

McGill Sustainability Systems Initiative
Initiative systémique de McGill sur la durabilité

ANNUAL REPORT

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McGill

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MSSI AT A GLANCE

Governance

Executive Committee

Anja Geitmann, Dean, Faculty of
Agriculture and Environmental Sciences

Bruce Lennox, Dean, Faculty of Science

Jim Nicell, Dean, Faculty of Engineering

Heather McShane, MSSI Program
Director and Catalyst-in-Chief (*ex-officio*)

MSSI Secretariat Staff

Heather McShane, Program Director
and Catalyst-in-Chief

Larissa Jarvis, Research Assistant

Nicole Middlemiss, Administrative
Assistant

Keelin Elwood, Communications Officer

Yutong Zhang, Research Assistant (MSSI
Dashboard and Database)

Geneva Yang, SDG Campus Coordinator

\$2M

In funds distributed
this fiscal year

216

MSSI faculty members

39

departments represented

A WORD FROM OUR PROGRAM DIRECTOR AND CATALYST-IN-CHIEF



Who could have anticipated as we started the year working from home that so many of us would be in a similar situation at its end? Nevertheless, despite the very real challenges many in the research community faced, with strong encouragement from our membership the MSSl continued to operate and support McGill sustainability research, albeit online rather than in-person.

Knowing the importance of connections for students, the MSSl Collective – a group of graduate students working on sustainability-related projects, many with funding from the MSSl – held 7 events over the last year (see p. 9). These helped the students develop and maintain connections with peers outside of their research groups, support that was particularly important for newly arrived students. We also held two funding competitions (Ideas; Innovation) which together attracted 34 high quality proposals, and disbursed more than \$330,000 to successful applicants to fund exciting and bold sustainability-related research (see p. 3).

The MSSl research themes realised some inspiring projects during the year, including the Sustainability Transformations theme's launch of PIVOT, an online peer-to-peer platform where SME business owners share their stories about steps they took to make their enterprises more sustainable (see p. 18). While initially uncertain about moving the Research Theme Symposium to an online format, we quickly realised that this opened up attendance to a much wider audience. The shorter virtual sessions took place over two days and included a keynote presentation from Professor Harini Nagendra who spoke to us from Karnataka, India (see p. 8). The symposium also included the launch of the MSSl's new research theme, CleanTech for Carbon and Energy Cycles (see p. 20). Another initiative launched this year is the MSSl Climate Change Cluster (see p. 9). The Cluster provides an opportunity for McGill's numerous researchers working on climate change to convene under a single umbrella, and is one of the MSSl's most timely and impactful initiatives.

Making connections in the online environment is demanding. We miss the convivial post-event socials when conversation flows over a coffee or glass of Faculty Club wine, new connections are made, and exciting research is dreamed up. Nevertheless, the MSSl has continued to be active and has supported as many initiatives and events as before. The new environment has brought challenges but also unexpected advantages, and going forward we find ourselves with a bigger toolbox – and a wider network.

Dr. Heather McShane

IDEAS & INNOVATION FUNDS: NEWLY FUNDED



Ideas Fund Awards

High risk/high reward projects are increasingly seen as avenues to move fields of research forward rapidly. The Ideas Fund provides seed funding to explore bold projects and novel ideas which, if successful, could make a significant impact on a sustainability-related challenge.

Five researchers were awarded grants of \$40,000 each to pursue the following projects:

Tough biodegradable protein nanofibers as plasticizers for sustainable commodity bioplastics: Noémie-Manuelle Dorval Courchesne (Chemical Engineering)

A unified approach towards understanding defect-tolerant materials for solar energy harvesting: Patanjali Kambhampati (Chemistry)

Mechanochemical synthesis of disordered-rock salt anodes for ultrafast-charging Li-ion batteries: Jinhyuk Lee (Mining and Materials Engineering)

Design of innovative clean technologies for sustainable use of marine biomass: Benjamin Simpson (Food Science and Agricultural Chemistry)

Green ammonia production using solar-plasma catalysis: Mélanie Tétreault-Friend (Mechanical Engineering)

Innovation Fund Awards

The Innovation Fund **accelerates the development of an idea or a technology towards widespread societal adoption** by funding research that informs policy or moves an innovation toward commercialization.

Two researchers were awarded funding totaling \$131,000:

Cellulose waste-derived material for targeted removal of microplastics and nanoplastics from water: Nathalie Tufenkji (Chemical Engineering)

Developing a near real-time sensor network for urban air pollution using street-level images and audio data combined with deep learning models: prototype evaluation: Scott Weichenthal (Epidemiology)

IDEAS & INNOVATION FUNDS: RESULTS

As the projects from the first two years of Ideas Fund and Innovation Fund competitions wrap up, here is a sample of what researchers were able to accomplish through these opportunities. In addition to supporting the development of novel ideas and innovations in sustainability research, this funding also contributed to training of the next generation of sustainability researchers. Over 65% of this funding was used to support undergraduate and graduate students, as well as postdoctoral researchers.

Recycling plastics sustainably

Lead researcher: Karine Auclair, Chemistry

Innovation Fund 2018

Polyethylene terephthalate – often used in water bottles, food packing and manufacturing – is the most commonly recycled plastic. The standard, heat-intensive recycling process results in a lower quality plastic that can't be recycled a second time. An alternative method breaks the plastic down into its molecular building blocks and allows recycling into an equally high-quality product, but relies on the use of hazardous chemicals and conditions, such as high temperature and pressure.

In this Innovation Fund project, Prof. Auclair and her team were able to demonstrate a viable alternate recycling method. This method uses environmentally benign and renewable enzymes derived from fungus as catalysts, thereby reducing the amount of energy, harsh chemicals, and other aqueous or organic solvent waste involved in the process.

