Equations" *Socio-Hydrology Opportunities and Challenges Workshop* Kumaraswamy Ponnambalam and S. Jamshid Mousavi	73
August 2019	Responsible Governance in a Complex World: A System of Systems Engineering Design *Socio-Hydrology Opportunities and Challenges Workshop* Keith W. Hipel	30
August 2019	Agent-based Modelling (ABM) *Socio-Hydrology Opportunities and Challenges Workshop* Kumaraswamy Ponnambalam	24
August 2019	Lake Urmia Adaptation to Changes (Case Study) *Socio-Hydrology Opportunities and Challenges Workshop* S. Jamshid Mousavi	23
August 2019	A Small Island Context for the Socio-Hydrology Approach *Socio-Hydrology Opportunities and Challenges Workshop* Steve Fletcher	16
August 2019	Multi-Scale Governance and Management of Stormwater *Socio-Hydrology Opportunities and Challenges Workshop* Dawn Parker	18

DATE	WICI SEMINAR TITLE AND SPEAKER	VIEWS*
August 2019	Partial Differential Equations *Socio-Hydrology Opportunities and Challenges Workshop* Kumaraswamy Ponnambalam	20
August 2019	Coupled Local-Global Systems *Socio-Hydrology Opportunities and Challenges Workshop* S. Jamshid Mousavi	22
September 2019	Origins: How the Earth Shaped Human History Lewis Dartnell	14
October 2019	How and Why do Cultures Change Michael Varnum	12
November 2019	Our Changing Biosphere: Understanding our Future from First Principles Mary O'Connor	0
February 2020	Life, but not Alive Kate Adamala	48
July 2020	Participatory Complexity: From Epistemic Drift to Epistemic Shift *Convergent Innovation Webinar* William Sutherland, Chrystopher Nehaniv, Nora Bateson, Zachery Stein, Alayne Adams	25**
September 2020	It's Complex: Future of Modelling and Simulation in a Changing Geospatial Data Environment Raja Sengupta	2

**Views are defined as: A view is counted each time the video player loads a video on Vimeo.com, or in some cases, wherever a video is embedded.*

***This video is on a YouTube page for a collaborating centre and its view count is not included in WICI's overall Vimeo analytics.*

3.6.4 OPEN HOUSE AND NETWORKING EVENTS

WICI's has held a number of informal networking events. Term open house events have welcomed a balance of new and current members and led to several important network connections, especially around modeling of risk and human-environment interactions. Prospective post-graduate students have been connected with potential supervisors, newsletter subscribers have been recruited, and connections have been made to generate a new working group through these informal events.

WICI held its first faculty networking event on February 28, 2019, with the goals of connecting faculty members across campus who share common research interests, to which complex systems methods might be usefully applied; and preliminary visioning for a "Canadian Network for Complex Systems". Participants were tasked with generating as many common research questions as they could in small groups, with the hopes of helping faculty establish new research connections.

A second faculty network event was organized on July 17, 2019, at the request of Shirley Tang, (ADR of Science) for WICI to co-host an event connecting the Arts, Environment and Science faculties. There were close to forty participants at this event, and a few promising connections made. Learning from the previous session, WICI graduate students helped to harvest keywords on self-identified methods, application areas, and disciplines, and WICI student member Perin Ruttonsha subsequently broke participants into thematic research clusters based on areas of focus, a list of which including harvested keywords, were shared with the Office of Research, Faculty of Science, WICI and event participants. A few new WICI members were recruited including Luis Sandoval (University Research Chair II & Associate

Professor, Chemical Engineering, connected through WIN) who offered to provide advice/feedback to Frontiers applicants, and WICI was referred to the Calgary Complex Systems Institute.

3.7 DEVELOPMENT OF A CANADIAN NETWORK FOR COMPLEX SYSTEMS

In 2019, WICI released a call for applications for external members, in exploration of the development of a Canadian Network for Complex Systems (CNCS). Currently, the CNCS is primarily a network of institutes/centres with shared research interests in complex systems. The long-term form, mission, and activities of CNSC are open for development.

Initial discussions have identified the following open questions and possible directions:

1. What goals/needs might CNCS serve?
    a. **Networking:**
        i. Identify and publicize active complex systems researchers across Canada—facilitate communication.
        ii. Provide scholar matchmaking services (i.e., for those seeking particular expertise, data, or research support for research collaboration, student supervision and examination, and grant partnerships).
        iii. Conduct network analysis (research) on the community of complex systems scholars.
    b. **Education:** Provide access to "get-started" educational materials for complex systems methods to students and other researchers.
    c. **Incentives for collaboration:** Incentivize network development, collaborative engagement and interdisciplinary research at the administrative level.
    d. **Interdisciplinary Scholarship:**
        i. Enable a cultural shift towards community and interdisciplinary engagement.
        ii. Reduce analytical and language barriers to facilitate collaboration across fields. Reduce barriers between theory and practice, or the abstract and the concrete.
        iii. Bring together those having expertise in theory and tools with those having applied problems.

2. What kind of structure might CNCS have?
    a. Roles and responsibilities of the 'main node'—to be determined, as well as whether the designation of 'main node' should be a fixed term.
    b. Decentralized nodes with a highly flexible structure, but a clearly-defined minimum hurdle for continued membership.
    c. Given that minimum, node size/involvement can be flexibly scaled, from minimal to significant engagement (i.e., online forums, events, participation in summer schools, collaborative projects).
    d. Have rotating activities with internal responsibility for funding (such as conferences, summer schools).

3. What kinds of activities might CNCS support?
    a. Identify grand challenges for complexity science that could frame national and international collaborations. Which are we working on? Which do we aspire to contribute to?
    b. Direct support and engagement with governmental actors at all levels, to provide research support for complex management challenges.

c. Host methodological workshops and develop modules that could be delivered within different courses across institutions.
d. A summer school, with rotating hosting, was highly supported.
e. Cross-university advising and student examination.
f. Host retreats to deepen connections among scholars.
g. Communicate funding priorities to tri-council and other funding bodies.
h. Large, multi-institutional grant and infrastructure initiatives.

4. How might CNCS be funded?

5. What might the CNCS mission be?
    a. Build capacity to achieve critical mass of complex systems scholarship within Canada.
    b. Advance the discipline broadly.
    c. Train the next generation of complex systems thinkers.
    d. In addition, have an applied focus – demonstrate what complex systems theory/methods applications can do.

Through this call, we have identified four major geographic nodes with potential for strong institutional support: British Columbia (University of British Columbia, Simon Fraser University, University of Victoria and the Cascade Institute), Ontario (University of Waterloo, University of Guelph and Western University), Montreal (McGill University and University of Montreal) and Newfoundland (Memorial University). Figure 8 illustrates the locations and collaborating institutions that have come forward to date. Administrative leaders of these nodes are designated "external node coordinators," and are also external core members of WICI. Several external core members have applied and have been accepted to WICI membership in 2019-2020.

Figure 8: Emerging Nodes of a Canadian Network for Complex Systems (CNCS)

3.8 COLLABORATION OPPORTUNITIES

During its lifetime, WICI has conferred with other research centres on campus as well as external and potential external collaborators who have contacted WICI to explore areas of possible partnership. Two thirds of the collaboration discussions that occurred over the past two years, were a result of WICI being discovered either from our web presence, internal referrals or through our network of researchers. This level of external engagement is very positive for WICI and signifies that the institute's name and reputation is appealing to a growing scientific and professional community.

The following is a list of some of the collaborative talks that WICI engaged in over the past two years, most of which were discussed more thoroughly in our 2019 and 2020 annual reports:

Dean of Science – improving engagement of Science faculty in WICI activities; areas of complementarity

Santa Fe Institute - consultation and strategic advice regarding funding opportunities, summer schools

Dean Toonen (University of Twente) - "resilient cities" meetings with Dean of Environment, INTACT Centre, Canadian Water Network, Water Institute, and several University of Waterloo faculty members

Waterloo Institute for Nanotechnology (WIN) - common thematic research areas, speaker co-sponsorship

Paul Heidebrecht, Director, Kindred Credit Union Centre for Peace Advancement– Co-sponsorship of Map the System Challenge, student team mentoring

Canadian Water Network (CWN) & Interdisciplinary Centre on Climate Change (IC3)– discussions regarding Climate Adaptation, Resilience, Innovation and Knowledge Mobilization in governance/management decisions

Complex Systems Institute of Paris Ile-de-France (ISC-PIF)– Strategic discussions around institutional development, Gargantext bibliographic mining program and Open Mole system for conducting sensitivity analysis for computational models

Waterloo Centre for Microbiology Research (WCMR) – areas of commonality, speaker co-sponsorship; connection with Laurette Dube with our developing Montreal node, Smart Health Cities grant development

Naresh Singh, Global Development Solutions Canada – connected with Kindred Credit Union Centre for Peace Advancement

CMHC Campus Visit – partnership in Open Research Area international grant application for "Exploring housing policy complexity: Cross-scale modelling of housing market drivers, interactions and impacts" and common areas of interest for future research in development of qualitative models to explore systems dynamics in housing markets

Robert Cutler Campus Visit– Senior Research Fellow for Energy Security, NATO, Senior Fellow in Energy Geo-economics, Canadian International Council, and Fellow with Canadian Energy Research Institute contacted WICI, joined as a practitioner and was subsequently connected with Balsillie School of International Affairs, Chair of Political Science, and our emerging Montreal node of WICI

Tamer Özsu (Waterloo Data Science Institute Application)– synergies and joint activities including a funded, staffed laboratory for computational modelling and analytics

Cascade Institute, Royal Roads University (BC) - WICI Core Member and former Director Thomas Homer-Dixon has established the Cascade Institute at Royal Roads University in British Columbia, as an outgrowth of WICI. WICI is now an Affiliated Institute for Cascade Institute, and several of our core, affiliate and student members are actively engaged with this institute as well. Cascade Institute is hoping to support two postdoctoral research fellows within WICI who can teach courses and develop curricular materials at University of Waterloo.

Office of Research Strategic Research Plan Consultation – written feedback provided including WICI's collaboratively developed list of thematic areas

Task Force on Interdisciplinary, Inter-Faculty Research, Academic Programming and Training – feedback on facilitators and barriers to interdisciplinary scholarship in teaching, scholarship, advising, faculty appointments, research funding and administration

Kisten Moy, Aspen Institute – discussion regarding education program for community development professinals who need tools and trainees for addressing complex systems problems

FuseForward - Mark Damm, CEO FuseForward contacted WICI to inquire about collaboration on a smart-campus model and similar projects going forward

Waterloo Institute for Social Innovation and Resilience – discussions around collaboration, merging and/or absorption of WISIR into WICI going forward, to streamline funding and efficiencies between the centres.

Larry Smith, Director and Founder, The Problem Lab – discussions about collaboration toward a professional development offering(s) and/or industry training/cooperative education connections.

4. GOVERNANCE

Given the interdisciplinary nature of WICI, administrative authority comes from the Office of Research rather than an individual Faculty. WICI maintains a Steering Committee who actively advises the administrative team regarding decisions related to staffing, budget and institutional priorities. The larger WICI Board meets annually to review annual progress reports and advise on future direction. The International Scientific Advisory Committee remains available to consult with WICI and provide direction related to scientific research in Complex Systems. Figure 9 below illustrates WICI's current governance structure.

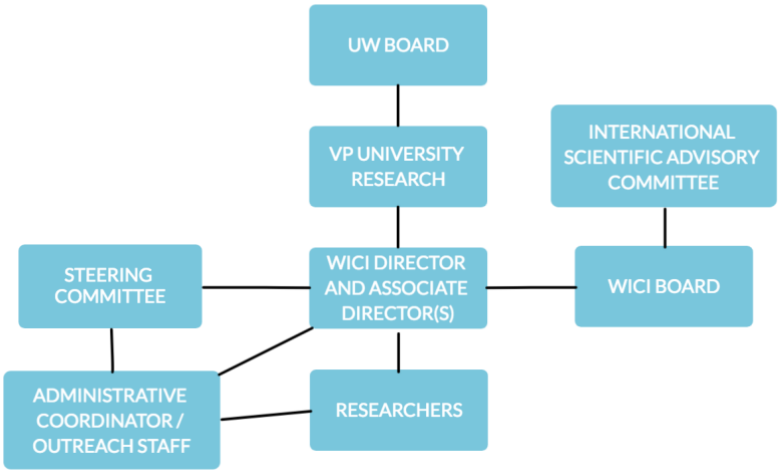


Figure 9: WICI's Governance Structure

4.1 BOARD

The Institute's Board is designed to provide advice on the general and financial management of the Institute, as well as guidance regarding the Institute's operation and research directions. The Board discusses the Institute's infrastructure needs and new initiatives, assisting WICI in identifying new areas for future growth.

