ANNUAL REPORT 2020: Staying Connected

PICS is hosted and led by the University of Victoria in collaboration with the University of British Columbia, Simon Fraser University and the University of Northern British Columbia.

University of Victoria · SFU Simon Fraser University Engaging the World · UBC The University of British Columbia · UNBC University of Northern British Columbia

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Cover image:
Staying connected at this time of isolation during the COVID-19 pandemic.
Source: Global Communication Networks (World Map Credit: NASA), iStock

THEME PARTNERSHIP

OPPORTUNITY PROJECT

FAST TRACK PROJECT

BIG FIVE PROJECT

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CONNECTED IN A TIME OF ISOLATION

2020 has truly been a year like no other due to the global upheaval wrought by the COVID-19 pandemic. The challenges we have faced, and continue to face, are unprecedented. The pandemic has also brought the larger existential challenge of climate change into sharper focus.

Rather than being pushed to the sideline, climate action has moved to the forefront of governance agendas around the world, as cities and countries grapple with embedding climate reform into their post-pandemic recovery. The urgency of addressing climate change, so successfully elevated by the youth movement of 2019, is now prominent in humanity's actions and dialogue – in media, within the investment community, and in new climate plans and strategies to transition to a low-carbon economy.

At PICS, I am proud of the creativity and innovation demonstrated by our project teams and staff who have ensured vital research and collaboration on climate change solutions has continued, despite the stress of the pandemic, and offices and labs being closed or restricted. Our in-person events and meetings have shifted online. While delays were inevitable, ultimately our research methods have also adapted to this new virtual world.

I invite you to read the stories in this report, including that of our Undersea Forests scientists who provided online training for First Nations partners' community members to conduct kelp fieldwork on their behalf; a truly collaborative solution that respected provincial travel restrictions while allowing the climate resilience research of these important ecosystems to continue.

It has been two years since the launch of the PICS collaborative research and engagement model which directly connects leading researchers with "solution seekers" – those decision-makers in government, First Nations, industry, NGOs and communities who will ultimately use those research results. The success of our partnership approach is apparent, with PICS research now being implemented by those who helped design it in the first place.

> *"The success of our partnership approach is apparent, with PICS research now being implemented by those who helped design it in the first place."*

An example is our UBC-led Adaptive Mitigation project, which has created a framework and tools for integrating green building and climate adaptation approaches for multi-unit residential buildings' design, construction and operations. BC Housing, the project partner, is now piloting these tools on an affordable housing project and others. Another example is our SFU-led Mobile Thermal Energy Project, which aims to collect and deliver waste energy from industrial sources into district energy systems. The project partner, the City of Surrey, views the technology as a possible solution in its transition to low-carbon energy.

Our research program supports climate solution innovations in energy, transportation, the built environment, natural environment, policy, and negative emissions technology. New projects in 2020 include two $1 million Theme Partnerships – Wildfire and Carbon, and Coastal Adaptation: Living with Water – which have both gained widespread media coverage and ignited online discussions on our expanding social media networks. PICS also launched new fast turnaround projects on hydrogen production, and on aligning COVID-19 recovery with local government climate action, plus a three-year project to provide climate action tools for municipalities.

I invite you to explore our 2020 projects outlined in this report, and also to visit our new website PICSCanada.ca, that showcases previous years' research results, our latest programs, and our new upcoming initiatives. There you may also sign up for our new-look newsletters and email campaigns launched in 2020.

I would like to extend my enormous gratitude to PICS staff, our project leads and teams, our "solution seeker" partners, and our enthusiastic PICS Scholars across our four partner universities – University of Victoria, University of British Columbia, Simon Fraser University, and the University of Northern British Columbia.

The year 2020 – one of the hottest on record - has reinforced the importance of collaboration and community in all walks of life, not least in meeting our most crucial challenge, climate change.

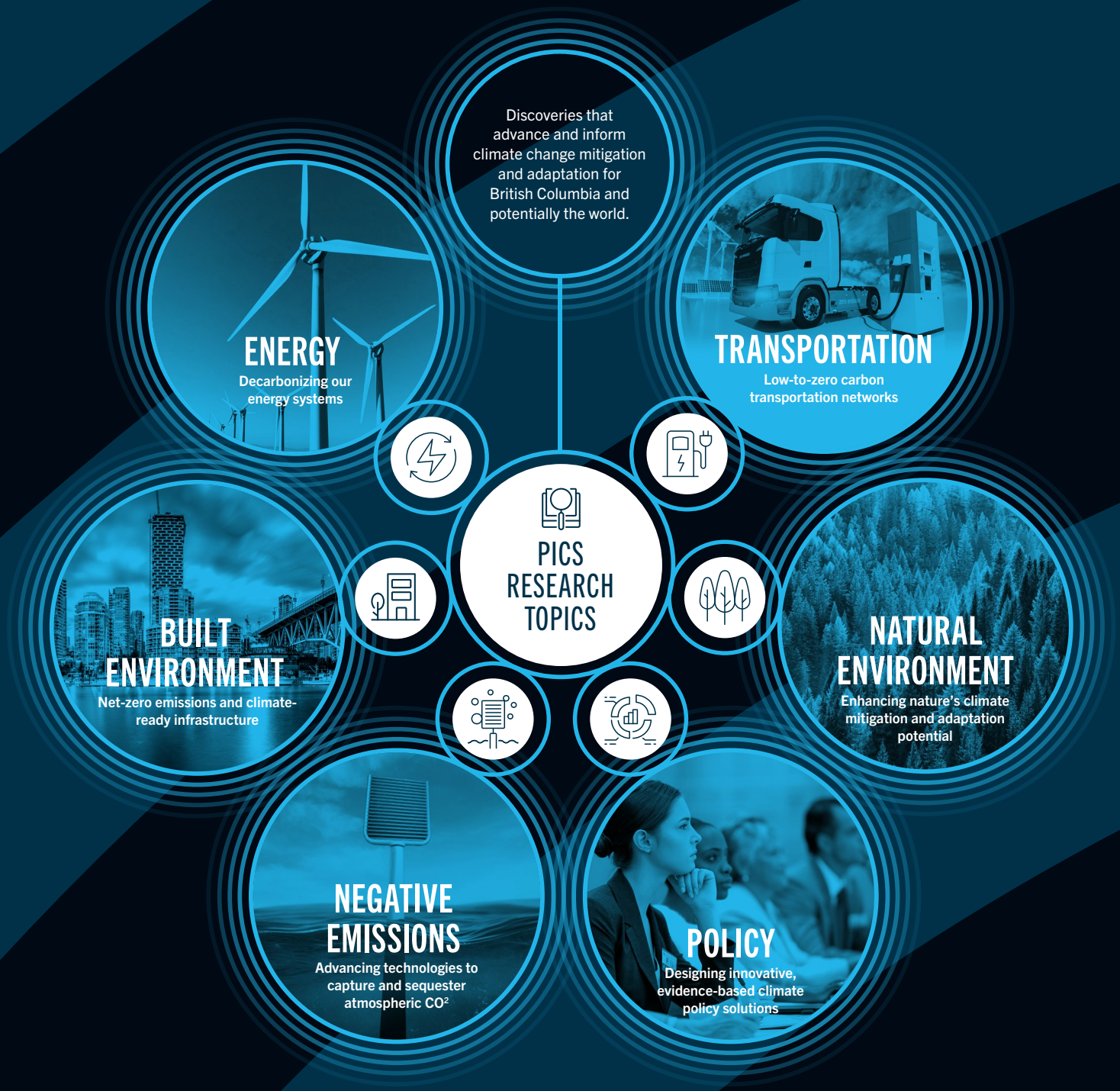
Sybil Seitzinger
PICS Executive Director

ADVANCING SOLUTIONS

Discoveries that advance and inform climate change mitigation and adaptation for British Columbia, Canada and potentially the world.

PICS develops evidence-based climate change solutions through collaborative partnerships which connect private and public sector solution seekers with experts from BC's four leading research universities – UVic, SFU, UBC and UNBC.