Reducing antibiotics use in poultry production

Lead researcher: Jennifer Ronholm, Food Science and Agricultural Chemistry

Ideas Fund 2019

Antibiotic resistance is a global health crisis resulting in bacterial infections that are untreatable by conventional methods. As a result, antibiotics are being slowly withdrawn from use in agriculture. However, without their use our current models of high-density agricultural practices are unsustainable due to the rapid expansion of bacterial infections in farmed animals.

The goal of this Ideas Fund project was to identify and isolate bacteria naturally occurring in poultry intestines that are able to kill select bacterial pathogens, and to develop these as anti-infective probiotics. The research team identified approximately 150 chicken commensals with the potential to prevent infection, raising the prospect of greatly reducing the need for antibiotics in high-density poultry production operations.

Modelling river and lake pollution

Lead researcher: Bernhard Lehner,
Geography

Ideas 2019

In order to protect surface water (lake and river) ecosystems and to sustain their many benefits to society, such as provision of safe drinking water, we need to know the sources and distribution of potentially harmful substances. With a lack of sufficient surface water quality testing, contaminant fate models (CFMs) can help us understand how pollutants behave in the environment. While numerous CFM models already exist, to date none includes the locations of the world's wastewater treatment plants, which can be important sources of contaminants.

In this Ideas Fund project researchers are developing a CFM that includes the location of over 58,000 wastewater treatment plants. This model will have applications across a wide range of important research topics, including environmental risk assessments related to effluents from domestic, agricultural and industrial sources.

Sustainable production of fuels

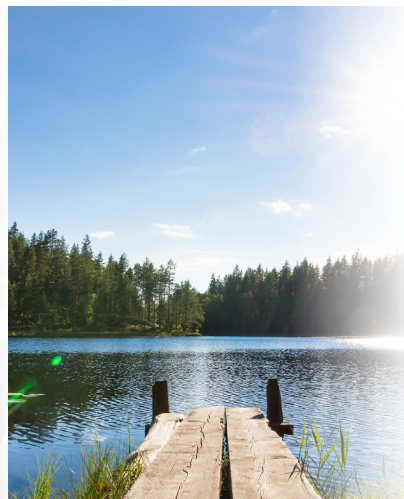
Lead researcher: Ali Seifitokaldani, Chemical
Engineering

Ideas 2019

Electrochemical reduction of carbon dioxide (CO_2) is a promising carbon capture and utilization technology. In this process, electrical energy is used to convert CO_2 into useful chemicals or alternative fuels that can help meet our needs for renewable energy sources. While promising, the efficiency of current technologies is not yet sufficient to make them viable for commercialization.

At the same time, biomass – organic material such as wood or agricultural waste – is considered an abundant renewable energy resource in Canada. However, the raw materials require upgrading to more functional forms before they can be used as fuel. Current systems rely on high temperature and pressure processes with significant carbon footprints.

The team has developed a flow electrochemical system which combines the fields of CO_2 conversion and biowaste upgrading. This process addresses both the efficiency limitations of current electrochemical systems as well as the carbon footprint in biomass upgrading.



FOCUS ON STUDENTS

The MSSI recognizes that - in addition to supporting innovative research to tackle important sustainability challenges - **we must support the next generation of researchers in developing the skills and expertise required to respond to the complex challenges presented by a changing world.**

62

Students and postdocs supported through our research themes

65%

The amount of Ideas and Innovation funding that directly supports students and postdocs

200+

The number of graduate students and postdocs on the MSSI Collective newsletter

MSSI Collective

An important challenge of sustainability research is that it requires working across many disciplines; the solutions we need do not lie within one field. This type of work is not yet the norm in university settings, where much research is still happening within the bounds of individual disciplines.

The MSSI Graduate Student and Postdoctoral Sustainability Research Collective - or the MSSI Collective - launched in summer 2020. Through the Collective, students and postdoctoral researchers are given the opportunity to network and learn with their peers from across McGill.

During its inaugural year, the MSSI Collective was led by a Steering Committee made up of six graduate students and postdoctoral fellows. With the support of the MSSI Secretariat, the Steering Committee developed a series of events that reflected the interests of the larger group. Learn more on [page 9](#).



"The MSSI Collective is a meeting of different minds, a conversation with disciplinary foreigners, and a community to foster collective wisdom to advance sustainable development."

Ling Chen, DCL candidate in the Faculty of Law

The MSSI Landscape Scholars

The Landscape Scholars cohort was a multidisciplinary group of eight graduate students funded through the Sustainable Landscapes Research Theme. The cohort collaborated on developing a framework for identifying and analyzing the embodied ecosystem services – all the natural resources used in the production of a commodity – in food value chains. They worked towards applying this framework to case studies in Central America and Tanzania, and have written an academic paper which is currently under review for publication. Their work provides a holistic view of food sustainability to the many stakeholders along the food value chain.

The program has now wrapped up, and members were invited to reflect on their experiences for an issue of [Frontiers in Ecology and the Environment](#). In a guest editorial, they highlighted the value of such interdisciplinary graduate collaborations, which for them encouraged skill sharing, cross-disciplinary communication, as well as autonomy, confidence, and legitimacy as researchers. You can learn more about the Landscape Scholars' research [here](#).

SDG Campus Coordinator

Geneva Yang – a second year undergraduate student – joined the MSSI in August 2020 as McGill's first Sustainable Development Goals (SDG) Campus Coordinator. The role, initiated through a collaboration with the Sustainable Development Solutions Network Canada, was developed to mobilize students around the United Nations SDGs, a set of 17 goals developed to end poverty, protect the planet, and improve the lives and prospects of everyone.