Members of WICI's Board consist of:

- Vice-President Academic and Provost;
- Vice-President, University Research;
- Deans or their representatives from the primary participating faculties;
- WICI Director;
- WICI Associate Director;
- Steering Committee members, other Core Members, or additional members drawn from university faculty, representing each of the UW Faculties; and
- Three external members who are leaders in the fields of complexity science and innovation and members of the International Scientific Advisory Council, ideally selected from the Southern Ontario region.

Table 18: WICI 2020 Board Members

WICI 2020 Board Members		
James	Rush	VP, Academic and Provost (*or delegate*)
Charmaine	Dean	VP, University Research (*or delegate)*
Sheila	Ager	Dean, Arts
Lili	Liu	Dean, Health
Mary	Wells	Dean, Engineering
Jean	Andrey	Dean, Environment
Mark	Giesbrecht	Dean, Mathematics
Bob	Lemieux	Dean, Science
Vanessa	Schweizer	WICI Director
Sharon	Kirkpatrick	WICI Associate Director
Igor	Grossmann	Associate Professor, Psychology
Chrystopher	Nehaniv	Professor, Systems Design Engineering
Dawn	Parker	Professor, Planning
Trevor	Charles	Professor, Biology
Keith	Hipel	Professor, Systems Design Engineering
Sarah	Tolmie	Associate Professor, Department of English Language and Literature
Monica	Cojocaru	Professor, Department of Mathematics & Statistics, University of Guelph
Anna	Lawniczak	Professor, Department of Mathematics & Statistics, University of Guelph
William	Sutherland	MD; Assistant Clinical Professor (Adjunct), Family Medicine, McMaster; Founder & Director, Institute for Complexity & Connection Medicine

4.2 STEERING COMMITTEE

WICI's Steering Committee (formerly Executive Committee) is designed to provide advice to the Director, Associate Director, and the Vice-President, University Research on matters relating to the regular operations of WICI, including its annual budget, major activities and strategic planning. The committee is mandated to meet three or four times per year, and it may correspond more frequently as required between meetings.

The Steering Committee consists of:

- WICI Director;
- WICI Associate Director;
- WICI Administrative Coordinator;
- Two or more Core Members representing different faculties; and
- One or two additional members drawn from the university faculty, representing participating Faculties.

Table 19: WICI 2020 Steering Committee Members

WICI 2020 Steering Committee Members

Vanessa	Schweizer	WICI Director, Associate Professor and Associate Chair of Undergraduate Studies, Knowledge Integration, University of Waterloo
Sharon	Kirkpatrick	WICI Associate Director, Associate Professor, School of Public Health & Health Systems, University of Waterloo
Dawn	Parker	Professor, School of Planning, University of Waterloo
Igor	Grossmann	Associate Professor, Psychology, University of Waterloo
Chrystopher	Nehaniv	Professor, Systems Design Engineering, University of Waterloo
Trevor	Charles	Professor, Biology, University of Waterloo (joined August 2020)

The Board and Steering Committee meet in a joint meeting annually, as an opportunity for in-depth discussion of WICI activities and strategic directions.

4.3 INTERNATIONAL SCIENTIFIC ADVISORY COUNCIL

WICI's International Scientific Advisory Council provides advice to the Board on the Institute's research priorities; it also assists WICI in establishing connections and maintaining its profile within the international complexity studies and innovation studies communities. The council is composed of outstanding complexity and innovation researchers from the university, Canada, and abroad who are Core or Affiliate Researchers of WICI.

Table 20: WICI 2020 International Scientific Advisory Committee Members

WICI 2020 International Scientific Advisory Committee Members

W. Brian	Arthur	External Professor, Santa Fe Institute
Robert	Axtell	Professor and Chair, Dept. of Computational Social Science, George Mason University
Yaneer	Bar-Yam	President, New England Complex Systems Institute
Michael	Batty	Professor of Planning, Director, Center of Advanced Spatial Analysis, University College London
Eric	Beinhocker	Executive Director, Institute for New Economic Thinking at the Oxford Martin School, University of Oxford
Monica	Cojocaru	Associate professor, Department of Mathematics & Statistics, University of Guelph
J. Doyne	Farmer	Professor of Mathematics and Director of Complexity Economics, Institute for New Economic Thinking at the Oxford Martin School, University of Oxford
Carl	Folke	Science Director, Stockholm Resilience Centre
Ian	Goldin	Director, Oxford Martin School, Oxford University
Matthew	Hoffman	Associate professor of political science, University of Toronto
Eric	Lambin	Professor, Dept. of Geography, University of Louvain; Professor, School of Earth Sciences, Stanford University
Jukka-Pekka	Onnela	Assistant Professor of Biostatistics, Department of Biostatistics, Harvard School of Public Health
Felix	Reed-Tsochas	Co-Director of the CABDyN Complexity Centre University of Oxford
Marten	Scheffer	Professor, Aquatic Ecology, Wageningen University
Lee	Smolin	Perimeter Institute; Adjunct Professor, Dept. of Physics, UW
William	Sutherland	MD, Assistant Clinical Professor (Adjunct), Family Medicine, McMaster University, and Founder and Director of the Institute for Complexity & Connection Medicine
Leigh	Tesfatsion	Professor of Economics, Mathematics, and Electrical & Computer Engineering, Dept. of Economics, Iowa State
Jan	Wouter Vasbinder	Director of the Complexity Program at the Nanyang Technological University at Singapore

In selecting governance committee members, WICI strives to obtain a diverse balance of disciplinary, research, and methodological perspectives. Further, the Institute strives to establish and maintain gender and ethnic diversity in its oversight and membership.

4.4 ADMINISTRATION

4.4.1 DIRECTORS

WICI is led by a Director who reports to the Vice-President, University Research, and who is responsible for the management of the Institute, supervision of WICI staff members, and guiding of research and

outreach agendas. **The Director is appointed by the Vice-President Academic and Provost on the recommendation of the Vice-President, University Research** for a term of up to three years, normally renewable once. WICI has had four Directors since being formally established in 2009. WICI owes its success to the collective contributions of these exemplary leaders.

> "The inspiration and encouragement [of the leadership of WICI] have been critical to the formation of [the Complex Adaptive Systems] group at Western. I am truly grateful for their initiative, example and vision."
>
> *-James Shelley*
> *Director, Complex Adaptive Systems Lab*
> *Western University*

2009-2012 Dr. Thomas Homer-Dixon

- Founded WICI with Frances Westley and Kristen Robinson (Wright)
- Gained senate approval and core funding for first 5 years
- Established core members, governance structure and International Scientific Advisory Council
- Initiated Critical Transitions Thresholds (WICI Core Project) funding commitments

2013-2015 Dr. Dawn Parker

- Data Visualization and Analysis Workshop
- Digging into Data (DiD) Grant obtained
- Initiated transition to Steering Committee model of governance
- Initiated competitive research small grants program
- Substantially increased gender diversity of WICI speakers

2015-2018 Dr. Madhur Anand

- 48% increase in WICI membership
- 275% increase in graduate student membership
- Attracted a Nobel Laureate to UW for a WICI Talk
- Established formal collaborations with Perimeter Institute and Field's Institute
- "What is a Complex System" outreach video project
- 2017 Conference on Resilience in Complex Natural & Human Systems
- Secured increased core funding for WICI

2018-2020 Dr. Dawn Parker

- Significant increase in graduate student membership & undergraduate representation through leading a Student Engagement Initiative
- New partnerships with Map the System and WCMR
- Development of a Canadian Network for Complex Systems
- Mapping Canadian Complex Systems Scholarship project

2020-Present Dr. Vanessa Schweizer

- Groundbreaking first steps toward Training Program Development
- Consolidation with WISIR (pending renewal)
- Lead in 2021 renewal process and 5 Year Strategic planning
- Introduction of a Science faculty member

4.4.2 ASSOCIATE DIRECTOR

The WICI Director is assisted by an Associate Director. The Associate Director is appointed by the Vice-President Academic and Provost on the recommendation of the Vice-President, University Research for a term of up to three years, normally renewable once. The Associate Director assists in guidance of research and outreach agendas, and normally consults with the director regarding resource allocation decisions. The Associate Director is also expected to contribute to WICI's networking and capacity building activities. WICI's current Associate Director is Dr. Sharon Kirkpatrick. The role was previously held by Dr. Vanessa Schweizer (2019), who has now assumed the role of WICI Director, and prior to that, Dr. Peter Deadman (2018), Dr. Chris Bauch (2016-2018), Dr. Thomas Homer-Dixon (2013-2015).

4.4.3 STAFF

The Institute employees an Administrative Coordinator on a part-time basis, who reports to the Director and manages general office operations. Specific responsibilities include coordinating WICI's Speaker Series, workshops and symposium; organizing travel arrangements; managing the Institute's website; advertising WICI globally through the mailing list and social media accounts; and assisting with the preparation of WICI's Institutional reports. The Coordinator handles the submission of pay claims to the University of Waterloo's Finance department, maintains good records of the organization's spending and annual budget, and serves as internal liaison with University of Waterloo academic departments and administrative units.

WICI also hires Graduate Research Student Assistants to oversee and administer various outreach projects to support attainment of WICI strategic goals. A summary of Graduate Research Student Assistants employed is discussed in Section 3.5.2: Students and Postdoctoral Fellows Employed by WICI.

4.5 EXTERNAL NODE COORDINATORS

As part of our development of a Canadian Network for Complex Systems, some of our external core members have indicated a desire and support to establish and lead their own 'hubs' of complex systems research at their respective Institutes. As such, WICI is developing a new governance category for External Node Coordinators.

EXTERNAL NODE COORDINATORS will be external Canadian practitioner, affiliate or core members of WICI who take an active leadership role, with institutional support, in developing and managing external nodes. We are currently exploring the designation of three of our external members as official Node Coordinators: James Shelley, Director of the Complex Adaptive Systems Lab at Western University, Mary O'Connor, Director of the Biodiversity Research Centre at University of British Columbia, and Raja Sengupta of McGill University in Montreal.

5. FINANCIALS: SUMMARY/OVERVIEW OF BUDGETS FROM 2015-2020

WICI has consistently operated on a modest operating budget with our largest expenses being Administrative salary and activities that support research and grant development. After it was advised that the Provost would no longer be able to provide operational funds for our centre, the Dean of Environment and the Office of Research generously offered contributions to cover half of our operating costs in 2020-2021, which were to be used for modest member-supporting activities and strategic planning. In August 2020, we were informed that the Office of Research had successfully procured our

full yearly operational budget and we were able to refund the Dean of Environment's contributions for this fiscal year.

A high-level summary of our financials for the past five years is detailed in Table 21 below, while the spreadsheet in Appendix D: Financial Report 2015/16 to 2019/20 provides an itemized, detailed breakdown of WICI's income and expenses from 2015-2020, and Appendix E: Financial Report (YTD) 2020-2021 details our current budget for the 2020-2021 fiscal year to date.

Table 21: Overview of Financials from 2015-2020

	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-Present
INCOME						
UW Funding	$55,000	$68,000	$70,000	$75,000	$75,000	$67,500
Other Funding**	$68,955	$70,238	$61,868	$21,136	$23,654	$40,686
Total Income	**$123,955**	**$138,238**	**$131,868**	**$96,136**	**$98,654**	**$108,186**
EXPENSES						
Salaries	$21,143	$22,379	$20,971	$27,446	$32,039	$41,745 †
Research & Grant Support	$28,297	$45,389	$41,347	$27,446	$16,100	$21,500 †
Events	$6,768	$10,657	$44,824	$15,795	$6,854	$2,625 †
Institutional Development	N/A	N/A	N/A	N/A	$1,856	$1,500 †
Office/Incidentals	$1,513	$4,122	$1,923	$1,609	$2,279	$2,574 †
TOTAL EXPENSES	**$57,721**	**$82,547**	**$109,065**	**$72,296**	**$59,128**	**$69,094**

**Other funding reflects funding that was carried over from the previous year as well as periodic co-sponsorship funds for conferences, and a WICI match from the one-time partnership development grant awarded to D. Parker in 2015.

†Expenses for 2020-Present reflect budgeted expenses for the whole year.

APPENDIX A: PROGRESS AGAINST WICI'S YEARLY GOALS 2015-2020

At its 2015 annual meeting, the WICI Board laid out five strategic directions for 2016-2020. The following pages are a collation of all documented WICI activities reported in support of these goals.