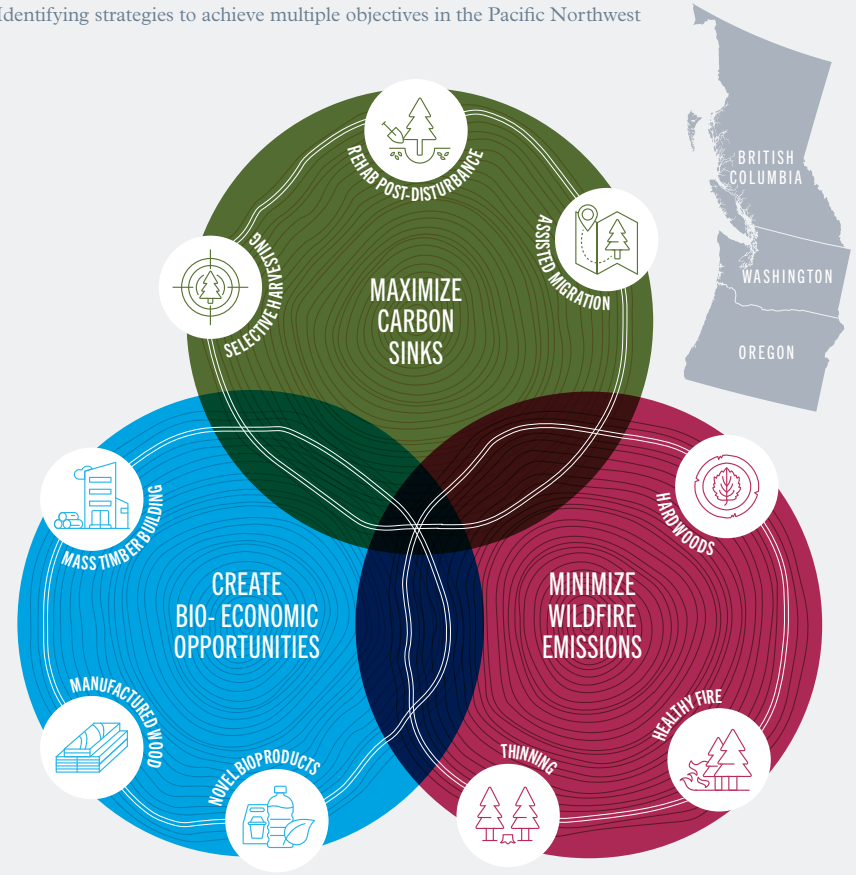
We invite you to explore our projects, and some of our 2020 research highlights.

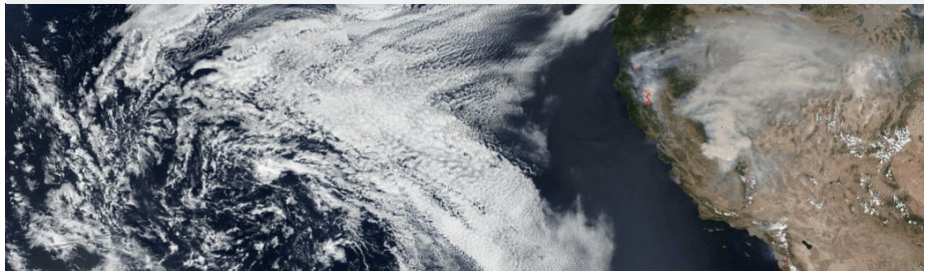


Natural Environment

The burning of fossil fuels is changing our planet. How do we enhance Nature's ability to slow climate change, and support adaptation?

Identifying strategies to achieve multiple objectives in the Pacific Northwest





ABOVE: Extreme wildfire events in recent years have created opportunities for public interest and engagement about the urgency and immediacy of wildfire risk. The launch of the project attracted mainstream and industry media coverage in British Columbia and Alberta, both home to recent extreme wildfires. *Image: NASA Worldview* LEFT: Aerial of Kitimat, Canada. *Image: Ben den Engelsen, Unsplash*

WILDFIRE AND CARBON

Developing strategies for wildfire and forest management that minimize climate impact and strengthen BC's bioeconomy.

Reducing wildfire greenhouse gas emissions and increasing the carbon sink of western North America's forests is the goal of the PICS $1M Theme Partnership project, Wildfire and Carbon, launched in January 2020. The four-year project brings together scientists from the University of British Columbia, University of Washington, US Forest Service, and Natural Resources Canada (NRCan).

By combining mitigation and adaptation strategies, Wildfire and Carbon aims to identify and enhance synergies between wildfire risk reduction activities and those that strengthen BC's forest-based-bioeconomy. Key research elements include integrating wildfire, carbon, and forest products models, and developing insights with a transdisciplinary approach. This project aims to deliver strategies to improve forest resilience, reduce wildfire risk and emissions, and create economic opportunities.

During its first year, the project has prioritized building relationships and identifying strategic partnerships, both within the project team and with "solution seekers", the end users of the research. The initial team of four, led by Principal Investigator and NRCan senior research scientist Werner Kurz, has grown to include 15 students, postdocs and researchers, including PICS Researcher-in-Residence Carly Phillips. Externally, the project has also partnered with BC Wildfire Service and Parks Canada.

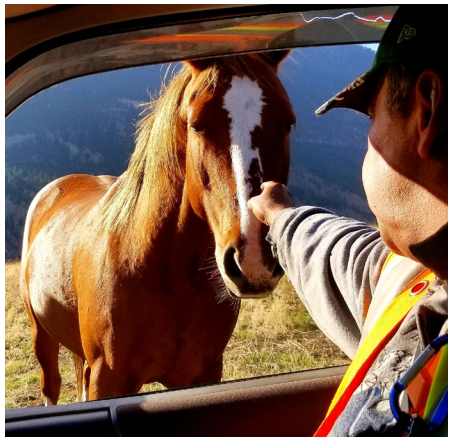
XAXLI'P FIRST NATION: WILDFIRE-FUEL MAPPING

From the air and on the ground, PICS research supports wildfire risk reduction on Xaxli'p First Nation territory

In partnership with the Xaxli'p First Nation, UNBC researchers are supporting landscape restoration planning for wildfire risk reduction in the Fountain Valley (Xaxli'p Survival Territory) near Lillooet BC. Under the supervision of Dr. Scott Green and Dr. Ché Elkin, MSc student Patrick Robinson is using airborne laser scanning (commonly known as LiDAR) to assess vertical and horizontal fuel loading at fine resolution throughout the valley. Increasing abundance of hazardous forest fuels on Xaxli'p land, resulting in large part from institutional legacies of wildfire suppression, prohibition of traditional burning practices, and commercial logging, has contributed towards a high risk of catastrophic wildfire.

In addition to the LiDAR work, there has been forest structure field work to develop a 'ground truthed' empirical dataset. Patrick spent fall 2020 with Xaxli'p First Nation Community Forest staff collecting sample plots. The resulting data are used to adjust the models being used to classify the LiDAR data. This creates accurate and meaningful fuel metrics and maps that will inform on-the-ground restoration work. The field work has improved the understanding of local perspectives on forest management, as well as provided the opportunity to observe and measure the impacts of past management practices.

Student Patrick Robinson using a hypsometer to collect tree height data in the Xaxli'p Survival Territory, near Lillooet, BC. *Image: Robert Bob*



Xaxli'p Community Forest Crew Leader, Robert Bob and friend. *Image: Patrick Robinson*

This project aims to enhance existing forest structure and fuels data provided by the Canadian Forest Service and the BC Wildfire Service, with the goal of informing responsible future forest management.

The two year-project is scheduled for completion in Oct. 2021.

CLIMATE ADAPTIVE PLANNING FOR BC'S PROTECTED AREAS

How can we adapt biodiversity conservation plans in British Columbia to minimize the impacts of a changing climate?

That is the question being answered by this UNBC-led project that started in 2019. Principal Investigator Dr. Oscar Venter is working with PhD student Xavier Corredor Llano, MSc Investigator Karen Dietrich and postdoc Richard Schuster in partnership with Dr. Peter Arcese at UBC, The Nature Trust of BC, the BC Parks Foundation, and the Canadian Parks and Wilderness Society (CPAWS).

The project team is developing a state-of-the-art online, open-access, and user-friendly tool able to support climate-adapted systematic conservation planning across the province. In 2020, they acquired and processed large datasets essential for integrating climate adaptation and landscape conservation planning. These data include current patterns of biodiversity, large intact natural landscapes, ecological processes and the geophysical setting. To anticipate and respond to future conditions, the team also incorporated data on areas likely to provide habitat for species displaced by climate change, existing climate refugia (areas projected to have the most stable climate), and areas that will provide ecological connectivity in a changing climate.

The team has since developed a Beta version of the planning tool, with the goal of supporting conservation planners on both private and public lands across BC. Potential users, beyond the project team, include First Nations land managers designing Indigenous Protected and Conserved Areas, or provincial government staff with BC Parks and the Ministry of Forests, Lands and Natural Resource Operations. Next steps in the project include finalizing the software, developing scenarios in support of partner goals, building additional partnerships with users, and promoting the tool.

TOP: Nature Trust, Currie Ranch Princeton Grasslands, Maple Cross Meadow. *Image: Graham Osborne*

RIGHT: Yellow-headed Blackbird. *Image: Alan Vernon*

UNDERSEA FORESTS

When COVID-19 travel restrictions stopped fieldwork in 2020, BC coastal First Nations partners in the project came to the rescue using new tech innovation.

Summer/fall 2020 was supposed to be packed with fieldwork for researchers with the Undersea Forests project—a research partnership between PICS, SFU, and the Central Coast Indigenous Resource Alliance (CCIRA). Then COVID-19 arrived, and so did restrictions on travel within BC. Planned in-person meetings and data-collection trips by the project scientists to Bella Bella and Klemtu were cancelled.

Fortunately, however, the fieldwork still went ahead. Principal investigator and SFU Prof. Anne Salomon and postdoctoral fellow Danielle Denley, in partnership with CCIRA's four Nations members (Heiltsuk Nation, Kitasoo/Xai'xais Nation, Nuxalk Nation and the Wuikinuxv Nation), provided virtual training for the Nations' Coastal Guardian Watchmen and technical staff who then gathered data and photos of BC's coastal kelp forests to help document the location and timing of any bryozoan outbreaks. The researchers adapted an existing mobile app to host their co-developed Bryozoan and Kelp Monitoring Survey with boxes to be ticked, automated GPS coordinates, and photos to help estimate real-time kelp-bed size, density, bryozoan and grazers. Information was shared through an online survey.