As part of her work, Geneva initiated McGill's first-ever SDG Week in February. A collaboration with 10 other student groups, the week featured a series of events focusing on major themes within the SDGs. She also mapped the research areas of the MSSI's faculty members to the SDGs to better understand where McGill sustainability research is contributing to the goals.

Geneva's role as the SDG Coordinator will continue through the McGill Office of Sustainability. You can learn more about Geneva's work in [this McGill Reporter article](#).



OUR MSSSI EVENTS

Research Theme Symposium

The MSSSI embraced a virtual format for its 3rd Annual Research Theme Symposium, held half-days on Nov. 9th & 10th, 2020. The online sessions made it possible for a geographically diverse audience, including members of Professor Nagendra's class in Karnataka, India, to get to know the MSSSI, with record attendance for each day's keynote lecture:

- Nov. 9th: **Urban Sustainability, A Global South Perspective.** Prof. Harini Nagendra, Azim Premji University, India
- Nov. 10th: **reciChain: Capturing The Value of Plastics Through Circular Economy.** Amy Sandhu, Head of Sustainability and Government Relations, BASF Canada

Other symposium activities included:

- Progress updates from all four established MSSSI research themes
- An introduction to a fifth research theme, CleanTech for Carbon and Energy Cycles ([see p. 20](#))
- A student panel discussion on the benefits of an interdisciplinary training environment for conducting sustainability research
- A virtual research fair for MSSSI-affiliated students

By 2050, we will be 75% urban

UN World Urbanization Prospects: 2014 Revision

Harini Nagendra
Director of the Azim Premji University Research Center

Screengrab from Dr Harini Nagendra's presentation at the MSSSI Research Theme Symposium.

Other Events

The MSSI kicked off the **Climate Change Cluster**, an initiative to bring together the many McGill researchers working on climate change-related topics. The first two events brought together more than 60 faculty researchers from across seven faculties:

- Feb 26th: **Climate Change Research & Machine Learning**. Seminar with Prof. David Rolnick, School of Computer Science & MILA
- Apr 19th: **Climate Change Cluster Networking**. Speed networking event for climate change researchers

Launched in summer 2020, the **MSSI Graduate Student & Postdoc Sustainability Research Collective** ([more information on p. 6](#)) has held several events to date. In addition to five monthly meetups where members had the opportunity to present their research and network, the Steering Committee organized two events open to all McGill graduate students and postdocs:

- March 9th: **Indeterminacy Workshop**. An interactive session on working with uncertainty, organized and facilitated by Dr. Stanzi Vaubel
- April 13th: **Sustainability Careers for Graduate Students**. A talk by Dr. Patrick Cortbaoui, Margaret A. Gilliam Institute for Global Food Security

In collaboration with The Climate Reality Project Canada and McGill Community Engagement and Partnerships, the MSSI has been developing a

series of public-facing conversations on climate change in Canada. The series was featured in the *Globe & Mail*. The first conversation in the series was:

- **A Conversation on Electric Vehicles**. Benoit Boulet (Professor, Department of Electrical and Computer Engineering) and Audrey Dépaült (Vice-President of the board of the Quebec Electric Vehicle Association), facilitated by student Michelle Brais

In fall 2020, the MSSI partnered with University Advancement to produce four webinars featuring MSSI researchers explaining some of the basic principals of sustainability. The webinars are titled *What is sustainability, anyway?*, *Will COVID-19 change the way we approach sustainability?*, *Why is sustainability research so challenging?*, and *How can sustainability research be translated into real-world changes?*

MSSI-Sponsored Events

- Joint with the Margaret A. Gilliam Lecture Series in Food Security: **Supporting Indigenous Food Sovereignty: A Community-led Approach to Reclaiming Food Systems & Nourishing Communities**. With representatives from Canadian Feed the Children. April 2021
- Sustainability Research Symposium: **Sustainable Business**. January 2021

ABOUT THE SECRETARIAT

A number of members have expressed interest in knowing more about the Secretariat and the role the team members play in keeping the MSSSI up-to-date and running smoothly.

The Secretariat is comprised of four staff members with support from student employees in specific areas.

The Program Director, **Heather McShane**, whose accompanying title of Catalyst-in-Chief perhaps best describes her work, is responsible for the overall program and its daily operations. Working closely with the Executive Committee, Heather designs and initiates new programs to promote the MSSSI's mission to support and build McGill's capacity in sustainability research. Heather also represents the MSSSI on a number of internal and external committees and boards.



The Research Assistant, **Larissa Jarvis**, works with the Program Director to develop new programs and workshops, and keeps up to date on other sustainability research organisations. She compiles data for reports and to evaluate the MSSSI's progress against its mandate. Larissa is also responsible for coordinating the MSSSI Student Collective.



The Administrative Assistant, **Nicole Middlemiss**, ensures that the MSSSI runs smoothly and efficiently. She books meetings (no easy feat with academics' busy schedules), takes meeting notes, and tracks all finances for the Secretariat and associated research projects. She also coordinates all aspects of the MSSSI funding competitions and is the first point of contact for the MSSSI.

The Communications Officer, **Keelin Elwood**, is responsible for all MSSSI's communications. Keelin writes reports, articles and newsletters and keeps the MSSSI website current. She designs and promotes MSSSI events and is the primary MSSSI contact with internal and external communications groups.



Yutong Zhang is a Masters' Degree student in Computer Science who maintains and develops the MSSSI Sustainability Dashboard, an online visualisation and query tool of MSSSI members and their research. This year, Yutong added information on the researchers and projects funded through the Ideas, Innovation and SSH Ideas competitions.