1. Strengthen core networks.
    a. Continue to actively support current core projects and members through grant writing assistance and complementary activities such as talks, workshops, and working groups.
        i. Yearly speaker series ongoing
        ii. 2016 seed grant competition
        iii. May 2017 WICI Conference on Resilience
        iv. June 2018 WICI Conference on Modelling Complex Urban Environment
        v. 2018 Core member support: travel grants (8), matching grant fund for IRPG, two funded and one co-sponsored workshop organized by core members
        vi. 2018 Other member support: One additional workshop, student travel awards (10), student fellowship awards (3), and funding for one reading group
        vii. 2018 member-presented WICI talk (1); two WICI student visitors in spring and summer 2018
        viii. 2019: Core member support: travel grants (8), matching SEED grant for Internal Affiliate member A. Klinkova, matching grant for Core Member D. Parker (1)
        ix. 2019 Other member support: student travel awards (4), other workshop funding for WICI student members (4)
        x. Several members presented at 2019/20 WICI talks (1 Core, 3 Students and 1 External Core member)
        xi. 2020 Core member support: matching funds for SSHRC proposal; travel grants converted
        xii. 2020 Other member support: Map the Systems finalists sponsored for a workshop; Piereder (student member) and Sengupta featured in WICI webinars; all WICI members for remaining planned talks

    b. Look for existing opportunities on campus to expand core membership in the areas of network science, human-environment interactions, expanding conventional economics, complexity and non-rational drivers of behavioural change, Psychological Dynamics of Catastrophic Dehumanization; Rapid Ideological Change/Ideological Conflict; and Embodied Cognition.
        i. 2016: Vanessa Schweizer and Peter Deadman brought into core membership
        ii. 2016: WICI formed a collaborative relationship with the Fields Institute through conference and workshop sponsorship through 2018
        iii. 2018: New Core members (2), new Affiliate members (5), and new Student members (10), WICI student visitors in Network Complexity Science
        iv. 2019: New Core member (1), New External Core members (4), new Affiliate members (2), new Practitioner members (2), and new Student members (6). Interactions with the Fields Institute continue; collaborations with other research institutes have been strengthened through cross-institute meetings, co-sponsored talks, and research networking sessions.
        v. 2020: New Core Member (1), New External Core members (2), new Affiliate member (1), new Practitioner members (3), and new Student member (1). Collaborations with WatSpeed, The Problem Lab, WISIR, McGill Centre for Convergence in Health and Economics (MCCHE) have been in progress.

c. Work with faculty units and deans to identify opportunities for new hires whose research has a complex systems focus.
    i. (2017) Targeted discussions were held with Chairs and Deans in Engineering, Mathematics, and Environment about the possibility of a targeted complex systems hire.
    ii. In 2018, we identified new hires in ENV and Systems who have a strong complex systems focus. A key WICI collaborator also returned to Applied Math.
    iii. 2020: Lisa Aultman-Hall was hired as the Chair of Systems Design Engineering and has joined WICI as an Affiliate member. Conversations with Engineering and Environment chairs, and/or a proposition to the provost to hire a complex systems Assistant Professor are being considered.

d. Seek out particular opportunities to establish core WICI members in under-represented faculties (AHS and Science).
    i. 2016: A workshop award was granted to S. Kirkaptrick (AHS) and 2 new student members joined from AHS.
    ii. 2017: A new affiliate member from Perimeter Institute joined, Sara Walker was invited to a WICI talk, WICI hosted a joint WICI/PI talk with Roald Hoffman.
    iii. 2018: Kirkpatrick was promoted from Affiliate to a Core WICI member from AHS, and joined the Steering Committee. For science, we worked with the Associate VP of Interdisciplinary Research to better reach out to the faculty. We increased poster promotion in science buildings, and we hosted our student project symposium in the Science Teaching Complex building. The Office of Research facilitated distribution of our funding calls across campus.
    iv. 2019: Core Member Sharon Kirkpatrick joined WICI in 2018, and continued to advance the complex systems work in Health Sciences. Three of the judges for our Complex Systems Student Project Symposium were from AHS. In July 2019, we collaborated with the Faculty of Science to host a research networking session, and we hosted two science-focused complexity talks which both saw great turnout and engagement from the science faculty, including the most recent talk from Dr. Kate Adamala, whose visit was co-sponsored with the Waterloo Centre for Microbial Research (WCMR). An award was made to Anna Klinkova in Chemistry, who has joined WICI as an Affiliate member.
    v. In 2020, Trevor Charles joined as a WICI Core and Steering Committee member representing Science. Another representative from math and/or science is currently being approached to join as well.

2. Facilitate interdisciplinary research.
    a. Host talks and workshops, striving to maintain a balance between bringing in global leaders in complex systems and highlighting local complex systems scholarship.
        i. The 2016-17 WICI speaker series and May 2017 conference on resilience; WICI's support for graduate students through travel support; and the 2016 WICI seed grant competition helped facilitate interdisciplinary research (goals 2a-c).
        ii. The 2017-2018 speaker series included one UW faculty member, two local scholars, and two high-profile external scholars. There was substantive overlap between the subjects of the talks and WICI's core research activities. The May 2017 WICI Conference on Resilience brought in a variety of speakers and provided presentation opportunities to local WICI members. WICI has

continued to support graduate students research through travel awards and this year's WICI student scholar competition. Also, 66% of the participants in the 2017 WICI Conference on Resilience were from outside the University of Waterloo. In 2017 an NSERC CREATE grant LOI was put forward by Kate Larson (Computer Science) which involved new collaborations between several WICI core members (Anand, Bauch & Crowley) and was successful at the institutional level.

iii. The 2018 WICI speakers included a UW faculty member, and four high-profile external scholars. There was substantive overlap between the subjects of the talks and WICI's core research activities. WICI also co-sponsored and co-organized a highly international Field's Workshop in March 2018 on human-environment systems and subsidized student attendance. The WICI 2018 conference on Modelling Complex Urban Environments included a balance of UW, local, and international speakers and participants.

iv. The 2019 WICI speakers included a UW faculty member, three UW graduate students, and four high-profile external scholars, including one new WICI External Core Member from UBC. WICI also promoted ongoing graduate student seminars in the spring 2019 term, and an internal Systems Design and Engineering Workshop in the fall term.

v. While workshops and conferences were not able to be organized this year, WICI continued with a speaker series via WebEx and has worked in plans to resume a regular workshop and conference schedule over the next five years. The 2020/21 WICI speakers have included thus far an External Core Member from McGill University and a PhD candidate from UW's Balsillie School of International Affairs, and we have collaborated with the McGill Centre for Convergence in Health and Economics (MCCHE) on delivery of webinars as well.

b. Support working groups, allowing their focus and scope to evolve with the interests and needs of membership.

i. In 2017/2018, WICI awarded three workshop grants, which supported the development of the research programs of core and affiliate faculty members.

ii. In 2018, a WICI student member (Perin Ruttonsha) led an interdisciplinary reading group and co-authored a paper with other WICI Student members. A GRA was hired to increase the cohesiveness and identity of WICI Student members. We also actively engaged WICI members to identify existing and potential networks.

iii. In 2019, the working groups supported were: Open Format Complexity Conversations with Dr. Bill Sutherland (held bi-weekly from May through November 2019), Graduate Student Complexity Seminars (held monthly in spring term 2019), and Complexity Networks and Organizations group organized by an affiliate member in Fall 2019. The School of Architecture also organized a group and led a WICI-supported Design Symposium at their campus in November 2019. This was a banner year for member-led working groups and initiatives.

iv. In 2020, an informal working group was arranged for those interested in the ABM course that was cancelled. Active engagement continues through our existing member network as potential collaborations continue to emerge. Interdisciplinary collaboration continues as WICI connects with other research

institutes on campus (WISIR, Data Science, WCMR) as well as establish a national network of complex systems researchers.

c. Offer support for grant development.
    i. In 2016, WICI support facilitated several grant submissions and provided matching funds for 3 WICI workshops.
    ii. In 2018, based on conversations with the Office of Research, WICI made targeting external partnerships funding a priority. WICI issued the challenge grant in fall 2018.
    iii. In 2019, WICI awarded one SEED grant to A. Klinkova and promised matching funds for D. Parker's Trans-Atlantic Partnership Social Innovation grant (not funded). It was agreed that WICI would offer grant development support as needed, if requested, including mentoring, reviewing and editing support.
    iv. In 2020, administrative and in-kind funding to support Grossmann's grant application for "World After Covid", which was successful.

3. Enhance public engagement.
    a. Improve WICI's web and social media presence, including the development of web pages for WICI core research projects and a set of introductory "What are complex systems?" materials.
        i. In 2016, WICI and several more of its members were added to the university's "Experts And Speakers" site, and WICI's Twitter feed and Facebook page were actively maintained. WICI's website was updated to include material which explains what complex systems are. Receptions before WICI seminars continued.
        ii. In 2017, WICI launched its new website (https://uwaterloo.ca/complexity-innovation/) which was well received, and continues to gain new visitors every week. In particular, from its launch date on September 8, 2017 until the time of the Annual Report, the WICI website received 3,200 visits, with its monthly visits growing dramatically, and exceeding previous performance. WICI's Twitter feed and Facebook page were actively maintained.
        iii. In 2018, the WICI website (https://uwaterloo.ca/complexity-innovation/) averaged over **1,075** visits per month, which is more than double the monthly average of 533 per month in 2017. Videos from core members on "What are complex systems?" were posted and viewed a total of 555 times in 2018; WICI's Twitter feed and Facebook page were actively maintained. Facebook events were introduced as a tool to publicize talks and workshops, that may be shared more easily via social media networks.
        iv. In 2019, the WICI website was updated extensively to improve navigation and access to information. The website (https://uwaterloo.ca/complexity-innovation/) averaged over **1,194** visits per month, a 7% increase from 2018; Videos from core members on "What are complex systems?" on our website were viewed a total of **685** times in 2019 (up from 555 times viewed in 2018); and WICI's Twitter feed and Facebook page were actively maintained. Facebook events continued to be used to publicize our talks and workshops, so they may be shared more easily via social media networks. The website was updated to reflect new members, new projects, and evolving core research projects.
        v. In 2020, the WICI website was updated to reflect current research projects, career opportunities, and the developing CNCS. The website (https://uwaterloo.ca/complexity-innovation/) was visited **12,996** times

between January 1 and December 31, 2020. Videos from core members on "What are complex systems?" have been viewed a total of **1792** times in 2020 (up from 685 times viewed in 2019); and WICI's Twitter feed and Facebook page are being actively maintained. WebEx has been utilized to host and co-host webinars.

b. Highlight WICI work through press releases and actively engage the media when opportunities arise.
    i. In May 2016, WICI was featured prominently in a "Guelph Today" article https://www.guelphtoday.com/columns/from-the-second-storey/from-the-second-storey-small-things-become-big-things-without-our-noticing-295879
    ii. In 2017, WICI core members contributed op-ed pieces to major outlets such as the Globe and Mail, and core member research projects were covered in the national and international media.
    iii. WICI core members contributed 12 radio and print interviews in 2018
    iv. WICI core members contributed 18 radio and print interviews in 2019
    v. WICI Core members continued to contribute to local radio and print interviews. Chris Bauch's work on modelling around Covid policy guidance in particular garnered a high profile in local media. Thomas Homer-Dixon and Igor Grossmann reported dozens of radio and print interviews. Overall, core members reported over 40 radio/print outreach opportunities in 2020.

c. Offer more public talks in the community.
    i. In 2017, WICI continued to broaden its audience through events such as the Poetry & Complexity Readings and Conversations with high profile guests such as Roald Hoffmann, Nobel Prize-winning theoretical chemist and poet, and Rae Armantrout, Pulitzer Prize-winning poet and Guggenheim Fellow.
    ii. The 2018 Modelling Complex Urban Environments conference keynotes were open to the public.
    iii. In 2019, after learning that WICI and research centers are facing a climate of fiscal restraint, WICI chose to shift priority from public community talks to focused allocation of resources to activities that directly support research. All WICI talks held on campus were recorded and the videos were posted on our website to share with the community at large. Community members on our mailing list regularly attended our talks.
    iv. In 2020 all talks have all been held virtually, thus enabling a broader participation among members of the community.

d. Continue informal receptions before talks with speakers and attendees.
    i. Receptions before WICI seminars have been well attended. The fall open house is also a well-attended, effective networking event. However, all in-person activities were suspended in 2020.