Infestations of these epiphytic marine invertebrate cause giant kelp to sink to the floor and disintegrate, as occurred in BC during a 2015 ocean warming. Kelp forests are vital marine ecosystems and provide cultural, commercial, food, social and ceremonial purposes.

Knowing exactly why, when and where outbreaks of this kelp-encrusting animal occur on Canada's west and east coasts is the first step towards being able to enhance the resilience of the kelp ecosystems—a key goal of this project launched in 2019.

LEFT: Heiltsuk Guardian Watchman Doug Newman holding up giant kelp with "melted" blades, possibly resulting from bryozoan encrustation, during surveys on the Central Coast. *Image: Max Johnson Jr.*
RIGHT: Giant kelp from one of the project study sites in Barkley Sound. *Image: Meredith Fraser*

Seasonal Timing and Peak Cover (%) of White Crust Bryozoan on Kelp Varied by Site in 2020, possibly due to Local Variation in Seawater Temperature and Wave Exposure.

Images: S. Hankewich, D. Newman, and M. Johnson Jr.

THE TRUE SIZE OF BC'S COLUMBIA BASIN GLACIERS

First-of-its-kind research shows that the glaciers that supply the Columbia River with meltwater are 38 percent thicker than previous estimates, but researchers say this won't offer a lifeline against melt due to climate change.

The Columbia River basin produces over 40 per cent of hydroelectricity in the US, with the Canadian portion of the upper basin providing 30 to 40 per cent of total runoff, predominately from snowmelt but also ice. The river is a vital downstream freshwater source and habitat for aquatic ecosystems.

The study—*Bias-corrected estimates of glacier thickness in the Columbia River Basin, Canada*—led by UNBC scientists, was published in the *Journal of Glaciology* in September 2020.

The researchers calculated the glaciers' true size by using ice-penetrating radar, towed by skis, to measure ice thickness over five glaciers (the Conrad, Kokanee, Zillmer, Illecillewaet, and Nordic) in BC's Columbia Mountains from 2015 to 2018. They then combined that data with two previous surveys for two glaciers (the West Washmawapta and the Haig) in the Rocky Mountains.

> *"At current rates of glacier mass loss for this region, our study shows that glaciers will disappear from the basin in about 65 to 80 years. Ice thickness measurements should be made for other glaciers such as BC's Coast Mountains, in order to improve models of glacier retreat and disappearance and their streamflow projections for regional and global purposes, including hydropower planning and downstream fish and aquatic ecosystem studies."*
>
> Ben Pelto, Lead Author of the study.

TOP LEFT: Conrad Glacier and the Bugaboo Spires. *Image: Ben Pelto* TOP RIGHT: PICS' announcement about this UNBC-led research captured the attention of journalists in North America and Europe, including CBC meteorologist Johanna Wagstaffe. ABOVE: Ben Pelto (left) and friend taking measurements while towing the radar on the Conrad Glacier. Ice thickness here was around 200 m. *Image: Jill Pelto*

After analyzing more than 34,000 data-points measured over 182 kilometres, researchers calculated that glacier thickness is, on average, 38 per cent thicker than previous computer model estimates. Also, that the ice volume for the Upper Columbia Basin is approximately 122 cubic kilometres, equivalent to roughly five times the volume of Okanagan Lake—23 percent greater than the range of previous estimates.

Ben Pelto, who successfully defended his PhD dissertation in October under the supervision of Prof. Brian Menounos, is the lead author.

He says some glacial ice at high elevations may exist years or even a couple of decades longer than anticipated, but unfortunately their large size is no lifeline. He says this aligns with evidence from separate studies showing that the basin's glaciers will lose 60 to 100 percent of their ice by 2100, depending on greenhouse gas emissions.

This UNBC research was supported by PICS, the Columbia Basin Trust, Natural Sciences and Engineering Research Council of Canada, Tula Foundation, BC Hydro, and other agencies.

Negative Emissions

Advancing technology to capture and sequester atmospheric carbon dioxide.

SOLID CARBON: NEGATIVE EMISSIONS TECHNOLOGY

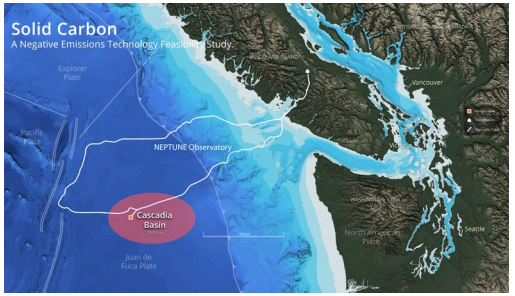
The international team behind Solid Carbon aims to design and deliver a reliable and scalable offshore negative emissions technology by 2040 to help global society achieve a net-zero emissions future.

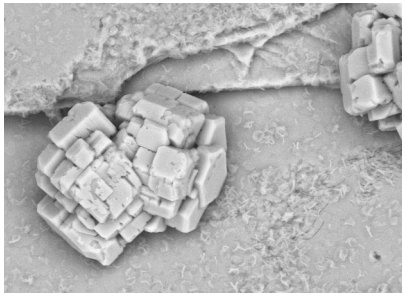
Solid Carbon has been expanding its expert capacity during 2020 with new hires, research advancements and increased collaborative outreach, while chalking up its one-year anniversary in October.

This feasibility study led by Ocean Networks Canada (ONC), a University of Victoria initiative, unites "solution seekers" and industry with an international team of researchers from Canada, the US and Europe. The vision is to extract carbon dioxide from the atmosphere, and inject it into sub-seafloor basalt reservoirs, where over time it will mineralize into rock.

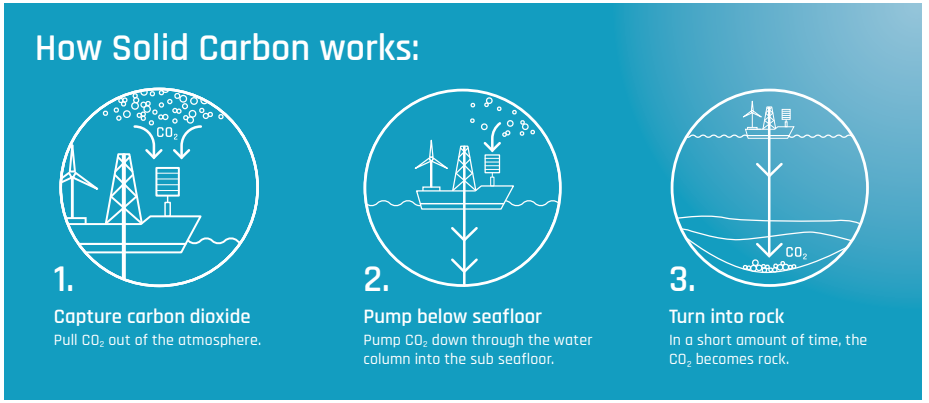
The project combines direct air capture, offshore drilling, and wind energy technologies as well as floating platform design. It is also exploring social and investor acceptance, and gaps in current legal frameworks for offshore carbon capture and storage (CCS) in Canada. A paper on the latter was produced in 2020 by project partners at the Columbia Law School Sabin Center for Climate Change Law.

The project leaders have brought onboard graduate students and postdocs spanning engineering, natural and social sciences, law and business. Joining the team in 2020 has been PICS Researcher-in-Residence Devin Todd, and the first of a series of student cohorts from the UVic MBA in Sustainable Innovation exploring NET business feasibility.





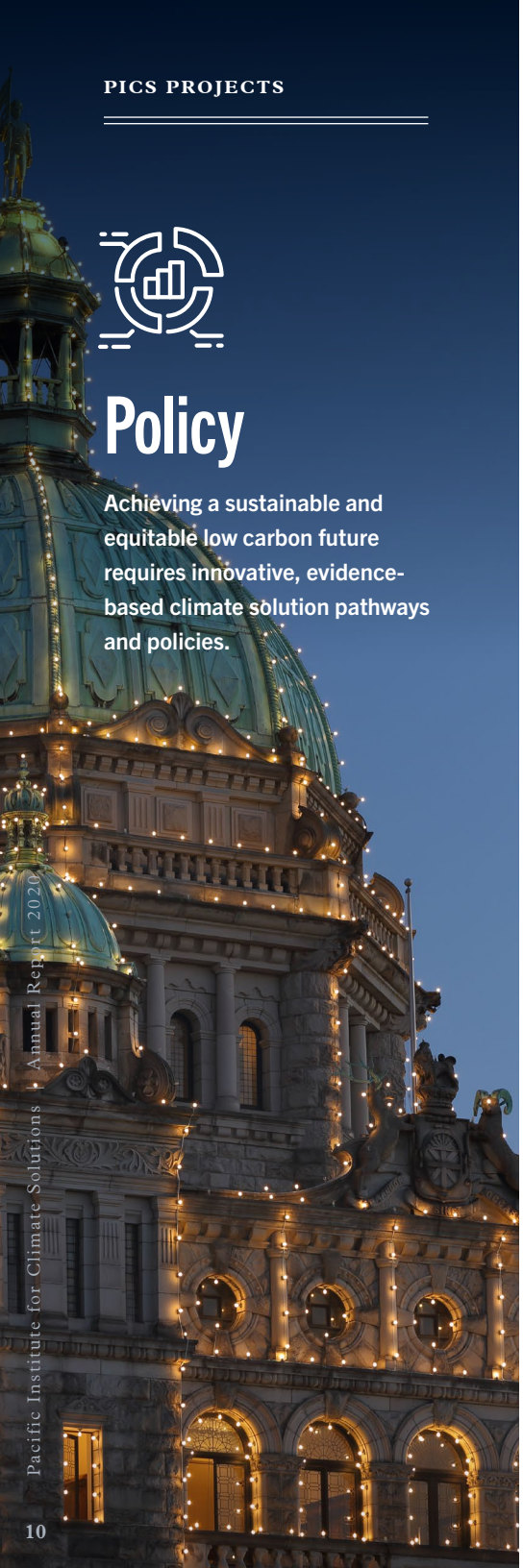
ABOVE: Planned location for testing Solid Carbon in the Cascadia Basin. *Image: ONC*
FAR LEFT and RIGHT: Lab experiments, conducted in 2020 by the University of Calgary's Reactive Transport Group for the Solid Carbon project, show a magnesite crystal growing on a grain of labradorite in a high CO2 (450 mmol/kg) seawater experiment. This shows how CO2 injected into basalt can be converted from a gas into a mineral form (mineral carbonation). *Image: John Byng*