Geneva Yang is a second-year undergraduate student and, through the MSSSI, McGill's first Sustainable Development Goals (SDG) Coordinator. You can read more about Geneva and her SDSN work on [p. 7](#).



RESEARCH THEMES

Creating Sustainable Materials

Researchers in the **Creating Sustainable Materials** theme are working in a holistic transdisciplinary manner to design novel materials that have similar or enhanced functionality to existing materials but reduced environmental impact and health risk during their production and use. They also evaluate the potential effects of existing materials which may be released into the environment through wear and tear or at end of life. **The results from this research will ultimately inform policy and lead to the creation of more benign materials.**



Niladri Basu,
Department of Natural
Resource Sciences
and School of Human
Nutrition, Faculty
of Agriculture and
Environmental Sciences




George Demopoulos,
Department of Mining
and Materials Engineering,
Faculty of Engineering



Audrey Moores,
Department of Chemistry,
Faculty of Science

Making new materials safer

There is increasing awareness of the need to consider the potential human and environmental health impact of elements and compounds in new materials. Incorporating toxicological tests and replacing potentially toxic compounds with more benign alternatives at an early stage in the material development cycle will produce safer materials and can save energy and resources. The team is also developing sustainability guidelines for use by researchers in early stages of their new material development projects and as graduate student training tool.



"It was inspiring to watch graduate students from toxicology and materials sciences discussing their research with each other."

Audrey Moores, Creating Sustainable Materials co-lead

Reducing risks from existing materials

Commercial uptake of novel materials can be hindered if they include elements of concern or their production requires the use of solvents known to be harmful to human health. Such is the case with lead-containing perovskites, which are used to convert natural light to electricity in solar power systems. MSSI materials engineers and toxicologists are working together to develop and test different formulations for perovskites to find the most benign alternatives. The team's research also includes replacing the toxic solvents used during the production of nanomaterials with mechanochemistry.

Considering the impacts of a material throughout its life cycle

In addition to testing new materials for their potential impacts on human and environmental health, it is also important to consider the possible effects of chemicals released as products age or are disposed of. Organisms in aquatic environments are particularly vulnerable to this form of exposure. The Materials team is investigating the impacts of silver and titanium dioxide nanomaterials released by commercial paints on fish. They are also conducting tests to evaluate the effects of cadmium-containing quantum dots, commonly used in TV and monitor screens, on mammalian cells. To emulate their form in natural waters, the nanomaterials are modified prior to contact with the test organisms or cells.

Adapting Urban Environments

As home to more than half the world population and rising, urban areas stand to face harsh effects from the changing climate.

The **Adapting Urban Environments** theme's mission is to pursue solutions that specifically address the unique complexities of sustainability issues in urban areas - from the neighbourhoods and cities we live in, to the national policies and global networks that inform and influence decision-making.

From defining sustainable cities to understanding the role of "big data" in urban sustainability, the Adapting Urban Environments theme generates and mobilizes knowledge to make cities more socially inclusive and less environmentally impactful while improving the well-being of residents.



Andrew Gonzalez,
Department of Biology,
Faculty of Science



Kevin Manaugh,
Department of
Geography, Faculty of
Science, Bieler School of
Environment



David Wachsmuth,
School of Urban
Planning, Faculty of
Engineering

Approaches to urban planning

Shifting the common perception of urban areas as threatening environmental and human well-being to one in which they provide opportunities for sustainable solutions and innovations is key to advancing the fight against climate change. In the last two decades, three significant historical developments - urban sprawl in the global North, informal settlements in the global South, and greenhouse gas emissions in all urban centres - have tilted the urban governance narrative towards cities as solutions to global environmental problems. Theme researchers found that the convergence of sustainability and urban planning discourses has led to the concept of "sustainable cities" which are poised to help solve many social, economic, and environmental problems.

Transportation equity

Due to their size and operational capacity, major services in urban settings such as transportation are typically handled by state or corporate institutions. Issues arise when those same institutions face criticism for perpetuating or exacerbating existing inequities. These include access limitations, noise, pollution, safety, and distribution of policing, which can have profound and unequal impacts on communities and neighbourhoods. That large institutions are principally self-regulating further exacerbates these issues. Members of the Adapting Urban Environments theme explored this issue and proposed shifting focus from transportation equity to a broader consideration of transportation justice, and more closely aligning with models of social change promoted in the environmental justice literatures and related movements.

Urban waste

Cities have long been regarded as waste-generating behemoths. One force driving this is the tendency of consumers to replace functioning items before their end of life, particularly in the high-tech arena. This high turnover production and consumption cycle is unsustainable. MSSl researchers set out to understand the decision-making process behind this consumer habit, concentrating on cellphone users in the United States. They found many factors contribute to the consumer decision to replace a functioning product. They discovered that the perceived value of a product, which extends beyond the product's functioning to the potential effect on social status and emotional impact, plays a significant role in consumer decision-making. Another major force is satiation or the decreased enjoyment of the product over time. With this knowledge, policies and products can be better designed to meet consumer needs for longer durations.



“The MSSl’s support has enabled researchers from three disciplines to address issues jointly.”

Kevin Manaugh, Adapting Urban Environments co-lead

Sustaining Landscapes

Landscapes connect communities to the natural capital needed for the sustainable provisioning of ecosystem services like food, energy, clean water, and regulation of key processes like floods and climate. In an interconnected world, where the socioeconomic and biophysical drivers of landscape change are increasingly linked to regional and global processes, decision-making at the landscape scale necessitates an integrated view that recognizes connectivity at different scales.