4. Enhance WICI's resource base and long-term viability.
    a. Prioritize efforts to obtain higher-level, external support to establish and support initiatives such as a staffed resource lab; funding for a graduate fellows programme; a competitive post-doctoral scholar programme; and funding for short-term (sabbatical or study leave) positions for more senior complex systems scholars.

i. In 2016, realizing that grant acquisition is a long-term process, WICI invested in 3 grant challenge awards with promise for success. WICI was successful in an application to the Fields Institute for workshop co-sponsorship.
ii. In 2017, WICI acquired $5,000 in external funding (sponsorship from The Field's Institute for Mathematical Sciences and the Canadian Applied and Industrial Mathematics Society for its 2017 Conference on Resilience, plus additional in-kind support). WICI also obtained over 20k in matching support from international partners as part of the IPRG application to support the Urban Complexity conference. Moreover, several of the sponsored workshops run in 2017 sought additional funding support from other partners. Since its inception, WICI has grown by 386%, and by 46% since its renewal in 2014, thereby building a critical mass for its long-term viability.
iii. In 2018, the WICI administrative team had extensive discussions with personnel in the Office of Research regarding alternative models for WICI support in its next phase. It became clear that WICI's current budget model, based on direct operating support from the Office of Research, was no longer viable moving forward, and it is also still not feasible to channel grant overhead directly to WICI to generate operating funds, as envisioned at our 2015 renewal. Alternatives considered have been 'staying small', recruiting basic operating support from several deans, or 'going big', striving to obtain University Centre status. The "go big" option would require, at a minimum, strong evidence of external partner funding relationships, and ideally, a secure external funding source such as a foundation or large tri-council operation grant. The 'go big' option was not seen as viable as of fall 2018, especially given the hold on university centers. However, it may soon be an option, following a bit more strategic assessment and planning.
iv. In 2019, the WICI administrative team continued discussions with the Office of Research regarding alternative models for WICI support in its next phase, and was approved for an extension to postpone our centre renewal application process by one year, therefore giving WICI until April 2021 to explore these various options to identify its next strategic goals and a path forward.
v. In 2020: WICI has been engaging in further strategic discussions with supporting Deans, Office of Research, Steering Committee members to determine the most viable funding model for WICI. In addition, a developing Canadian Network for Complex Systems with connections at University of British Columbia, McGill University, St. John's University and Western University will provide leverage to attract substantive external funding.

5. Raise our profile.
    a. Focus on academic and media outreach to highlight WICI's unique contributions on a national and global scale.
        i. In 2016, WICI and several of its members were added to the university's "Experts And Speakers" site, and WICI's Twitter feed and Facebook page were actively maintained. WICI core members presented at national and international conferences, notably the Sackler Colloquim at the National Academy of Sciences, USA.
        ii. In 2017, WICI's Twitter feed and Facebook page were actively maintained. WICI launched its new website (https://uwaterloo.ca/complexity-innovation/) which was well received, and continues to gain new visitors every week. WICI core

member W. Hipel was elected Officer of the Order of Canada. Our activities all brought new engagement with WICI both within the University of Waterloo and externally. For example, 66% of participants in the 2017 WICI Conference on Resilience were from outside the University of Waterloo, and 13% were international.

iii. In 2018, our core members made 12 media appearances, notably Paul Thagard's CBC Interview '*The psychology of climate change: Why people deny the evidence'* (December 2018), and Chris Bauch's CBC interview on '*Land use implications of dietary trends'* which aired on 9 CBC stations across Canada. The 2018 Conference on Modelling Complex Urban Environments attracted an international scope of participants.

iv. In 2019, WICI core members made 18 media appearances, notably twelve of those by newest Core Member, Igor Grossmann. In addition, Kevin Church, a student member and fellowship awardee from Applied Mathematics, was featured on CBC Radio presenting his work on Timing of Vaccinations in Controlling Disease Outbreaks, in June 2019.

v. In 2020, WICI continued maintaining its Twitter feed, Facebook page, and website, monitoring traffic and engagements, and optimizing outreach where possible. The website was updated to reflect new members, new projects, evolving core research projects and an emerging national network of members. Core member Chris Bauch has received a high amount of local media attention for his modelling work with Covid-19 this year. Collectively, members are reporting well over 40 separate media outreach-related activities.

2019 WICI MEMBERSHIP SURVEY REPORT

Prepared by Brenda Panasiak, Administrative Coordinator
March 1, 2020

Introduction

In fall 2019, WICI sent a survey to all current members to gage their past interaction with the Institute and solicit their thoughts on our direction moving forward. Thirty-five people completed the survey. Feedback from the survey identifies interdisciplinarity as WICI's comparative advantage, encourages WICI to strengthen our position as a Complex Systems networking hub, with a focus on training and education opportunities for students and faculty in the future. The full results are included starting on page 5 of this report (note, names and email addresses of the respondents have been excluded for confidentiality purposes, but respondents who requested to be contacted with the results will receive a copy of this report).

Membership

Core members accounted for 17.65% of the responses; 23.5% were from Student Members; and 14.28% from Affiliate Researchers. Interestingly, the largest number of responses to the survey (41.18%) were from non-members in attendance at a WICI talk.

Engagement

Many of the ways respondents have engaged with WICI in the past five years (Question 2 in the survey) would not apply to the 41.18% of people who are not members. Thus, of the 20 members who responded, half indicated they have attended and/or presented at a WICI conference in the past 5 years; 30% indicate that they have organized a workshop and/or conference; 30% have advised, served on the committee of, or examined a WICI student(s); and 30% have received WICI travel funds.

Thirty percent of the total number of respondents have viewed recorded WICI talks/Occasional papers on the website, and 30% of total respondents (or 60% when looking at only those responses by WICI members) participated in a WICI research networking event.

Perceived Value

The majority of respondents suggested that WICI's greatest value lies in sharing current research through the speakers series (32%) and/or network-building for complex systems research on campus and beyond (28%). The next two greatest values WICI provides appear to be in direct support for cross-faculty collaborative research (17%) and training/education opportunities through workshops, reading groups or working groups (16%).

I have attended several Speaker Series organized by WICI and have always learned a great deal about complex problem solving from diverse perspectives."

Some of the comments about how WICI has provided value:

- "WICI networking event led to collaboration on a New Frontiers grant"
- "I need a peer reference group for sharing, deepening and pursuing interests in complex systems"
- "WICI can play a key role, since it is otherwise hard to get a variety of researchers from different faculties together"

- [WICI provides value by]"connecting with local off-campus experts in complex systems & innovation"
- "Support for grant acquisition"

Areas for Development

Thirty percent of respondents suggested that WICI could strengthen its activities in training/education opportunities through a WICI workshop, reading group or working group. The next most popular choice for an area to develop was in directly supporting cross-faculty collaborative research (21%), followed by network building (11%) and sharing research through speakers series/occasional papers (10%).

Some of the comments offered in response to areas for WICI development:

- "Well-timed workshops, mini-retreats"
- "Funding and organizing interdisciplinary, problem-based research teams"
- "WICI could be more intentional about [network building], employing software to help WICI members make connections (e.g. Exaptive) or supporting student members in identifying appropriate internal-external committee members for exams/defences"
- "More nodes which would interact with one another as well as with WICI in Waterloo"
- "We could raise the profile of WICI Occasional Papers for people to deposit working papers or even commission working papers"
- "Occasional papers could be leveraged more"
- "Please find a way to livestream activities. I suggest free-of-charge zoom.us which I have used before. No extra hardware needed."
- "Make more of an effort to foster industry links through relevant complex systems research"
- "Opportunities for students to see non-academic opportunities"

Comments relating to training/education opportunities specifically:

- "Regular trainings for students would be great"
- "Training on existing tools and methodologies: integrating approaches to complex problems"
- "More exploratory/conversational opportunities would be very interesting"
- "Best if these can include remote participation somehow"
- "Training/education opportunities could be considered that target post-docs and faculty"
- "Complex systems certificates (grad/undergrad) esp. methods classes at Waterloo"

When asked for additional activities that WICI could consider engaging in (Question 5 of the survey), one member suggested designing initiative(s) to attract industry:

- "Initiatives designed to attract industry. This could be a "problems solved" seminar detailing how a company solved a problem through an analysis of complex systems. Alternatively, this could be a "hard unsolved problems" series where industry presenters seek to take a complex systems approach to difficult problems they face. This could better actualize the "innovation" part of WICI."

To determine perception of WICI's scope and mission, question six asked how respondents would describe the mission and scope of WICI to someone outside of WICI. The responses to this question reflect that WICI is primarily viewed as a networking organization that facilitates and promotes interdisciplinary collaboration on complex research problems.

> "[WICI is the] leading applied Institute…and the leading Canadian center of Complex Systems."
>
> *-Kirsten Wright*
> *WICI Student Member*

In response to what respondents see as WICI's comparative advantage, many emphasized network building capacity and interdisciplinarity in the topic area of complex systems and systems thinking. One respondent indicated that WICI is the "leading applied institute of complex systems and the leading Canadian centre of complex systems" and that the University of Waterloo "has an opportunity to sustain this advantage by acting decisively/investing now."

Members were also asked about possible areas of improvement for WICI. Respondents felt WICI could do more to promote itself to University of Waterloo faculty and students and improve engagement within our membership. Main themes that were mentioned in the comments for this question include:

- Improving engagement throughout the departments/schools by having WICI representatives (faculty and student) in each, tasked with promoting WICI, recruiting members, and leveraging collaboration opportunities
- Consider accessibility of events outside of business hours (and possibly with remote livestream) to allow industry/practitioner members and community participation
- Facilitating organization and leadership that can be more active to allow for regular, reliable event scheduling, improved promotion and advertising
- Narrowing the scope of the mission, and/or focus of core project(s) to be more specific

The following were suggestions were received on the topic of a vision for WICI's next five years (Question 9 of the survey):

- "Orienting scholarship and graduate work towards pressing problems of our time, like climate change, AI, and political-economic shifts needed in the 21st century"
- "WICI may wish to work in conjunction with the Office of Research and time any seed grant offerings to support the success of Waterloo interdisciplinary grant programs (e.g., Trailblazer, NFRF)"
- "Promoting collaborative work to address global problems such as climate change that require complex coordination"
- "Build and lead Canadian Complex Systems Network"
- "Try to develop more industry linkages….facilitate hiring co-operative students in their upper years to solve complex problems with organizations, [enabling] Canadian organizations to experiment with innovation while providing students with research-industry experience"
- "Organizing speaker series that highlights student research and combines with professionals from related fields and industry[…]facilitated sessions for complex problems, presented by professional members, to be problem solved through an event or seminar, with the outcome being open source or reported back to the professional who presented the problem"

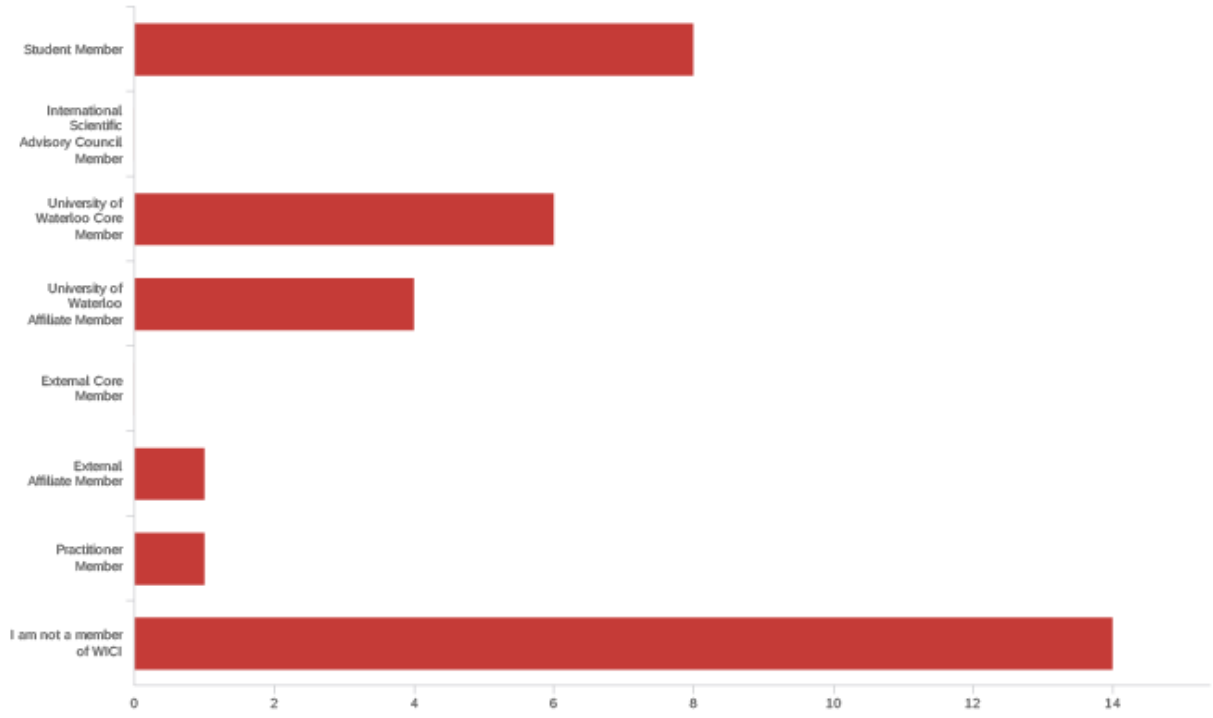
Finally, a concept that was introduced in the 2019 survey was the idea of pursuing and developing a Canadian Network for Complex Systems. Question 10 of the survey asked respondents to share their vision for a such a network.