Early research outcomes were showcased at the virtual *GeoConvention 2020*, the American *Geophysical Union Fall 2020* meeting, and the 2020 *American Association for the Advancement of Science*. Popular media highlights include radio interviews, news blogs, and a podcast.

2020 has seen increased emphasis on carbon management policy by Canadian federal and provincial governments. Internationally, Canada has joined 13 other countries in an Ocean Panel with sustainability goals that include advancing CCS in the sub-seabed and mapping the storage potential of sub-seabed geological formations.

Together, these have buoyed Solid Carbon's outreach with government, NGOs, and private sector stakeholders as the team, led by ONC President and CEO Kate Moran, seeks to build capacity for field testing Solid Carbon in the Cascadia Basin node of ONC's NEPTUNE Observatory.



Policy

Achieving a sustainable and equitable low carbon future requires innovative, evidence-based climate solution pathways and policies.

SFU-UBC FAST TRACK PROJECT | DURATION: FIVE MONTHS

ALIGNING COVID RECOVERY WITH LOCAL GOVERNMENT CLIMATE ACTION

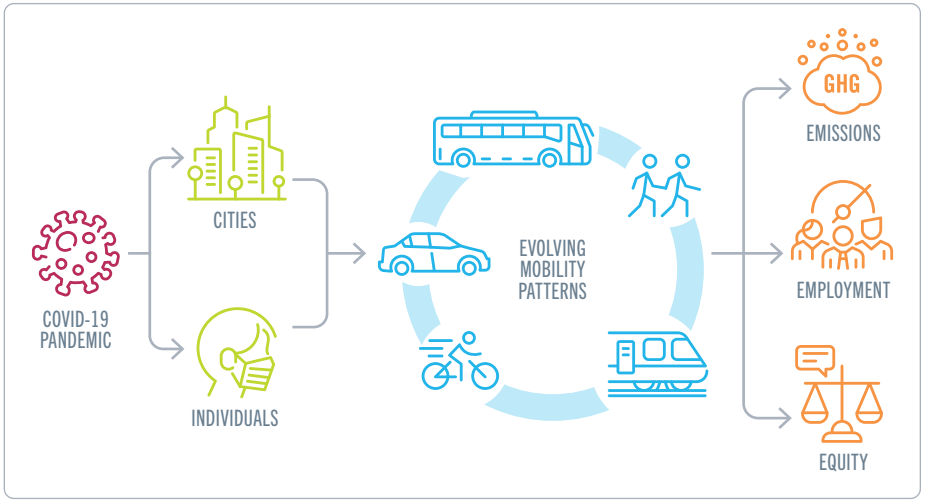
Recognizing the pandemic recovery as an opportunity, PICS partnered with the Community Energy Association (CEA) to identify priority actions for communities to create jobs, reduce GHGs and enhance equity.

The CEA had already established a successful Climate Leaders Playbook for local governments across BC, highlighting big moves in transportation, buildings and waste for major emissions reductions. The PICS-supported project will produce a COVID-19 supplement to the Playbook, recommending actions that can be scaled up in large and small communities.

To do this work, PICS and CEA engaged two research teams. A team from SFU, led by Prof. Anthony Perl and master's student Leandro Corrêa, tackled public transit, distilling lessons from cities in New Zealand and the US. Where transit authorities quickly restored levels of service and introduced free fares, ridership substantially rebounded. Local governments can play an important supporting role in communicating the low risk of infection on transit.

A team from the UBC Collaborative for Landscape Planning (CALP), led by Professor Stephen Sheppard and Research Scientist Angela Han, is focusing on reducing emissions in existing buildings and shifting behaviour around waste. Drawing from examples around BC and beyond, they emphasize the need for backbone organizations to coordinate and enhance hyper-local climate action at the scale of the block or neighbourhood.

PICS and CEA are working together to package the results of these projects to cater to the needs of diverse communities around BC.



The COVID-19 pandemic has influenced cities and individuals in their evolving mobility patterns and choices. This evolution in terms of travel behaviour may be reflected in terms of GHG emissions, employment, and equity. *Image: Adapted from an infographic in Correa, L. S. & Perl, A. Aligning COVID Recovery with Local Government Climate Action: Zero-Emission challenges in Urban Mobility Future After COVID-19*

A screenshot from the The Climate Leaders Playbook: Solutions for a Zero Carbon Community.

Downtown Victoria, British Columbia. *Image: Armon Arani, Unsplash*

CLIMATE MITIGATION AND ADAPTATION SOLUTIONS FOR MUNICIPALITIES

Municipalities are at the forefront of the fight against climate change, but often lack the tools and evidence to make effective policy decisions. This project addresses that gap.

Providing municipalities with the tools they need to make better climate mitigation and adaptation choices is the focus of this PICS research partnership involving the City of Victoria and UVic that started in April 2020. The city has set ambitious targets in its Climate Leadership Plan, including an 80 percent reduction in GHG emissions by 2050. A key question this project, led by UVic Assistant Prof. Ralph Evins, is helping to answer is: what are the best ways for the city to achieve these targets – in terms of buildings, transportation, and energy - while also considering alternatives and trade-offs?

In 2020 project partners met with transportation planners and experts to share and gather data relevant to the project. They also met with land use planners to explore potential levers for future management of climate mitigation and adaptation goals, such as zoning or bus rerouting.

By the end of its three-year term, this project will have co-developed a framework that city officials can not only use to make decisions more efficiently, but also ensure these are evidence-based and in-line with public consultation and communication objectives.

CLIMATE CHANGE DISPLACEMENT: MAPPING THE BC CONTEXT

Helping British Columbia prepare for the movement of people due to climate change.

In July 2019, the Centre for Global Studies at the University of Victoria partnered with the Climate Migrants and Refugees Project to better understand and foster partnerships around climate change displacement in British Columbia. During its 11-month term, project partners were able to develop a better understanding of the context of climate displacement into and within BC as well as the many organizations whose work is relevant to this topic. Partners identified future research priorities and shared lessons with their international counterparts. This project, led by UVic Prof. Oliver Schmidtke with support of PhD candidate Nicole Bates-Eamer, has improved awareness and capacity for the integration of climate change displacement considerations into future policy and programming in BC and beyond. The project will be releasing a report on its work in 2021.

Extreme weather events such as major flooding, wildfires, and record heat are becoming more frequent due to climate change, affecting Canadians and their homes. *Image: iStock*

VANCOUVER ISLAND AND COASTAL COMMUNITIES CLIMATE PLAN

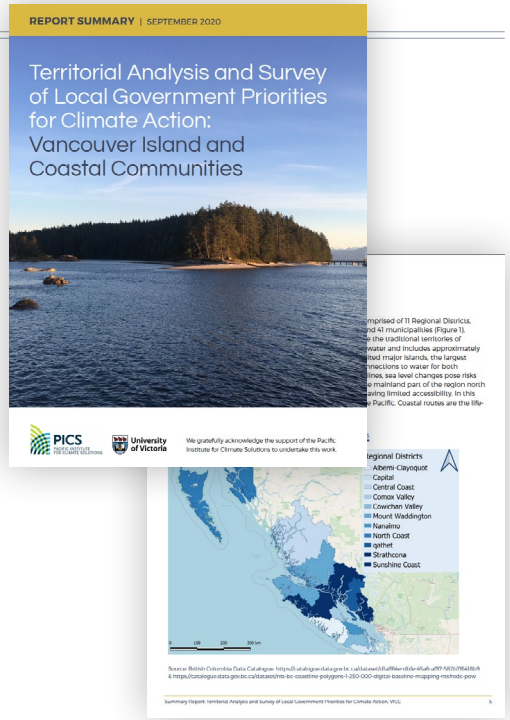
PICS-backed research is supporting the creation of a unified climate action plan for Vancouver Island and coastal communities.