The **Sustaining Landscapes** theme is developing methods and tools to assess landscape sustainability and better link science, engineering, social and economic needs, and policy.



Elena Bennett,
Department of Natural
Resource Sciences,
Faculty of Agricultural
and Environmental
Sciences, Bieler School
of Environment



Brian Robinson,
Department of
Geography, Faculty of
Science



Laxmi Sushama,
Department of Civil
Engineering and Applied
Mechanics, Faculty of
Engineering

Northern research

Canada's Arctic is warming at more than twice the global rate. The Northern Landscapes group addresses climate change adaptation and mitigation in these regions, improving our understanding of the evolving landscapes of the North and the implications for communities and infrastructure.

The team has modelled past, present, and future Arctic cyclone events, including precipitation and surface wind speeds for the period 1981–2099. Model results successfully reproduced measurements up to the current period, suggesting accuracy of future projections. Results for 2070–2099 indicate that winter cyclone intensity and frequency, as well as associated precipitation, will increase over the Aleutian region and decrease over the Icelandic Low region. This study provides important insights on the use of modelling in risk assessment studies.

Managing resilient landscapes


The theme is also exploring how we can manage landscapes to ensure long-term resilience while maintaining their capacity to deliver ecosystem services – the many benefits that nature provides for humans.

This is a challenging task that requires a strong understanding of the complexity of landscapes, how and where ecosystem services are delivered and accessed, and collaboration amongst the many stakeholders involved.

Agricultural landscapes offer a good example of this complexity. These landscapes provide a very important ecosystem service – they produce our food. They also provide many non-food services such as flood protection and pollinator habitats. Researchers found that agricultural intensification to meet growing demands for food has often been at the expense of these important but often overlooked ecosystem services. This has led to a decrease in resilience of these landscapes in the face of changing conditions.

There is also often a mismatch between the ecosystem services people want and those that they obtain, as highlighted in a case study on Quebec's Outaouais River. Led by PhD student and Landscape Scholar Dalal Hanna, researchers worked with various stakeholders to identify these discrepancies and co-develop ideas for potential solutions.

The theme has also explored efforts to restore landscapes. A study in the Haihe River Basin region in China found that replacing trees on land to slow or halt processes such as soil erosion and desertification had unintended consequences that only become evident years later. This highlights that careful attention needs to be paid to the potential long-term impacts of restoration projects on both the target landscape and any associated areas that might also be affected.



"Improving our ability to assess landscape interactions is essential for improving sustainability at all scales."

Brian Robinson, Sustaining Landscapes co-lead

Sustainability Transitions

In Canada, **90% of private-sector workers are employed at SMEs**, making these companies critical social, cultural, and economic change players. The MSSI's **Sustainability Transitions** research theme's mission is to collaborate closely with small-and-medium enterprises (SMEs) to produce innovative research to help stimulate, support, and understand transitions towards sustainability in that sector.

This theme brings together co-leads from the Faculties of Science, Law, and Management.

Its two main focuses are understanding and sharing the sustainability transitions related to decision-making, motivations, and obstacles SMEs face, and studying and promoting tools and metrics that could stimulate and support the transition of SMEs towards more sustainable practices.



Jaye Ellis,
Faculty of Law, Bieler
School of Environment



Dror Etzion,
Desautels Faculty of
Management



Catherine Potvin,
Department of Biology,
Faculty of Science

PIVOT project

This unique research project uses social media, storytelling, and close contact with businesses to inspire SMEs to accelerate the implementation of sustainable business practices.

In partnership with the National Film Board of Canada (NFB), PIVOT helps businesses become more sustainable by using digital storytelling and social networking to highlight the challenges and successes faced by their peers in their journeys. The PIVOT web platform features the stories of SME leaders like Annie Rouleau, who found that having measurable goals was one of the main factors contributing to her success in making her fragrance-free home and body product company, The Unscented Company, more sustainable. By offering clients a refill program, the company has cut its plastic bottle production by 350,000 units. Not only does she believe they will be able to cut a million plastic bottles from their production next year, but The Unscented Company also grew by 333% as she adopted this sustainable practice.

As the COVID-19 pandemic became a global phenomenon, SMEs faced new and unprecedented challenges relating to employee health and safety, supply chain disruptions, and often shifting public health guidelines and restrictions. As a result, the PIVOT project shifted focus temporarily during this time to highlight SME responses to the pandemic, thus emphasizing this group's ability to respond quickly and efficiently to societal changes.

Sustainability metrics

This project aims to tackle one of the main challenges for evaluating sustainability: lack of simple, robust, and trustworthy indicators and standards. It studies and promotes the development of metrics to stimulate transitions and measure SMEs' progress. Researchers are investigating the practice and effects of inclusivity on sustainability standard-setting and are testing the robustness of targets and indicators.

*"The MSSSI
opened the doors
for conducting
interdisciplinary
research."*

Dror Etzion, Sustainability
Transitions co-lead

CleanTech



Jeff Bergthorson,
Department of
Mechanical Engineering,
Faculty of Engineering



Salmaan Craig,
Peter Guo-hua Fu
School of Architecture,
Faculty of Engineering



Hong Guo,
Department of Physics,
Faculty of Science



C.J. Li,
Department of Chemistry,
Faculty of Science

The **CleanTech for Carbon and Energy Cycles** research theme, launched November 2020, develops viable replacements for current greenhouse gas-intensive technologies and industrial design. **Projects in the theme consider societal, environmental, and economic aspects of new technologies throughout their lifecycles.**

The theme revolves around three projects:

Replacing fossil fuels with metals as an alternative source of energy

Designing sustainable buildings using wood and natural air flow

Mimicking photosynthetic processes to capture solar energy

Find out more about the co-leads in [the CleanTech Appendix](#)



About CleanTech

One of the most pressing and complex challenges of our time is how to reduce humanity’s impact on the climate due to excess greenhouse gases emissions without reducing quality of life. CleanTech seeks to replace current high-emission technologies with very low-emission alternatives. The MSSI CleanTech theme brings together three research teams, each of which addresses this challenge in a different way.