- "Identifying existing researchers and institutions dedicated to complexity and building strong networks and collaborations between them through conferences, social media platforms, annual meetings"
- "Raising the profile of Canadian work in this space; promoting Canada as a world leader in this space"
- "Source & network to support collaboration projects and funding, esp. in complex systems & government/funding agency awareness to fund complex systems initiatives, wholistic approaches to solving societies'/world's 'wicked problems', e.g. global warming, water, integrate systems thinking for planet earth"
- "Network to request for interest in collaboration based on expertise, a network to market relevant research, a network to share students and improve recruitment opportunities"
- "I would like to see WICI continue with building its grass roots organization among researchers while also extending its reach both nationally and internationally. I like the idea proposed of increasing the industry engagement of WICI. This could provide increased funds and greater recognition of the relevance of complex systems research among policy makers and the general population"
- "Key to leveraging Waterloo's position as a first mover into advancement in fundamental and applied research in complex systems."

In conclusion, it was strongly felt from this survey that WICI members recommend a clearly defined mission and scope, which includes a continued commitment to maintaining and growing a strong local (and national) network of complex systems scholars, regular delivery of activities that include talks and or/workshops, additional training and/or education initiatives, with consideration for external members and/or partners as well as students.
Please see the full survey report on the following pages for a complete picture of all responses received. The full survey report was also included in the WICI 2019 Annual Report appendix.

Fall 2019 Waterloo Institute for Complexity and Innovation Member Survey
March 3, 2020 11:08 AM MST

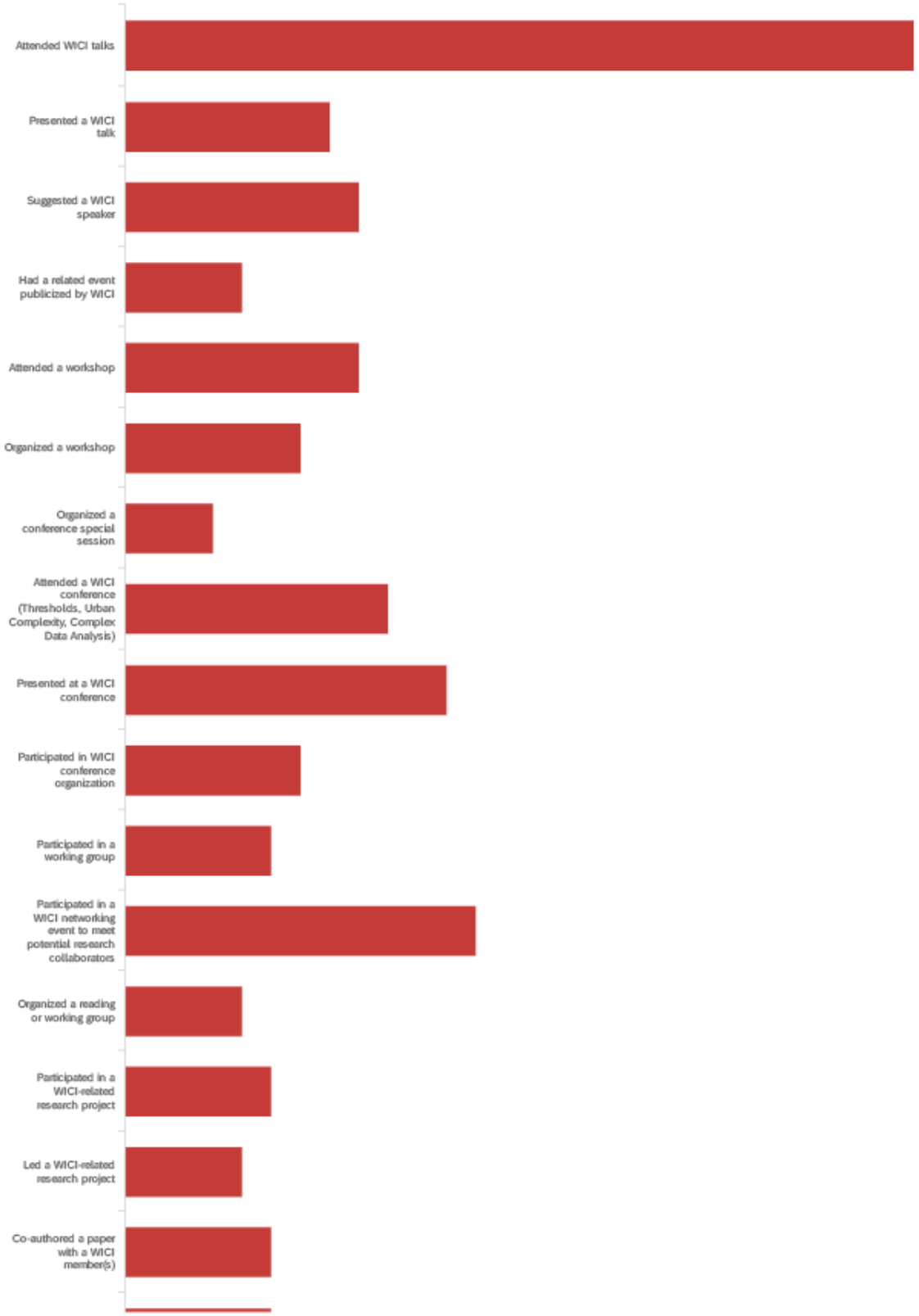
Q1 - What is your membership category?

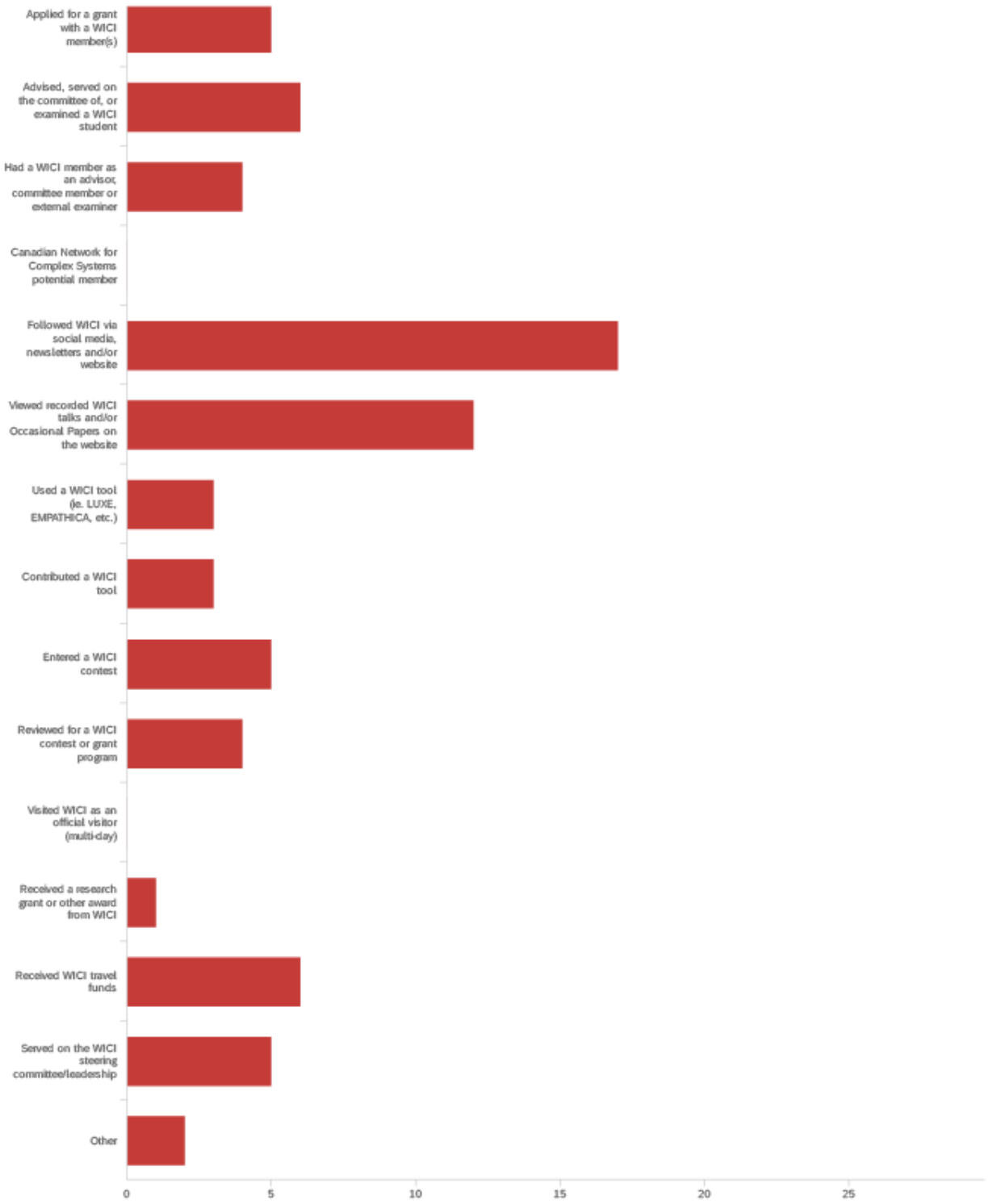


#	Field		Choice Count
1	Student Member	23.53%	8
2	International Scientific Advisory Council Member	0.00%	0
3	University of Waterloo Core Member	17.65%	6
4	University of Waterloo Affiliate Member	11.76%	4
5	External Core Member	0.00%	0
6	External Affiliate Member	2.94%	1
7	Practitioner Member	2.94%	1
8	I am not a member of WICI	41.18%	14
			34

Showing rows 1 - 9 of 9

Q2 - How have you engaged with WICI in the past 5 years? (Please select all that apply).