Seeking to galvanize regional climate planning, in 2019, three Vancouver Island mayors, Lisa Helps (Victoria), Michelle Staples (Duncan), and Josie Osborne (Tofino) convened a Vancouver Island and Coastal Communities Climate Leadership Plan Steering Committee.

The committee consisted of representatives from each of the island's regional districts and the Sunshine Coast as well as researchers from the University of Victoria. As an ad hoc committee, they were under-resourced and the UVic researchers (Drs. Tamara Krawchenko, Katya Rhodes, Kara Shaw, Astrid Brousselle, and Tara Ney) saw an opportunity for PICS funding to have an impact.

Ultimately, PICS supported two aspects of the project: First, a research component, funding master's student Katherine Pearce and undergraduate Kimberly Harrison to conduct a territorial analysis and survey of regional priorities under the supervision of the UVic research team. A Highlights Report and the Full Report of the "Territorial Analysis and Survey of Local Government Priorities for Climate Action: Vancouver Island and Coastal Communities", were released in October 2020.

Second, PICS supported an intern (Catriona Mallows) based at the City of Victoria to prepare for and convene a Community Resilience Summit held on November 6, 2020; from which more than 150 elected officials and staff members from across the region developed shared climate action goals. The group determined that a social justice and equity lens must be placed on all climate change decision-making, using the draft goals to support consultation with youth and First Nations. Other goals span food security, the circular economy, infrastructure resilience and building retrofits.



LEFT: An image from the report, Russell Road washed out by flooding, Sunshine Coast in 2019. *Image: Donna McMahon* RIGHT: An aerial view of the Sunshine Coast

Built Environment

Transforming our cities and towns into energy efficient communities with net-zero emissions and climate resilient infrastructure and land-use planning.

ADAPTIVE MITIGATION: ASSESSING CLIMATE CHANGE SOLUTIONS IN URBAN MULTIFAMILY BUILDINGS

The project's new IBAMA tools are being piloted on affordable housing and other projects throughout 2021.

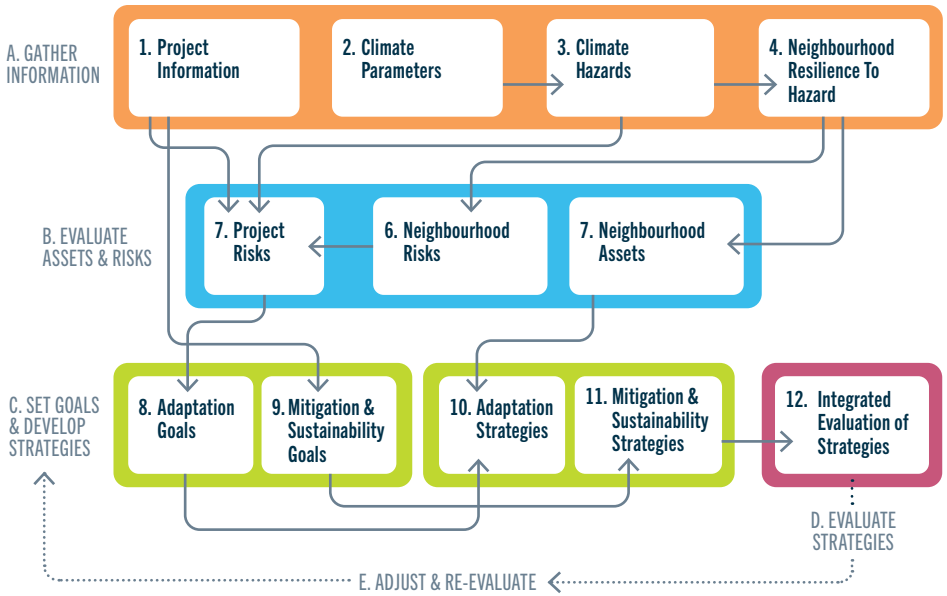
In partnership with BC Housing, this University of British Columbia-led project has completed its investigation into how green building and climate adaptation approaches can be effectively integrated into the design, construction and operations of multi-unit residential buildings (MURBs).

The Integrated Building Adaptation and Mitigation Assessment (IBAMA) framework and tools are now publicly available on the PICS website, and are being piloted on affordable housing and other projects. The tools were developed in recognition of the challenges that practitioners face when trying to ensure residential buildings are future-ready for the changing climate. Buildings and their occupants face increasing climate hazards such as extreme heat, drought, wildfires, poor air quality, flooding and power outages while also targeting greater energy efficiency and GHG emissions reductions.

Ilana Judah, lead researcher at UBC under Prof. Stephanie Chang, says adaptation initiatives have mainly been developed separately from, or as add-ons to, green building systems. She says unifying the two approaches can help identify solutions that benefit both environmental performance and climate adaptation, while minimizing those that create conflicts between the two paradigms.

The IBAMA framework has been shared at several industry events in 2020 such as the *Adaptation Canada 2020* conference, Pembina's *Reframed Tech Series*, and the *Understanding Risk BC 2020* symposium. Presentations were also given to industry stakeholders at BC Housing and the Ministry of Environment and Climate Change.

Fort St. John Passive House by Low Hammond Rowe Architects. *Image: Silentsama*



The long-term goal is that the IBAMA framework will influence future building codes, standards, and construction best practices in BC, Canada and abroad. The IBAMA Primer, an IBAMA Reference Guide, and IBAMA Excel Tool are now available for use on the PICS website.

> *"The process and tools developed in this research will help building developers, owners and managers concerned about the durability and value of their assets, the safety of occupants, and the sustainability of their projects; policy-makers focusing on climate solutions; and building industry professionals seeking tools to help them translate complex climate issues into appropriate design solutions"*
>
> Ilana Judah,
> Architect and UBC Project Lead Researcher

"This project integrates and respects the importance of Indigenous knowledge and stewardship values in guiding creative and effective solutions to coastal adaptation."

Sarah Dal Santo,
Natural Resources Planning Manager at Tsleil-Waututh Nation &
Kathleen Edwards,
Environmental Manager at Squamish Nation (Skwxwú7mesh).

COASTAL ADAPTATION: LIVING WITH WATER

Preparing for climate change and sea level rise on BC's South Coast

A major research project to help communities on British Columbia's South Coast prepare and adapt for sea level rise and flooding was announced by PICS in mid-December 2020. It is the third $1 million project to be funded under the PICS Theme.

The four-year Living with Water project is led by researchers at UBC in partnership with SFU, University of Waterloo, Wageningen University in the Netherlands and West Coast Environmental Law. The "solution seeker" partners in the project include the City of Surrey, City of Vancouver, District of Squamish, Squamish Nation (Skwxwú7mesh), Tsleil-Waututh Nation, and the BC government.

Currently no authority has the jurisdiction (federal, provincial, municipal or territorial) to implement a regional coastal flood adaptation plan for BC's South Coast, which includes the Fraser River Delta, Burrard Inlet and Squamish Delta. Instead, the responsibility for flood-risk management lies with municipalities and First Nations, who face resourcing and legislative barriers to planning beyond their own boundaries.

Dr. Kees Lokman, principle investigator of the PICS Living with Water project.

With the scale and frequency of coastal flooding projected to increase due to climate change, this project aims to support the integrated approach needed to ensure the best societal, environmental and economic outcomes—Vancouver alone has as much as $19 billion in property values in its flood plain.

Living with Water will develop new planning, design, and decision-making tools to strengthen the three key areas shown below:

1.

Integration of community values and Indigenous knowledge and perspectives.

2.

Broadening the solutions toolkit to consider alternative cutting-edge solutions (e.g. nature-based, managed retreat, multi-functional dikes) as well as the more traditional hard infrastructures (dikes and seawalls).

3.

Addressing governance challenges (legislation, bylaws, policies, regulations and strategies).

LEFT: 3D simulation of energy and emission reducing growth through infill in a BC community. *Image: elementslab*

ENERGY EFFICIENCY IN THE BUILT ENVIRONMENT

Developing solutions that reduce energy demand and emission in BC's cities and towns while improving the quality of life for residents.

The PICS Energy Efficiency in the Built Environment project has capped off its sixth and final full year with the release of two studies in 2020 that show ways that cities can leverage different technologies and urban planning strategies to reduce their greenhouse gas (GHG) emissions, and meet climate targets.

Aiming to test proposed local emissions reductions approaches, the UBC elementslab developed a "spatial sandbox" to evaluate built environment policy for the whole range of community types across BC from small to large, cold to mild, and high growth to low growth. The researchers engaged with city staff in Victoria and Prince George to determine the most useful neighbourhood case studies to test out combinations of urban development, retrofit and transportation policies.