Developing zero-carbon energy technologies

Project lead: J. Bergthorson

This project examines the novel approach of using metals such as aluminum as a low-emission source of energy. Metal technologies can also be efficient vehicles for energy storage, so this research is of particular interest for use in heavy-duty transportation systems and in remote communities. As well as developing the science of this innovative technology, the team will assess its economic viability, societal acceptance, and environmental impacts.

Buildings as a global carbon sink

Project lead: S. Craig

This project studies the use of wood in building design to replace energy-intensive concrete and steel. Combined with the inherent carbon storage of a wood-based structure, the team investigates the use of air circulation to increase a building’s thermal efficiency and thus reduce or remove the need for artificial heating and cooling. Integral to the project is the focus on forest health and ensuring that biodiversity can be maintained while meeting the demand for wood as a building material.

Producing energy through artificial photosynthesis

Project leads: H. Guo & C. J. Li

This project draws inspiration from the natural photosynthetic process through which plants convert light and carbon dioxide into oxygen and chemical energy. The team is developing laboratory-based methods to capture solar energy and artificially convert carbon dioxide into commercially valuable energy-storing materials such as hydrogen, syngas (a mixture of carbon monoxide and hydrogen), and methane, thus replacing fossil fuels.

APPENDICES



Appendix 1: Research Themes

I - Creating Sustainable Materials

Supported Internal Network

- Research funding support for nine co-principal researchers from across five faculties.
- Research funding support for 13 graduate students and post-doctoral fellows.
- Networking and professional development opportunities for 40 additional graduate students and post-doctoral fellows.

External Network (Partnerships, Collaborations)

- Steve Maguire (University of Sydney)
- Andrew Maynard (Arizona State University)
- Clara Santato (Polytechnique Montreal)
- Joe Tickner (University of Massachusetts, Lowell)
- BASF Canada
- Environment and Climate Change Canada

Selected Activities

- Theme retreat, August 19, 2020

External Research Funding Obtained Through Involvement with the MSSI

- Nanotools III. Canadian Foundation for Innovation. Demopoulos, G., Grutter, P., Perepichka, D. \$7,210,301.
- Etude holistique de la toxicité des points quantiques commerciaux. FQRNT Projet de recherche en équipe. George, S., Ghoshal, S., McKeague, M., Moores, A. \$190,500.

Selected Publications

Bechu, A., Liao, ... McKeague, M., Ghoshal, S., & Moores, A. (2021). Cadmium-containing quantum dots used in electronic displays: Implications for toxicity and environmental transformations. *ACS Applied Nano Materials*, 4, 8417–8428. <https://doi.org/10.1021/acsanm.1c01659>

Krebs, J., & McKeague, M. (2020). Green toxicology: Connecting green chemistry and modern toxicology. *Chemical Research in Toxicology*, 33, 2919–2931. <https://doi.org/10.1021/acs.chemrestox.0c00260>

Mittal, K., Rahim, A. A., George, S., Ghoshal, S., & Basu, N. (2021). Characterizing the effects of titanium dioxide and silver nanoparticles released from painted surfaces due to weathering on zebrafish (*Danio rerio*). *Nanotoxicology*, 15, 1–15. <https://doi.org/10.1080/17435390.2021.1897173>

Llanos, M., Yekani, R., Demopoulos, G. P., & Basu, N. (2020). Alternatives assessment of perovskite solar cell materials and their methods of fabrication. *Renewable and Sustainable Energy Reviews*, 133, 110207. <https://doi.org/10.1016/j.rser.2020.110207>

Pain, G., Hickey, G., ... Basu, N., & Maguire, S. (2020). Drivers of and obstacles to the adoption of toxicogenomics for chemical risk assessment: Insights from social science perspectives. *Environmental Health Perspectives*, 128, 1–12. <https://doi.org/10.1289/EHP6500>

Yang, L., Moores, A., Friščić, T., & Provatas, N. (2021). Thermodynamics model for mechanochemical synthesis of gold nanoparticles: Implications for solvent-free nanoparticle production. *ACS Appl. Nano Mater.* 4, 1886–1897. <https://doi.org/10.1021/acsanm.0c03255>

II - Adapting Urban Environments

Supported Internal Network

- Collaborations with four researchers from across two faculties.
- Research funding support for 16 graduate students, postdoctoral fellows, and research assistants across four faculties.

External Network (Partnerships, Collaborations)

- Hillary Angelo (UC Santa Cruz)
- Ariel Espino (SUMA)
- Parnjali Deshpande (Institute for Transportation and Development Policy, India)
- Future Earth
- Jose Fabrego (UTP)
- Javier Sanchez Galen (UTP)
- Omar Lopez (SENACYT)
- Prasad Pathak (FLAME University, Pune, India)
- Marie Carmen Ruiz (FAO)
- Mark Torchin (STRI)
- Vivre en Ville

External Research Funding Obtained Through Involvement with the MSSI

- Perspectives, méthodes et pratiques alternatives et innovantes pour la réduction de risques de désastres. Fonds de recherche du Québec – Société et culture, Soutien aux équipes de recherche. Wachsmuth, D. (lead investigator Lizarralde, Université de Montréal). \$318,755.