#	Field	Choice Count
1	Attended WICI talks	13.71% 27
2	Presented a WICI talk	3.55% 7

#	Field	Choice Count
3	Suggested a WICI speaker	4.06% 8
4	Had a related event publicized by WICI	2.03% 4
5	Attended a workshop	4.06% 8
6	Organized a workshop	3.05% 6
7	Organized a conference special session	1.52% 3
8	Attended a WICI conference (Thresholds, Urban Complexity, Complex Data Analysis)	4.57% 9
9	Presented at a WICI conference	5.58% 11
10	Participated in WICI conference organization	3.05% 6
11	Participated in a working group	2.54% 5
12	Participated in a WICI networking event to meet potential research collaborators	6.09% 12
13	Organized a reading or working group	2.03% 4
14	Participated in a WICI-related research project	2.54% 5
15	Led a WICI-related research project	2.03% 4
16	Co-authored a paper with a WICI member(s)	2.54% 5
17	Applied for a grant with a WICI member(s)	2.54% 5
18	Advised, served on the committee of, or examined a WICI student	3.05% 6
19	Had a WICI member as an advisor, committee member or external examiner	2.03% 4
20	Canadian Network for Complex Systems potential member	0.00% 0
21	Followed WICI via social media, newsletters and/or website	8.63% 17
22	Viewed recorded WICI talks and/or Occasional Papers on the website	6.09% 12
23	Used a WICI tool (ie. LUXE, EMPATHICA, etc.)	1.52% 3
24	Contributed a WICI tool	1.52% 3
25	Entered a WICI contest	2.54% 5
26	Reviewed for a WICI contest or grant program	2.03% 4
27	Visited WICI as an official visitor (multi-day)	0.00% 0
28	Received a research grant or other award from WICI	0.51% 1
29	Received WICI travel funds	3.05% 6
30	Served on the WICI steering committee/leadership	2.54% 5
31	Other	1.02% 2

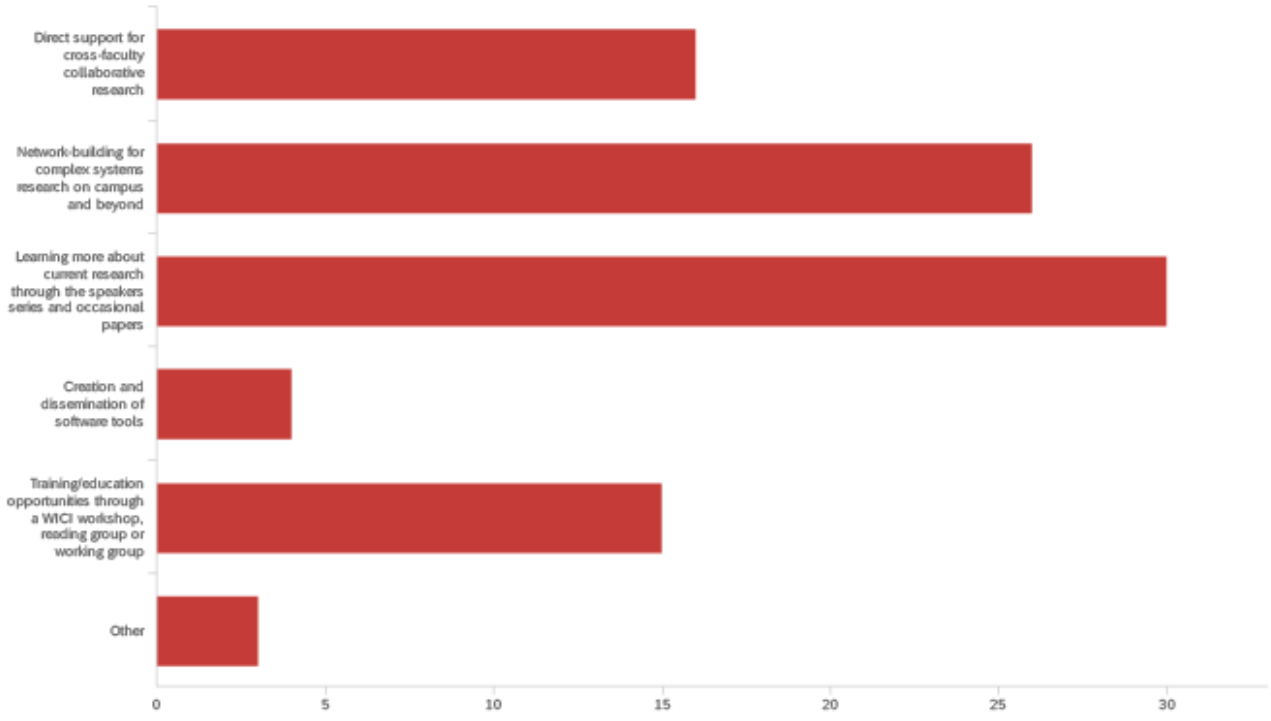
#	Field	Choice Count
		197

Showing rows 1 - 32 of 32

Q2_31_TEXT - Other

Other
I have joined WICI only in Fall 2019, so I have not yet the possibility to give this question specific answers.
received award for artistic contest

Q3 - In which areas do you see WICI providing value, for yourself or others in the community? (Please select all that apply, and please provide specific examples for each response if applicable).



#	Field		Choice Count
1	Direct support for cross-faculty collaborative research	17.02%	16
2	Network-building for complex systems research on campus and beyond	27.66%	26
3	Learning more about current research through the speakers series and occasional papers	31.91%	30
4	Creation and dissemination of software tools	4.26%	4
5	Training/education opportunities through a WICI workshop, reading group or working group	15.96%	15
6	Other	3.19%	3
			94

Showing rows 1 - 7 of 7

Q3_1_TEXT - Direct support for cross-faculty collaborative research

Direct support for cross-faculty collaborative research

Potentially only a small number of faculty notice WICI CFPs

Often only a small group of faculty notice WICI CFPs. If it could be leveraged with more visible interdisciplinary programs, that might help WICI name recognition.

Q3_2_TEXT - Network-building for complex systems research on campus and beyond

Network-building for complex systems research on campus and beyond

wici networking event led to collaboration on a New Frontiers grant

I need a peer reference group for sharing, deepening and pursuing interests in complex systems.

The opportunity to talk to other students as well as professionals in very valuable to me

I've participated because it's a local nexus for complexity topics.

Q3_3_TEXT - Learning more about current research through the speakers series and occasi...

Learning more about current research through the speakers series and occasi...

Dr. Mary O'Connor's talk

WICI can play a key role, since it is otherwise hard to get a variety of researchers from different faculties together.

This has been my main way of engaging with WICI.

I need a peer reference group for sharing, deepening and pursuing interests in complex systems.

I have attended several speaker series organized by WICI and have always learned a great deal about complex problem solving from diverse perspectives.

Many of the talks have been excellent

I've attended public lectures in the past.

Q3_4_TEXT - Creation and dissemination of software tools

Creation and dissemination of software tools

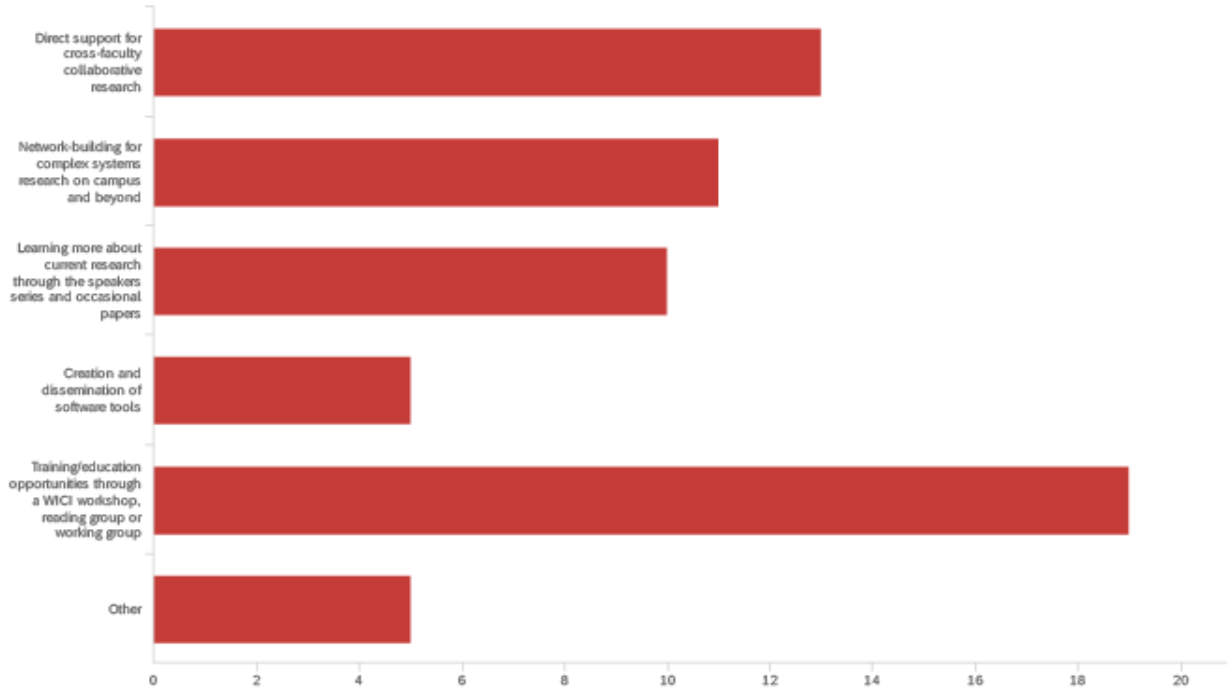
Q3_5_TEXT - Training/education opportunities through a WICI workshop, reading group or...

Training/education opportunities through a WICI workshop, reading group or...
seminars (grad student, discussions with Dr. Sutherland)

Q3_6_TEXT - Other

Other
In general, although I don't get many opportunities to take advantage of what WICI offers, it always seems good quality
Connecting with local off-campus experts in complex systems & innovation
Support for grant acquisition

Q4 - In which of these areas do you think WICI could strengthen their activities? (Please select all that apply, and please provide clarification if any, in the space provided).



#	Field		Choice Count
1	Direct support for cross-faculty collaborative research	20.63%	13
2	Network-building for complex systems research on campus and beyond	17.46%	11
3	Learning more about current research through the speakers series and occasional papers	15.87%	10
4	Creation and dissemination of software tools	7.94%	5
5	Training/education opportunities through a WICI workshop, reading group or working group	30.16%	19
6	Other	7.94%	5
			63

Showing rows 1 - 7 of 7

Q4_1_TEXT - Direct support for cross-faculty collaborative research

Direct support for cross-faculty collaborative research
Well-timed workshops, mini-retreats

Direct support for cross-faculty collaborative research

Funding and organizing interdisciplinary, problem-based research teams

Q4_2_TEXT - Network-building for complex systems research on campus and beyond

Network-building for complex systems research on campus and beyond

Mini-retreats

Possibly WICI could be more intentional about this, employing software to help WICI members make connections (e.g. Exaptive) or supporting student members in identifying appropriate internal-external committee members for exams/defences.

More nodes and which would interact with one another as well as with WICI in Waterloo.

Q4_3_TEXT - Learning more about current research through the speakers series and occasi...

Learning more about current research through the speakers series and occasi...

I remember accessing an occasional paper years ago. Do we receive regular contributions? If not, we could raise the profile of this for people to deposit working papers or even commission working papers.

Occasional papers perhaps could be leverage more

Please find a way to livestream activities. I suggest free-of-charge zoom.us which I have used before. No extra hardware needed.

Q4_4_TEXT - Creation and dissemination of software tools

Creation and dissemination of software tools

Q4_5_TEXT - Training/education opportunities through a WICI workshop, reading group or...

Training/education opportunities through a WICI workshop, reading group or...

Regular trainings for students would be great.

Training on existing tools and methodologies; integrating approaches to complex problems

More exploratory / conversational opportunities would be very intersting.

Best if these can include remote participation somehow.

see below

Q4_6_TEXT - Other

Other
hard to say because I don't take full advantage of WICI resources
Training/education opportunities could be considered that target post-docs and faculty.
Complex systems certificates (grad/undergrad) esp. methods classes at Waterloo
Make more of an effort to foster industry links through relevant complex systems research.
Opportunities for students to see non-academic opportunities

Q5 - Are there other activities, not listed above, that you suggest WICI could engage in?

Are there other activities, not listed above, that you suggest WICI could e...
Training/education opportunities could be considered that target post-docs and faculty.
Summer schools or other credentialing have been discussed. Possibly trainings could also be developed that target professors. Recently I received word about a program at American University targeting professors doing research in international affairs. It combined the benefits of training at an appropriate level with being a multi-day retreat. Might there be value in directing such a training program toward post-docs and professors, where possible outputs include a working paper, draft grant application, etc?
Opportunities for grad students to take part in collaborative research
NA
Initiatives designed to attract industry. This could be a "problems solved" seminar detailing how a company solved a problem through an analysis of complex systems. Alternatively, this could be a "hard unsolved problems" series where industry presenters seek to take a complex systems approach to difficult problems they face. This could better actualize the "innovation" part of WICI. Email: jon.mackay@gmail.com
Group discussions on new Complex Systems topics of interest.
I have answered quickly to make sure you have this, while my dad plays with my kids before bed. If there is any place where you want a good quote I will draft/suggest!
Please find a way to stream WICI events on the Web. Not only would this be valuable to me as a Montreal-based Practitioner Member, but also may I suggest there would be significant value-added through greatly increased potential networking amongst researchers.
The idea of design charrettes was brought up at a WICI meeting at the UW Architecture school (in anticipation for the upcoming round table/ colloquium) and I think that this could be a truly fascinating experience with a transdisciplinary audience who has attended other WICI events.
Could do more for students - more & better advertised working groups More non-academic opportunities (socials & industry-related talks/sessions)
There's a need for complexity literacy in the broader culture, and part of that is addressed in the way subject matter specialists like WICI structure their offerings. Sadly, that means "credentials". WICI can do little for me right now; I work an operational 9-5 job at a charity, but I'd like to expand my scope. In my work, I see that, as the culture becomes more hardened, people find it convenient to treat unpredictable social outcomes as personal moral failures. Funders who demand accountability can learn that, even if everyone acts reasonably "deterministically", unexpected social outcomes still can occur. Complexity analysis might offer techniques, drawn from agent-based modelling or computational social science, to design social programs to make the risks of giving manageable. A study that discusses such things, issued under WICI's imprimatur, would have some momentum to it. But then I'm the weak link when citing it. I can't justify the disruption to my employer--schedule disruption during studies, post-graduation changes in my work remit, making a disruptive business case drawing on Complexity-branded resources--without a trellis to hang those slow-growing vines on. Sadly, sheepskins matter. I'm well aware there's a Sisyphean process involved in establishing recognized credentials. I fully expect that, as happens at any academic centre/lab/institute, WICI has at least had discussions on certificates, licentiates, and whatever other credentials might be sustainable and marketable. I'm writing to say rolling that boulder would be worth it. Encouraging esp. your Math faculty to address the burgeoning interest in applied math by working professionals/hobbyists with tailored structures would be a good & timely activity for WICI. (Or maybe evade the usual processes altogether & do something with Blockchain. Somehow, these days everything always comes back to Blockchain...)