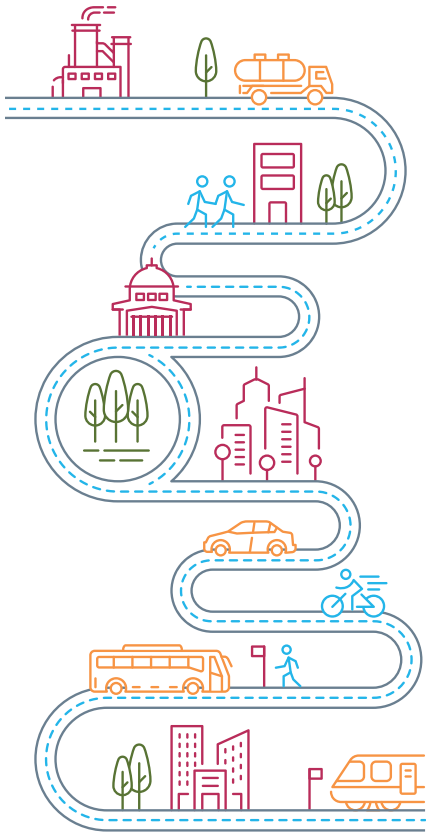
> *"The City of Victoria is committed to creating compact, complete, low carbon communities. This valuable work with the UBC elementslab allowed us to test out different scenarios for reaching our goal through identifying the necessary emissions reduction policies for buildings, transportation, and land use planning."*
>
> Robyn Webb,
> Community Energy Specialist, City of Victoria

The studies in both of those cities have been revealing. Even though those cities are in very different climates and have different growth patterns and pressures, in both cases, deep retrofits including both the shell and building technology had by far the biggest impact. This means that simple measures such as upgrading insulation and fuel switching (from oil and gas to heat pumps) could be very effective across the province.

In addition, the team found that both corridor and neighbourhood centre approaches to densification led to moderate emissions reductions over dispersed development. This suggests that where cities are growing, they should commit to some form of targeted densification strategy, to both reduce emissions and improve livability, in line with best planning practices.

What is the Built Environment?

The built environment is a complex intertwined multi-scale system of cities, towns and neighbourhoods whose energy performance and emissions are shaped by factors such as land use, building design, transportation and utility infrastructure and the behaviour of its inhabitants. In BC, 55 per cent of all GHG emissions originate in the built environment.



Energy

Embracing an energy revolution: accelerating the shift from a fossil fuel-based economy to a decarbonized energy future.

LEFT: West Village Park and Energy Centre, Surrey. *Image: jaredkorb.com*
ABOVE: The City of Surrey pipe network expansion project. *Image: City of Surrey.*

MOBILE THERMAL ENERGY STORAGE: USING WASTE HEAT TO POWER COMMUNITIES

In collaboration with the City of Surrey and Canmet ENERGY, this SFU-led project aims to develop a mobile thermal energy storage (M-TES) prototype that will enable the transmission and use of waste heat from industries such as data centres, large scale refrigeration, chemical, pulp and paper, bioenergy, lime and cement.

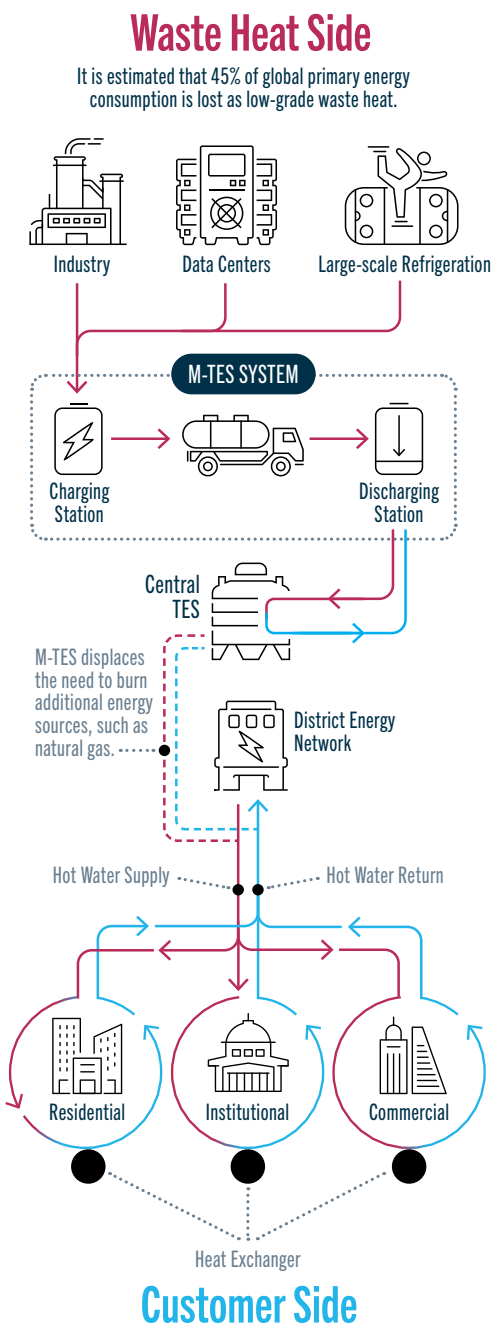
The heart of M-TES is a thermochemical liquid sorption system proposed and designed by the project team. The goal is to deliver industrial waste heat to the City of Surrey's district energy network (DEN), which already supplies space and water heating to many buildings ranging in size from 12 to 50-plus storeys. There, the thermal energy would be released and distributed, displacing a substantial portion of the network's natural gas consumption and the associated greenhouse gas (GHG) emissions.

The energy storage density of the thermo-chemical solution is key to the feasibility of the system. The researchers, led by Dr. Majid Bahrami's team at SFU's Laboratory for Alternative Energy Conversion, has several promising candidates, with potential to store energy up to ten times the density of hot water.

Furthermore, an initial techno-economic analysis has found M-TES systems are cost competitive with common low-carbon energy sources such as biomass, renewable natural gas, and sewer heat recovery when the waste heat source is within 30 kilometers of the DEN.

Based on the Surrey district energy network's thermal energy needs in 2022, as few as six trucks making six trips a day could supply a baseload of 40 per cent of its peak space and water heating needs, according to a recent analysis published in the journal, *Applied Sciences*.

This three-year project was launched in September, 2019



Transportation

Reimagining travel pathways and supporting clean-tech solutions for vehicles, vessels and aircraft.

COULD BC'S PULP AND PAPER MILLS PRODUCE HYDROGEN?

Hydrogen Generation in BC's Pulp and Paper Sector: An Opportunity to Diversify our Energy and Transportation Systems.

A PICS-supported pre-feasibility study into the potential economic - and climate - benefits of BC pulp and paper mills incorporating hydrogen production (via electrolysis) into their operations was released in December 2020.

> *"This type of green hydrogen innovation could support the increased production of renewable gas and provide carbon-free fuel, while also helping the forestry industry diversify and compete."*
>
> Sybil Seitzinger, PICS Executive Director

Hydrogen is fast gaining traction among industry and policymakers nationally and internationally as a zero-emissions transport fuel and energy source.

The study, carried out by Zen Clean Energy Solutions on behalf of the BC Bioenergy Network (BCBN) and in partnership with Fortis BC, PICS and the BC Pulp & Paper Bio-Alliance, was published just ahead of the release of the federal government's Hydrogen Strategy for Canada.

The premise for the BCBN study is for pulp mills to incorporate electrolysis into their operations using renewable electricity to split water into hydrogen and oxygen. It investigated multiple end-use applications for hydrogen, including sale to the transportation and industrial gas markets, internal use at the mill and blending with the natural gas network.

The study determined that mills could be ideal sites for hydrogen production as they have access to significant energy infrastructure with concentrated demand for gaseous heating fuel and oxygen. A lighthouse project that demonstrates the advantages of integrating an industrial site such as a pulp mill with hydrogen production could help launch the renewable hydrogen economy in B.C.

> *"Pulp mills could support the new emerging energy landscape and provide a key building block for future investment in hydrogen solutions across BC."*
>
> Bob Lindstrom,
> Manager of the BC Pulp & Paper Bio-Alliance

The study also recognized that electrolyzer projects require large up-front capital investments, generate lengthy returns on investment, and require low-cost power to drive stable long-term demand for the hydrogen gas. Recognizing these hurdles to implementation reveals the necessity for a more in-depth economic analysis.

The pre-feasibility report and presentation are available on the PICS website.

Pulp and Paper Mill. *Image: iStock*

STUDENT ENGAGEMENT PROGRAM

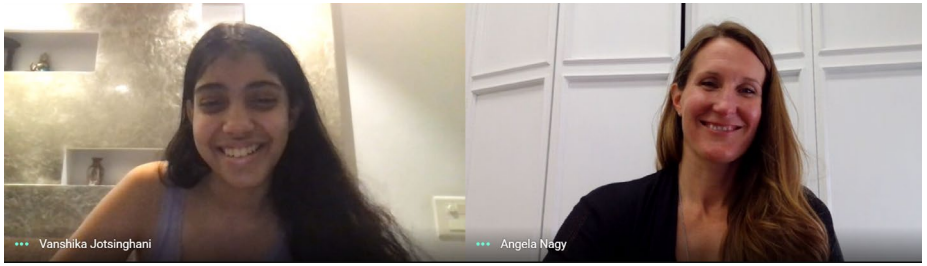
Our Student Engagement Program aims to enrich students' experience as members of the PICS community. We offer career connections, mentorship, knowledge mobilization, and support to help students better communicate, collaborate and share their research.

PICS INTERNSHIPS 2020

PICS interns continued to advance the climate action programs of our solution seeker partners throughout 2020 despite the challenges of the pandemic.