Other Outputs

- [White paper: Vers un plan sud pour Québec.](#) Gonzalez, A.
- Paper and presentation to the Ville de Montréal on the proposed Pink Métro Line: **Analyse de la contribution de la ligne rose à l'équité sociale en matière de transport en commun à Montréal.** Manaugh, K., Wachsmuth, D.

- [Op-ed: Harmonizing, co-ordinating scientific initiatives key to filling gaps in knowledge of Canada's biodiversity.](#) The Globe and Mail. Gonzalez, A. March 31, 2021.

Selected Publications

Angelo, H., & Wachsmuth, D. (2020). **Why does everyone think cities can save the planet?** *Urban Studies*, 57, 2201–2221. <https://doi.org/10.1177/0042098020919081>

Dodds, K., Broto, V. C., ... Wachsmuth, D., et al. (2020). **The COVID-19 pandemic: territorial, political and governance dimensions of the crisis.** *Territory, Politics, Governance*, 8, 289–298. <https://doi.org/10.1080/21622671.2020.1771022>

Essl, F., Lenzner, B., ... Leung, B., et al. **Drivers of future alien species impacts: An expert-based assessment.** *Global Change Biology*, 26, 4880–4893. <https://doi.org/10.1111/gcb.15199>

Hou, C., Jo, M. S., & Sarigöllü, E. (2020). **Feelings of satiation as a mediator between a product's perceived value and replacement intentions.** *Journal of Cleaner Production*, 258, 120637. <https://doi.org/10.1016/j.jclepro.2020.120637>

Karner, A., London, J., Rowangould, D., & Manaugh, K. (2020). **From transportation equity to transportation justice: Within, through, and beyond the state.** *Journal of Planning Literature*, 35, 440–459. <https://doi.org/10.1177/0885412220927691>

McCann, K. S., Cazelles, K., ... Lapointe, B., & Gonzalez, A. (2021). **Landscape modification and nutrient-driven instability at a distance.** *Ecology Letters*, 24, 398–414. <https://doi.org/10.1111/ele.13644>

III - Sustaining Landscapes

Supported Internal Network

- Collaborations with 28 researchers from across five faculties.
- Research funding support for 19 graduate students, postdoctoral fellows, and research assistants across four faculties.

External Network (Partnerships, Collaborations)

- Adirondack Park Agency
- ArcelorMittal
- Conseillère au développement du réseau des fermiers de famille, Equiterre
- Government of the Northwest Territories
- The Nature Conservancy (New York; US Science Unit)
- New York Department of Environment Conservation
- NSERC ResNet consortium (collection of 10+ universities and 20+ institutional and governmental partners)
- Programme on Ecosystem Change and Society (PECS)
- Resilience Alliance
- Statistics Canada
- University of Maryland

External Research Funding Obtained Through Involvement with the MSSJ

- Dynamic flood inundation modelling in regional earth system models guided by space-based observations and machine learning. Canada Space Agency. Sushama, L. \$250,000.

Selected Publications

Bennett, E. M., Baird, J., *et al.* (2021). **Ecosystem services and the resilience of agricultural landscapes.** *Advances in Ecological Research*, 64, 1–43. <https://doi.org/10.1016/bs.aecr.2021.01.001>

del Giorgio, O., Crowley, M. A., Lu, L. X., & Schreiber, K. (2020). **Building capacity through interdisciplinary graduate collaboration.** *Frontiers in Ecology and the Environment*, 18, 479. <https://doi.org/10.1002/fee.2267>

Hanna, D. E. L., Roux, D. J., Currie, B., & Bennett, E. M. (2020). **Identifying pathways to reduce discrepancies between desired and provided ecosystem services.** *Ecosystem Services*, 43, 101119. <https://doi.org/10.1016/j.ecoser.2020.101119>

Li, R., Zheng, H., ... Robinson, B. E., *et al.* (2021). **Time and space catch up with restoration programs that ignore ecosystem service trade-offs.** *Science Advances*, 7, 1–10. <https://doi.org/10.1126/sciadv.abf8650>

Oh, S. G., Sushama, L., & Teufel, B. (2020). **Arctic precipitation and surface wind speed associated with cyclones in a changing climate.** *Climate Dynamics*, 55, 3067–3085. <https://doi.org/10.1007/s00382-020-05425-w>

Teufel, B., Sushama, L., ... Sasmito, A. P., *et al.* (2021). **Impact of COVID-19-related traffic slowdown on urban heat characteristics.** *Atmosphere*, 12, 243. <https://doi.org/10.3390/atmos12020243>

IV - Sustainable Transitions

Supported Internal Network

- Collaborations with six researchers from across four faculties.
- Research funding support for three graduate students, postdoctoral fellows, and research assistants across two faculties.

External Network

- Météo Média
- The National Film Board of Canada
- Québec Net-Positif

PIVOT-related activities

- www.gopivot.org: An online platform for SMEs to interact, share their success stories, and inspire peers.

- Focus group activities with participant SMEs.
- Third round of interviews with SMEs focused on sustainability practices.
- Preparation for an in-person workshop focusing on the collaborative aspect of low carbon reduction strategies.
- Film: [Covid 19: The Future of Food](#). The National Film Board.

External Research Funding Obtained Through Involvement with the MSSI

- PIVOT: Mobilizing online platforms to promote climate action in Canadian Small- and Medium-Size Enterprises (SMEs). SSHRC Partnership Development. Etzion, D., Potvin, C. \$200,000.

V - CleanTech

About the Co-leads

The CleanTech for Carbon and Energy Cycles (or simply CleanTech) research theme is led by four established McGill researchers running three projects:

Jeff Bergthorson is a member of the Faculty of Engineering's Department of Mechanical Engineering, where he runs the Alternative Fuels lab. His research on metals as an alternative source of energy has received international attention.

Salmaan Craig recently joined the Faculty of Engineering's Peter Guo-hua Fu School of Architecture. His research investigates the use of biogenic building materials such as wood as heat-exchangers. He previously lectured at the Harvard Graduate School of Design after having worked for several years as an industrial designer in the private sector.

Hong Guo is a member of the Faculty of Science Department of Physics. His research focuses on the areas of quantum electronic transport theory and modeling in nanoelectronics, and materials physics of nanotechnology. He is a Fellow of the Royal Society of Canada and of the American Physical Society.

C.J. Li is a member of the Faculty of Science Department of Chemistry where his research centres on a green chemistry approach to catalysis and synthesis of biologically active compounds. He is a fellow of many prestigious societies, including the Royal Society of Canada, the American Association for the Advancement of Science and the UK's Royal Society of Chemistry.

Internal Network

- Developing zero-carbon energy technologies: Mathieu Brochu (Materials Engineering), Matthieu Chemin (Economics), Sylvain Coulombe (Chemical Engineering), Dror Etzion (Desautels Faculty of Management), David Frost (Mechanical Engineering), Fiona Zhao (Mechanical Engineering).
- Buildings as a global carbon sink; Benoit Côté (Natural Resource Sciences), Michael Jemtrud (Architecture), Kiel Moe (Architecture).

Selected Publications

Craig, S., Halepaska, A., Ferguson, *et al.* (2021). **The design of mass timber panels as heat-exchangers (dynamic insulation)**. *Frontiers in Built Environment*, 6, 1–21. <https://doi.org/10.3389/fbuil.2020.606258>

Appendix 2: Publications from Ideas & Innovation Funds Projects

Adhikari, T., Hebert, A., ... & McCalla, E. (2020). **Development of high-throughput methods for sodium-ion battery cathodes**. *ACS Combinatorial Science*, 22, 311–318. <https://doi.org/10.1021/acscombsci.9b00181>

Estakhrianhaghighi, E., Mirabolghasemi, A., ... Lessard, L., & Akbarzadeh, A. (2020). **3D-printed wood-fiber reinforced architected cellular composites**. *Advanced Engineering Materials*, 22, 2000565. <https://doi.org/10.1002/adem.202000565>

Moradian, M., Islam, M. S., & Van De Ven, T. G. M. (2021). **Insoluble regenerated cellulose films made from mildly carboxylated dissolving and kraft pulps**. *Industrial and Engineering Chemistry Research*, 60, 5385–5393. <https://doi.org/10.1021/acs.iecr.1c00485>

Oliva, C., Huang, ... Ronholm, J., ... & Wang, Y. (2020). **Concentrated sulfuric acid aqueous solution enables rapid recycling of cellulose from waste paper into antimicrobial packaging**. *Carbohydrate Polymers*, 241, 116256. <https://doi.org/10.1016/j.carbpol.2020.116256>

Soni, N., Altartouri, B., ... & Kushalappa, A. C. (2021). **TaNAC032 transcription factor regulates lignin-biosynthetic genes to combat Fusarium head blight in wheat**. *Plant Science*, 304, 110820. <https://doi.org/10.1016/j.plantsci.2021.110820>

Soni, N., Hegde, N., Dhariwal, A., & Kushalappa, A. C. (2020). **Role of laccase gene in wheat NILs differing at QTL-Fhb1 for resistance against Fusarium head blight**. *Plant Science*, 110574. <https://doi.org/10.1016/j.plantsci.2020.110574>

Thorpe, J. D., O'Reilly, D., Friščić, T., & Damha, M. J. (2020). **Mechanochemical synthesis of short DNA fragments**. *Chemistry - A European Journal*, 26, 8857–8861. <https://doi.org/10.1002/chem.202001193>

Trowell, K. A., Goroshin, S., Frost, D. L., & Bergthorson, J. M. (2020). **Aluminum and its role as a recyclable, sustainable carrier of renewable energy**. *Applied Energy*, 275, 115112. <https://doi.org/10.1016/j.apenergy.2020.115112>

Trowell, K. A., Goroshin, S., Frost, D. L., & Bergthorson, J. M. (2020). **The use of supercritical water for the catalyst-free oxidation of coarse aluminum for hydrogen production**. *Sustainable Energy & Fuels*, 4, 5628–5635. <https://doi.org/10.1039/D0SE00996B>

Appendix 3: The MSSI in the Media

[A more sustainable way to make DNA-based medications.](#) Faculty of Science news, August 24th, 2020.

[Protecting Canada's rivers and lakes.](#) McGill Reporter, September 30th, 2020.

[McGill students create inaugural Sustainable Development Goals Week.](#) McGill Reporter, February 4th, 2021.

[Leadership in sustainable research and planning bring in big points for McGill's latest sustainability rating.](#) McGill Reporter, February 5th, 2021.

[Panel highlights Canada's failure to meet Indigenous communities' needs.](#) McGill Tribune, February 16th, 2021.

[From agriculture to arts: McGill Sustainability Systems Initiative Graduate & Postdoc Sustainability Research Collective.](#) McGill Reporter, February 22nd, 2021.

[impact200: Creating 'bright spots'.](#) McGill Reporter, March 16th, 2021.

[New online platform will help businesses make the PIVOT to sustainability.](#) McGill Reporter, March 26th, 2021.

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Designed and produced by Arian Zarrinkoub.



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