Q6 - How would you describe the mission and scope of WICI to someone outside of WICI?

How would you describe the mission and scope of WICI to someone outside of...
Interdisciplinary collaboration and thinking in an integrative fashion.
not sure
WICI is a networking organization that also pools some resources for seed/travel grants.
WICI is a networking organization and pools useful resources such as descriptions of courses offered in complex systems. Small seed/travel grants are also available for faculty and students. Special events give members opportunities to present their work.
Research node investigating the complex dimensions of social and ecological problems.
Network building & agenda-setting to promote research on complex systems & innovation in this space
Support integrative complex systems thinking, activity, networking and funding across disciplines at U Waterloo and beyond
To be honest, I actually have no idea who/what WICI is and what you do (sorry!)
I'm brand new to WICI - don't know anything about it but was super interested in the talk with Mary O'Connor so learned of WICI b/c of that
Network-building for complex systems research
Not aware of this much.
WICI is concerned with better understanding complex systems in the many ways that they occur and through many perspectives including mathematical, physical and in the social sciences.
Complexity is a highly interdisciplinary domain, and so WICI provides the breadth to bring interdisciplinary people together into a common context.
Complex systems research is fundamental science that deepens our understanding of the common principles that drive physical, biological, and social system. The study of complex systems also has immediate application to improving technology, health, quality of life, and policy design. Waterloo with a concentration in fundamental science, policy, and engineering applications has an advantage in taking innovation from fundamental science through application.
Just joined WICI, so I hold my peace. :)
When I describe WICI to others I have described the groups focus as the ability to conceptualize complex systems and to work with transdisciplinary teams to solve wicked problems.
WICI is a cross-disciplinary group that brings together those who are interested in complex systems.
To advance interdisciplinary research using systems methods and thinking.

Q7 - What do you see as WICI's comparative advantage?

What do you see as WICI's comparative advantage?
Thinking in systems and providing a place to connect with different specialities
not sure
The topic: Complex systems
The topic area: complex systems. No one else at Waterloo is doing this.
Based at the University of Waterloo, a top university in the world.
Membership from across different faculties
harnessing local talent & expertise
Interdisciplinary, complex systems & systems modelling perspective
Interdisciplinary focused on complexity
Interdisciplinary
Highly interdisciplinary
To what? I could not understand the question.
WICI's comparative advantage is that it is cross disciplinary. Because WICI is housed in the University of Waterloo it has access to some of the brightest minds in Canada. This also gives it the status to form links with other international and national research groups concerned with complexity.
I don't understand the question -- in comparison to whom or what?
Leading applied institute of complex systems and the leading Canadian center of complex systems. Waterloo has an opportunity to sustain this advantage by acting decisively/investing now.
Great potential cross-disciplinary and applied potential in the Canadian space.
I see the opportunities presented by WICI as an ability to look at problems from multiple perspectives in one setting and to offer up creativity as a pathway to find solutions through innovation.
Studies cool topics & has engagement from people in really varied areas Brings in strong guest speakers
Complex systems are cool? Also inherently cross-disciplinary?
The fertile math & science ecology at Waterloo.
Potential for collaboration with people from different fields.

Q8 - What do you see as WICI's weakest aspect(s)?

What do you see as WICI's weakest aspect(s)?
Lacking in core tenets or project focuses.
not sure
Organization/leadership seems a bit laissez-faire. Regular well-timed events might help members be more engaged.
WICI may be too laissez-faire (as opposed to implementing targeted activities), which may be why engagement is mixed.
Advertising and community engagement; maintaining interest
Not sure
1 - Lack of core courses available for students of complex systems/systems thinking 2- What is meant by 'complex systems'
Advertising itself and it's talks, etc.
Broad definition, makes it hard to pinpoint the actual work
Can be difficult to build a strong network when addressing highly interdisciplinary content
few guest speakers have seemed relevant to my area of research interests
The mission is not clear.
Currently, there is very little overlap with industry.
I think Complex Systems is *so* big, that it is hard to have sufficient focus. WICI is perhaps spread too thin, and needs to focus a little?
Possibility of missing the opportunity to lead in this space in Canada.
Weak engagement at the department/school level. I suggest you have WICI representatives (faculty and student) in each department/school, tasked with promoting WICI, recruiting members, and leveraging opportunities to collaborate/share resources.
Just joined WICI, so I hold my peace. :)
I am perhaps too new of a member to have noticed any:)
generally low level of activity Even with WICI faculty as advisors, hard to fit WICI activities into overall grad student career - this is another factor limiting engagement.
It is not always clear whether those outside the university are welcome to participate.
- gaining & maintaining momentum, as with any project/movement. - barriers to new participants (talks in early afternoon are inaccessible to 9-5ers without a very good justification).

What do you see as WICI's weakest aspect(s)?

Using the same language; lack of unified mission statement

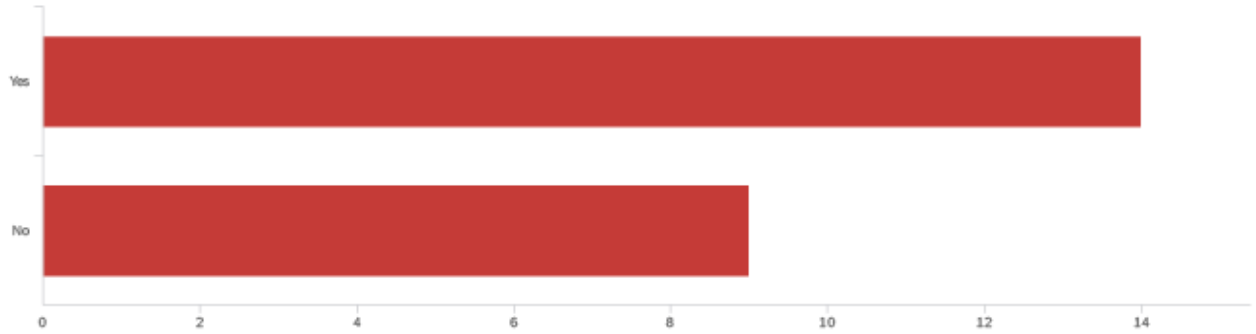
Q9 - What is your vision for WICI's next phase? What specific suggestions might you offer for WICI as we move into our third 5-year term?

What is your vision for WICI's next phase? What specific suggestions might...
WICI as orienting scholarship and graduate work towards pressing problems of our time, like climate change, AI, and political-economic shifts needed in the 21st century.
It's likely my fault, but I don't often hear or notice events, and when I do, I can't make them
Now that there are new grant programs encouraging interdisciplinary scholarship (e.g., Trailblazer, NFRF), WICI may wish to time any of its seed grant offerings in the run-up to the deadlines for those competitions. Similarly, WICI could provide targeted events that are timed in the run-up to those competitions to get faculty mingling/brainstorming/etc. Perhaps WICI could work in conjunction with OR to provide supportive events that might increase the success of Waterloo competitions. Similarly WICI might make it more clear how it can bring value to student members. It is already good that occasional poster presentations and workshops are offered. It might be good to make decisions about what events to offer regularly so that WICI does not seem to be rebuilding wheels.
Focus on promoting collaborative work to address global problems such as climate change that require complex coordination
Build and lead Canadian Complex Systems network
I think WICI should try to develop more industry linkages. Imagine if WICI advertised with industry and facilitated hiring co-operative students in their upper years to solve complex problems with organizations. Students could be based at a company and on UW campus. In effect this could be considered more of a consulting relationship rather than a employee relationship. One way to do this would be to support research into problems that a company sees as potentially relevant but where the way forward is not immediately clear. Companies could support upper year co-op students to look into complex-systems oriented problems they have. Students could leverage the academic excellence of UW while also conducting research into a problem in a limited amount of time. This could give industry a way to follow-up on research ideas without formally setting aside in-house resources. Canadian companies are particularly bad at investing in research so this type of initiative could provide real value to the companies that engage with this program. At the end of a term progress could be analyzed to determine if the basic research sprint had some promising results and was worth re-investing in further research sprints. This would be a low-risk way for Canadian organizations to experiment with innovation while also providing students with research-industry experience.
We need ways to bring people together to actually work together on hard problems.
Clarity of purpose. WICI is uniquely situated but as new entrants move into complexity, we will loose the chance to lead if we don't take advantage to build on where we are and to communicate what we are doing to a larger community. I think it is time to go big in clarity and ambition of purpose. (can refine if you want pieces on this etc.)
Just joined WICI, so I have no "baseline" from which to speak.
I found the workshop/conference on human and planetary health to be very inspirational as well as the presentations on Urban Complexity. I think that organizing speaker series that highlights student research and combines with professionals from related fields and industry provides an interesting audience. Perhaps a call could be made through WICI's professional members for a complex problem to be presented and to be problem solved through facilitated sessions throughout an event or semester, with the outcome being open source for participants to use or to report back to the professional who presented the problem.
Interdisciplinary research projects

Q10 - What is your vision for a Canadian Network for Complex Systems?

What is your vision for a Canadian Network for Complex Systems?
What are Canadian priorities that would benefit from a complex systems approach? A few potential ones include designing regional complex systems approaches, clusters, and core principles.
don't have one
My vision for this is not very well developed, but I think WICI is doing the right thing to look at other models in the world (e.g. Santa Fe Institute) to consider what features WICI would also like to emulate.
Identifying existing researchers and institutions dedicated to complexity and building strong networks and collaborations between them through conferences, social media platforms, annual meetings.
Raising the profile of Canadian work in this space; promoting Canada as a world leader in this space
Source & network to support collaboration projects and funding, esp. in complex systems & government/funding agency awareness to fund complex systems initiatives, wholistic approaches to solving societies'/world's "wicked problems", e.g. global warming, water, integrate systems thinking for planet earth
network to request for interest in collaboration based on expertise, a network to market relevant research, a network to share students and improve recruitment opportunities
I would like to see WICI continue with building its grass roots organization among researchers while also extending its reach both nationally and internationally. I like the idea proposed of increasing the industry engagement of WICI. This could provide increased funds and greater recognition of the relevance of complex systems research among policy makers and the general population.
Key to leveraging Waterloo's position as a first mover into advancement in fundamental and applied research in complex systems.
Just joined WICI, so I have no "baseline" from which to speak.
I don't feel that I have enough information to comment specifically, but generally I think that being able to link real world complex problems encountered by professionals throughout Canada with a diverse cross section of academics would be really valuable!
Not sure what this is.

Q11 - Would you like to receive a summary of our survey results? (If yes, please provide an email address in Q5).

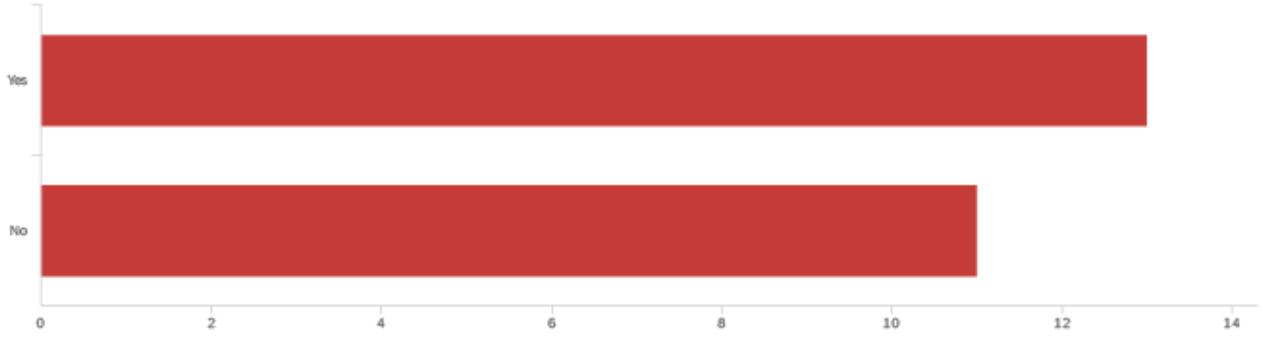


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Would you like to receive a summary of our survey results? (If yes, please provide an email address in Q5).	1.00	2.00	1.39	0.49	0.24	23

#	Field		Choice Count
1	Yes	60.87%	14
2	No	39.13%	9
			23

Showing rows 1 - 3 of 3

Q12 - Could we contact you to discuss your responses? (If yes, please provide name and email address in Q4 and Q5).



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Could we contact you to discuss your responses? (If yes, please provide name and email address in Q4 and Q5).	1.00	2.00	1.46	0.50	0.25	24

#	Field		Choice Count
1	Yes	54.17%	13
2	No	45.83%	11
			24

Showing rows 1 - 3 of 3

APPENDIX C: CORE MEMBER PUBLICATIONS 2014-2020*

*based on annual self-reports by WICI core members

N. Jain, J. P. Koeln, **S. Sundaram** and A. G. Alleyne. (2014). "Hierarchical Decentralized Control of Large-Scale Variable-Refrigerant-Flow Systems in Buildings." Journal of Process Control, vol. 24, no. 6, pp. 798-819.

E. Moradi-Shahrivar and **S. Sundaram**. (2014). "Multi-Layer Network Formation via a Colonel Blotto Game." The 2nd IEEE Global Conference on Signal and Information Processing.

M. Pirani, T. Costa and **S. Sundaram**. (2014). "Stability of Dynamical Systems on a Graph." The 53rd IEEE Conference on Decision and Control, pp. 613--618, Los Angeles, CA.

S. Pequito, S. Kar, **S. Sundaram** and A. P. Aguiar. (2014). "Design of Communication Networks for Distributed Computation with Privacy Guarantees." The 53rd IEEE Conference on Decision and Control.

M. Pirani and **S. Sundaram**. (2014). "The Spectrum of the Grounded Laplacian with Applications to Consensus with Stubborn Agents." Proceedings of the 33rd American Control Conference.

N. Ringa, **C.T. Bauch** (2014). 'Impacts of constrained culling and vaccination on dynamics and control of foot and mouth disease in near-endemic settings: a pair approximation model'. *Epidemics* **9:** 18-30.

E. Thommes, A. Chit, G. Meier, **C.T. Bauch** (2014). 'Examining Ontario's universal influenza immunization program with a multi-strain dynamic influenza model'. *Vaccine* **32(39):** 5098-5117.

N. Ringa, **C.T. Bauch** (2014). 'Dynamics and control of foot-and-mouth disease in endemic countries: a pair approximation model'. *Journal of Theoretical Biology* **357**: 150-159.

C.L. Murrall, K.S. McCann, **C.T. Bauch** (2014). 'Revising ecological assumptions about human papillomavirus interactions and type replacement.' *Journal of Theoretical Biology* **350:** 98-109.

T. Oraby, **C.T. Bauch** (2014). 'The influence of social norms on dynamics of paediatric vaccinating behaviour'. *Proceedings of the Royal Society of London B* **281:** 20133172.

A.L. Espindola, D. Girardi, T.J.P. Penna, **C.T. Bauch**, B.C.T. Cabella, A.S. Martinez (2014). 'An antibiotic protocol to minimize emergence of drug-resistant tuberculosis'. *Physica A* **400:** 80-92.

L. Barlow, J. Cecile, **C.T. Bauch**, M. Anand (2014). 'Modelling interactions between forest pest invasions and human decisions regarding firewood movement restrictions. *PLOS ONE* **9(4):** e90511.

Milkoreit, M. and **Mock, S**. (2014). "The networked mind: Collective identities as the key to understanding conflict," Chapter 8 in *Networks and Network Analysis for Defense and Security,* ed. Masys, A.J, Springer.

Chillo V, Ojeda R, Capmourteres V, **Anand M.** (2016). Functional diversity loss with increasing livestock grazing intensity in drylands: the mechanisms and their consequences depend on the taxa. Journal of Applied Ecology.

Galvani, A. P., Bauch, C. T., **Anand**, M., Singer, B. H., & Levin, S. A. (. (2016). Human–environment interactions in population and ecosystem health. Proceedings of the National Academy of Sciences. 113(51): 14502–14506.

Capmourteres V, **Anand M.** (2016). Assessing ecological integrity: a multi-scale structural and functional approach using Structural Equation Modelling. Ecological Indicators. 71: 258-269.

Bell W, Lamb E, Sharma M, Hunt S, **Anand M**, Dacosta J, Newmaster S. (2016). Relative influence of climate, soils, and disturbance on plant species richness in northern temperate and boreal forests. Forest Ecology and Management. 381: 93-105.

Dietrich, R., Bell, F. W., Silva, L. C., Cecile, A., Horwath, W. R., & **Anand, M.** (2016). Climatic sensitivity, water-use efficiency, and growth decline in boreal jack pine (Pinus banksiana) forests in Northern Ontario.Journal of Geophysical Research: Biogeosciences. 121(10): 2761-2774.

Jiang, Z., Ma, K., **Anand, M.** (2016). Can the physiological tolerance hypothesis explain herb richness patterns along an elevational gradient: a trait-based analysis. Community Ecology. 17(1): 17-23.

Yodzis M, Bauch C, **Anand M.** (2016). Examining the role of social feedbacks and misperception in a model of fish-borne pollution illness. Mathematical and Computational Approaches in Advancing Modern Science and Engineering: 341-351.

Anand M. (2016). Unified Fields: Science and Literary Form by Janine Rogers. University of Toronto Quarterly. 85(3): 534-53
Leon Cordero R, Torchelsen P, Overbeck GE, **Anand M.** (2016). Analyzing the landscape characteristics promoting the establishment and spread of gorse (Ulex europaeus) along roadsides. Ecosphere. 7(3): e01201

Henderson, K. A., Bauch, C. T., & **Anand, M.** (2016). Alternative stable states and the sustainability of forests, grasslands, and agriculture. Proceedings of the National Academy of Sciences. 113(51): 14552– 14559.

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APPENDIX D: FINANCIAL REPORT 2015/16 TO 2019/20

Financial Report 2015-2020	2015-16	2016-17	2017-18	2018-19	2019-20
INCOME					
Actual Carryforward from previous year	$45,955.18	$66,238.00	$55,578.00	$21,136.00	$23,654.02
University of Waterloo Funding	$55,000.00	$68,000.00	$70,000.00	$75,000.00	$75,000.00
Conference Registrtation Fees			$4,442.48		
External Conference Support/sponsorship		$4,000.00	$1,848.00		
Parker 2015 Partnership Grant	$23,000.00				
TOTAL INCOME	**$123,955.18**	**$138,238.00**	**$131,868.48**	**$96,136.00**	**$98,654.02**
EXPENSES					
SALARIES					
Administrative Coordinator	$15,600.00	$22,379.64	$20,971.68	$19,638.66	$21,942.83
Graduate Research Assistant(s)	$5,200.02			$7,806.69	$10,096.30
IT Technician - Research Group Websites	$343.20				
SPEAKERS SERIES, WORKSHOPS AND OTHER EVENTS					
Catering for Speakers Series and Meetings	$2,193.44	$1,630.04	$1,390.17	$1,079.86	$1,442.69
Travel, Accommodation and Meals for Speakers Series	$3,028.13	$8,402.82	$6,498.42	$3,166.11	$3,287.29
External Core Member Visits					$1,869.86
Promotion and Marketing	$110.34	$469.32	$636.74	$532.37	$253.66
Sponsored Workshops	$1,435.51		$21,000.00		
Conference Costs		$155.00	$15,297.92	$11,017.41	
GRANT SUPPORT EXPENSES					
Research Honorarium for WICI Director	$10,000.00	$10,000.00	$10,000.00	$10,000.00	$7,500.00
WICI Partnership Grants/SEED Grants	$14,108.00	$236.86	$8,892.00	$8,000.00	
2016 Grant Challenge		$29,150.00			
OTHER RESEARCH FUNDING					
Core Members Travel for Conferences and Networking	$3,189.24	$3,015.25	$2,898.84	$4,384.60	$4,467.80
Student Research and Travel Grants	$1,000.00	$2,985.78	$4,555.79	$3,530.96	$2,320.41
Additional travel support for Asc. Director					$1,812.28
WICI Student Membership Initiative			$3,000.00	$1,530.05	
2017 WICI Award of Excellence			$12,000.00		
OTHER					
IT Development and Maintenance	$1,259.31	$3,781.07	$1,168.33	$812.99	$1,275.77
Contracted Services (*including editing of publications*)				$263.90	
Telephone Service	$219.49	$241.06	$240.64	$239.68	$239.38
Miscellaneous/Incidental	$34.28	$100.00	$514.19	$292.20	$763.75
ORGANIZATIONAL DEVELOPMENT					
Institutional Development					$1,855.87
TOTAL EXPENSES	**$57,720.96**	**$82,546.84**	**$109,064.72**	**$72,295.48**	**$59,127.89**
Projected Carryforward for the next fiscal budget	$66,234.22	$55,691.16	$22,803.76	$23,840.52	$39,526.13

APPENDIX E: FINANCIAL REPORT (YTD) 2020-2021

FINANCIAL REPORT 2020-2021

INCOME	BUDGETED 2020-21	Confirmed Budget as of Sept 30, 2020	Variance	
2020-21 Carryforward	$14,450.00	**$40,686.00**	$26,236.00	1
UWaterloo committed funding for 2019-20	$60,000.00	$67,500.00	$7,500.00	2
TOTAL INCOME	**$74,450.00**	**$108,186.00**	**$33,736.00**	

EXPENSES	BUDGETED 2020-21	Actual Expenses to date	Funds to April 30, 2021	Variance	
SALARIES					
Administrative Coordinator	$25,055.96	$21,186.15	$3,869.81		
GRA Spring 2020 - Educational Resource Development	$8,000.00	$8,339.08		($339.08)	
GRA Fall 2020 - Educational Resource Development	$8,000.00	$2,550.10	$5,449.90	$0.00	3
SPEAKERS SERIES, WORKSHOPS AND OTHER EVENTS					
Catering for Speakers Series and Meetings	$2,000.00			$2,000.00	4
Travel, Accommodation and Meals for Speakers Series	$3,000.00			$3,000.00	5
External Core Member Visits	$4,000.00	$500.00	$1,000.00	$2,500.00	6
Promotion and Marketing	$250.00		$125.00	$125.00	
GRANT SUPPORT EXPENSES					
Research Honorarium for WICI Director Vanessa Schweizer	$10,000.00	$10,000.00			
In-kind funding to Igor Grossmann for outreach project			$500.00	($500.00)	7
OTHER RESEARCH FUNDING					
Core Members Travel for Conferences and Networking	$2,000.00	$941.17	$1,558.83	($500.00)	8
Additional travel support for SC Core Members (carried over)	$1,500.00	$1,000.00	$500.00		
Additional support for AD			$2,000.00	($2,000.00)	
Student Research and Travel Grants	$5,000.00		$5,000.00		9
Map the System Sponsorship	$500.00		$500.00		
OTHER					
IT Development and Maintenance	$1,250.00	$1,024.30	$225.70		
Contracted Services (*including editing of publications*)	$1,500.00		$1,000.00	$500.00	
Telephone Service	$240.00	$199.50	$40.50		
Office Supplies & Miscellaneous	$250.00	$83.74		$166.26	
ORGANIZATIONAL DEVELOPMENT					
Institutional Development	$2,500.00		$1,500.00	$1,000.00	10
TOTAL EXPENSES	**$75,045.96**	**$45,824.04**	**$23,269.74**	**$5,952.18**	
NET TOTALS					
Uncommitted funds to be used or carried over	**$39,092.22**				

Notes

[1] coronavirus cancellations and unused travel amounts caused carryover to be higher than planned

[2] 75K from OR less 10% budget cut (15K from ENV returned Oct 2020)

[3] Deferred to Winter term 2021

[4] catering not required due to cancellation of in-person events

[5] speakers to be offered honoraria in lieu

[6] $500 honoraria offered in lieu of campus visits

[7] Approved by SC in June 2020

[8] $500 ea for SC members (excl. Director and AD) - new SC member joined in 2020

[9] Most travel amounts unused due to COVID

[10] For expanding CNCS connections