Ten internships were awarded, each receiving 12,000 dollars in support from PICS. Among the highlights:

Does your organisation want to play its part in combatting climate change but doesn't know where to start? A "how-to" guide to assist industry and professional associations mitigate and adapt to climate change was produced by PICS intern **Brennan Strandberg-Salmon**, an SFU undergraduate student working with the British Columbia Council for International Cooperation (BCCIA). This guide contains barrier-busting strategies, a business case and roadmap to make your association future-fit for climate change. There has been widespread uptake of the report, plus endorsements by the Canadian Institute of Planners and the Fisheries Council of Canada, and the Canadian Society of Association Executives.



PICS UBC intern Vanshika Jotsinghani in Bombay meets with Angela Nagy from Greenstep.

Working all the way from Bombay, **Vanshika Jotsinghani**, a UBC undergrad majoring in International Economics, supported the EcoFund program led by GreenStep, analyzing data and measuring the impacts of energy efficiency measures on hotels' energy costs and carbon footprints.

Catriona Mallows, a UVic graduate student, worked with the Vancouver Island and coastal communities to help organize the Community Resilience Summit in November, 2020, which is helping to shape the Vancouver Island and Coastal Communities Climate Leadership Plan.

> *"We are very grateful both to Catriona and to the PICS Internship Program. The internship allowed us to pursue a collaborative process that—while still ongoing—is already having important impacts on climate action in the region. This is exactly the kind of rapid, effective climate action that we need at this moment, and it is fantastic that PICS is able to offer this support to help it happen".*
>
> Mayor Lisa Helps, City of Victoria

Modelling forest carbon sequestration in the capital region from 2007-2019 to quantify the magnitude of forests as a carbon sink or source was the main task undertaken by **Katie Fisher**, SFU graduate student and PICS Intern with the Capital Regional District (CRD).

> *"The Capital Regional District was fortunate to have access to a student internship to help us better understand the roles forests play in sequestering carbon across the capital region, threats and opportunities".*
>
> Nikki Elliott, CRD Climate Action Program Coordinator & PICS Intern Supervisor

The awarded recipients were: BCCIA, Capital Regional District, City of Victoria, City of Kelowna, Climate Action Secretariat, Cowichan Estuary Restoration and Conservation Association, Engineers and Geoscientists BC, Galiano Conservancy Association, GreenStep Solutions Inc. and the Northern Health Authority, Population and Public Health Support Unit.

To date PICS has funded 128 internship positions worth more than 1.35 Million. PICS SFU Program Manager Nastenka Calle manages the PICS Internship Program.

STUDENT FORUM

Shifting to a virtual format for the PICS Student Forum 2020 proved no barrier to participation with 46 people registering to attend the event held on October 15 and 16.

This annual event, which is part of PICS Student Engagement Program, provides career-building skills and well as the opportunity for PICS Scholars to collaborate and network among academic peers across our four partner universities – UVic, UBC, SFU and UNBC.

Some of the participants in the first virtual PICS Student Forum.

With a theme of Engaged Research for Climate Solutions, the first day focussed on strengthening research partnerships with "solution seekers." A skills-building workshop hosted by facilitator Susanna Haas Lyons explored the motivations—and barriers—for different stakeholders to engage in co-developed research. Day two highlighted current research advances via a series of lightning talks by scholars, now available on the PICS website.

SFU'S LIVING LAB

Simon Fraser University is transforming its three campuses into a testing ground for sustainable solutions through its Living Lab program launched in fall 2020. This new initiative—supported by PICS SFU Program Manager Nastenka Calle who also serves on its advisory committee—applies the university's sustainability and climate research to its own infrastructure and facilities.

Since the launch, the Living Lab has announced its first pilot projects to reduce GHG emissions. The projects, led by teams of graduate students, faculty and staff, will focus on four areas: renewable energy technology, bioplastic alternatives, electrifying vehicle fleets and the carbon impact of streaming media.

PICS is proud to sponsor one of the pilot projects, the **Life Cycle Assessment (LCA) Analysis for SFU Fleet Electrification**. With a goal of reducing vehicle emissions and improving air quality, School of Sustainable Energy Engineering (SEE) graduate student and

PICS Scholar Kamaria Kuling eyeing up a clean, and healthy, energy future for SFU.

PICS Scholar **Kamaria Kuling** will investigate the benefits and challenges of replacing SFU's operational vehicle fleet with low or zero emission vehicles such as electric vehicles, hybrid electric vehicles and hydrogen fuel cell vehicles. The research team includes SFU Assistant Professor Taco Niet, and David Agosti, Director of SFU Parking and Sustainable Mobility. The research team will use the Fleet LCA tool (developed by SFU Associate Professor Erik Kjeang and postdocs/students). The LCA tool has been use in other case studies and a briefing note that were supported by PICS.

The Living Lab is an integral component of the SFU's 2025 Sustainability Plan which prioritizes Climate Action. The lab's findings will be shared with local and global communities.

NEW IN 2020: CLIMATE SOLUTIONS TOOLKIT

Students asked and we listened! Following the feedback from the PICS 2019 UVic Student Survey, the PICS at UVic program developed and launched the **Climate Solutions Toolkit**, an online community resource filled with climate solutions information and assets for, and at, the University of Victoria. With support from the PICS-supported **Climate Solutions Navigator** initiative, the toolkit has identified the wide-ranging research expertise and courses available on both climate solutions and sustainability across all faculties at UVic and is being updated as more information is available. Visit the **PICS website** or contact PICS UVic Program Manager Kristy Faccer to find out more.

1

PICS EVENTS IN 2020

Advancing climate change solutions — PICS events build knowledge networks and inspire innovation.

Our Event Partnership Program supports climate solution-focused events of all kinds, from seminars and meetings to workshops and conference sessions.

In line with COVID-19 safety protocols, in spring 2020 PICS cancelled all in-person events, and where possible, recalibrated for an online format.

Here is a snapshot of the events PICS led or co-hosted in 2020.

CLIMATE LITERACY 101, SFU

The virtual 'lunch and learn' series, *Climate Literacy 101: On a Path to Climate Success*, was held online on May 27, June 3 and June 10, offering the opportunity to directly engage with leading climate science and policy experts at SFU. The first session on 'The State of the Climate' was led by Dr. Kirsten Zickfeld who explained the science behind climate change, while the second session, 'From Myths to Effective Climate Action', led by Dr. Mark Jaccard, explored effective climate action pathways. The third session focussed on climate action initiatives underway at SFU. See the recordings on the PICS event archive. The event was hosted in partnership with Embark Sustainability, a student-run group at SFU.

DATA-DRIVEN DECISION-MAKING: VICTORIA FORUM

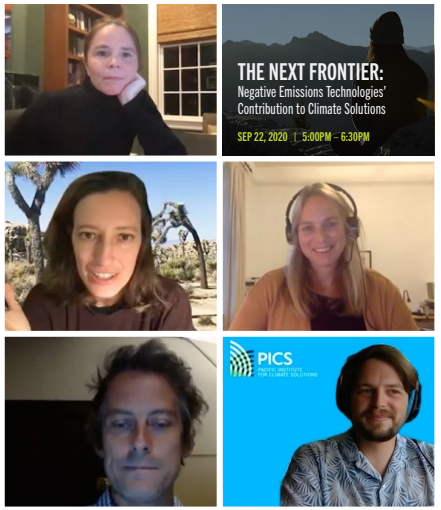
How can lessons from the current pandemic be applied to other wicked problems such as climate change? This question and others related to the interconnectedness of risk and how the pandemic sheds light on the role of science in health and climate change were explored in the PICS-supported webinar, *Data-Driven Decision-Making: Truth & Trust in Science*, held at the Victoria Forum on August 6, 2020. Panelists in the discussion were Mark Campanale, founder of Carbon Tracker UK; Diane Finegood, Professor, SFU; Thomas Homer-Dixon, Director at Cascade Institute; and Ivan Semeniuk, science journalist with The Globe and Mail). The event was moderated by PICS UVic Program Manager Kristy Faccer.

THE NEXT FRONTIER: NETS CONTRIBUTION TO CLIMATE SOLUTIONS

Curious about the emerging field of Negative Emissions Technologies (NETs)? Visit the PICS website to watch our NETs panel discussion featuring climate experts and innovators from Canada and the United States, held on September 22, 2020.

NETs are systems that remove and permanently sequester carbon dioxide from the atmosphere, and they are an essential tool for offsetting otherwise hard-to-decarbonize sectors. Furthermore, all pathways to limit warming to 1.5°C require the input of NETs.

With backgrounds spanning the sciences, engineering, policy and implementation, the panel tackled carbon budgets and the role of NETs, alongside their feasibility, risks and potential benefits. The panelists were Holly Jean Buck, Assistant Professor at the University at Buffalo; Christopher Neidl, co-founder of OpenAir; Jennifer Wilcox, Professor at the University of Pennsylvania and Senior Fellow at the World Resources Institute; and SFU Professor Kirsten Zickfeld. The event host was Devin Todd, PICS Researcher-in-Residence, NETS.



NET Event Panelists

CULTIVATING RESILIENCE IN THE FACE OF THE CLIMATE CRISIS, UBC

Combining insights from psychology, sociology, social movements, mindfulness, and the environmental humanities, author Sarah Jaquette Ray offered an "existential tool kit" for the climate generation, in this popular webinar co-presented by the UBC Sustainability Initiative, PICS and Thrive UBC on November 5. 2020. Dr. Ray teaches environmental studies at Humboldt State University in Arcata, California, and is author of *The Ecological Other: Environmental Exclusion in American Culture.*

PICS STRENGTHENING WORKSHOPS

Strengthening workshops, an offering under the PICS Research Engagement Program, aim to expand the scope and impact of select Theme Partnership preproposals, before applicants submit a full proposal. The workshops bring together PICS staff, researchers and solution seeking partners to refine and strengthen project goals, objectives and intended outputs. Two strengthening workshops for two proposals were held (virtually) in 2020, with the Living with Water project securing the $1 million award.

OUR PEOPLE

Meet the PICS staff who are the driving force behind PICS' vision, program delivery, and the building of an expert climate change solutions community.

PICS HQ

Sybil Seitzinger
Executive Director

Hannah Teicher
Researcher-in-Residence
Built Environment

Devin Todd
Researcher-in-Residence
Negative Emissions
Technologies

Kristina Wallace
Administrative Coordinator

Bentley Allan
Associate Director

Carly Phillips
Researcher-in-Residence
Wildfire and Carbon

Robyn Meyer
Senior Communications
Officer

PICS SATELITTE OFFICES

Nastenka Calle Delgado
Program Manager,
Simon Fraser University

Sara Muir Owen
Program Manager,
University of British
Columbia

Kristy Faccer
Program Manager,
University of Victoria

Michelle Connolly
Program Manager,
University of Northern
British Columbia

PICS continued to broaden its in-house expertise, welcoming four new specialist staff members in 2020:

Bentley Allan, the new Associate Director, joined in July from his previous position as Associate Professor of Political Science at Johns Hopkins University, bringing research expertise in global environmental politics.

Carly Phillips, PICS Researcher-in-Residence Wildfire and Carbon arrived from the Union of Concerned Scientists and Woods Hole Research Center in June, armed with a resume in ecosystem ecology, biogeochemistry and carbon cycling. Her PICS *Vancouver Sun Op-Ed* published in fall has led to an invitation to speak at *TEDxBearCreekPark* in 2021.

Devin Todd joined PICS in March as a Researcher-in-Residence Negative Emissions Technologies and team member of Solid Carbon. Previously he worked with start-ups and investors to advance their cleantech projects.

Kristina Wallace, moved from her job with the BC government to join PICS in spring 2020 in the multifaceted role of Administrative Coordinator.

In 2020, PICS welcomed back **Michelle Connolly**, Program Manager UNBC, from a one-year leave working with the BC Assembly of First Nations. And congratulations to **Sybil Seitzinger**, PICS Executive Director, for receiving the ASLO's A.C. Redfield Lifetime Achievement Award in 2020.

The entire PICS team hopes to reconnect in-person in 2021, but in the meantime will continue to push the limits of creativity with Zoom backgrounds and silly hats.

Department of Gratitude: thanking friends who left PICS in 2020.

Ged McLean – Associate Director - a driving force behind delivering the new PICS strategic collaborative research agenda including the launch of the Opportunity Projects and $1M Theme Partnership Program. His plans to sail around the Arctic scuttled by travel bans, Ged is immersed in new projects in the capital.

Nancy Chan – Executive Assistant – now retired, UVic was fortunate to have her skills and dedicated service (as well as kindness and sense of humour) for almost 40 years, including seven years at PICS.

Heather Mitchell and **Savannah Boreland**– respectively, temporary UNBC PICS Program Manager and Casual Coordinator, representing UNBC for PICS during Michelle Connolly's year away. We thank you.

2020 BY THE NUMBERS

A snap shot of our 2020 investments in research, people, results and outreach.

INCREASING KNOWLEDGE, ENGAGEMENT, AND IMPACT IN 2020

209 No. of People Directly Contributing to PICS Projects (including Researchers, Solutions Seekers, and other Stakeholders)

38 No. of Faculty Awarded Funding

25 No. of Solution Seekers (e.g. Govt. Ministries, Companies and First Nations)

44 No. of PICS-funded Graduate Students and Postdoctoral Fellows

10 No. of Companies, Govt. Ministries, or Organisations Employing PICS Interns (FY20)

76% Increase in Total Followers across all Social Media from 2019-2020

f		in
5%	11%	142%

225% Increase in Total Page Clicks

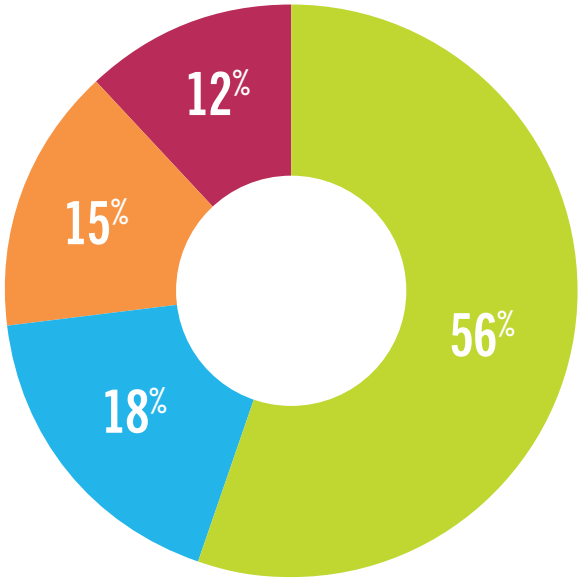
66% Increase in Total Post Shares

38% Increase in Total Social Engagement from 2019-2020

422% Increase in Website Visitors from Social Media
2019: 540
2020: 2,821

PICS research attracted widespread coverage by major media outlets in 2020 including *CBC News, Globe and Mail, CTV Television, Vancouver Sun, National Post, Calgary Herald, Times Colonist, National Observer, Toronto Star, Canadian Press,* plus industry press and radio.

PICS EXPENDITURE FY 2020



Research	$1,696,322
Operations	$532,321
Intercampus Coordination	$429,006
Communications	$366,080
TOTAL EXPENDITURE	**$3,023,729**

Fiscal Year ending March 31, 2020

ROLL CALL

The following individuals led PICS projects in the calendar year 2020, either as researchers or supervisors of masters or PhD students.

Peter Arcese
Faculty of Forestry,
University of British Columbia

Jonn Axsen
Resource and Environmental Management,
Simon Fraser University

Majid Bahrami
School of Mechatronic Systems Engineering,
Simon Fraser University

Stephanie Chang
School of Community and Regional Planning and Institute for Resources, Environment, and Sustainability,
University of British Columbia

Laurence Coogan
School of Earth & Ocean Sciences,
University of Victoria

Curran Crawford
Department of Mechanical Engineering,
University of Victoria

Lori Daniels
Department of Forest & Conservation Sciences,
University of British Columbia

Brent Doberstein
Geography and Environmental Management,
University of British Columbia

Andréanne Doyon
Resource and Environmental Planning Program,
University of British Columbia

Ché Elkin
Ecosystem Science and Management,
University of Northern British Columbia

Ralph Evins
Department of Civil Engineering,
University of Victoria

Cynthia Girling
School of Architecture & Landscape Architecture,
University of British Columbia

David (Dave) Goldberg
Lamont-Doherty Earth Observatory,
Columbia University

Scott Green
Ecosystem Science and Management,
University of Northern British Columbia

Paul Hessburg
United States Forest Service

Mark Jaccard
Canadian Industrial Energy End-Use Data and Analysis Centre,
Simon Fraser University

Ron Kellett
School of Architecture & Landscape Architecture,
University of British Columbia

Werner Kurz
Canadian Forest Service,
Natural Resources Canada

Rachel Lauer
Department of Geoscience,
University of Calgary

Kees Lokman
School of Architecture and Landscape Architecture,
University of British Columbia

Margaret Low
School of Community and Regional Planning,
University of British Columbia

Tara Martin
Department of Forest and Conservation Sciences,
University of British Columbia

Walter Mérida
Faculty of Applied Science,
University of British Columbia

Kate Moran
Ocean Networks Canada. and School of Earth and Ocean Sciences,
University of Victoria

Anthony Perl
Urban Studies and Political Science,
Simon Fraser University

Adam Rysanek
School of Architecture & Landscape Architecture, University of British Columbia

Dominik Roeser
Department of Forest Resources Management,
University of British Columbia

Anne Salomon
School of Resource and Environmental Management,
Simon Fraser University

Terre Satterfield
Institute for Resources, Environment and Sustainability,
The University of British Columbia

Oliver Schmidtke
Centre for Global Studies,
University of Victoria

Richard Schuster
Department of Biology,
Carleton University

Carolyn Smyth
Pacific Forestry Centre,
Canadian Forest Service

Stephen Sheppard
Faculty of Forestry,
University of British Columbia

Tim Takaro
Faculty of Health Sciences,
Simon Fraser University

James Tansey
Sauder School of Business,
University of British Columbia

Benjamin Tutolo
Department of Geoscience,
University of Calgary

Jantsje van Loon-Steensma
Department of Environmental Sciences,
University of British Columbia

Oscar Venter
Ecosystem Science and Management,
University of Northern British Columbia

Connect with us online to stay up to date: