

# The importance of preserving functional links

**Drs Elena Bennett, Andrew Gonzalez, and Martin Lechowicz** reflect on their work blending ecosystem services, biodiversity and landscape connectivity, and how this collaborative effort is supporting a significant step change in land use planning perspectives on managing the expanding perimeter of metropolitan regions

**Can you describe the innovative conceptual framework for interactions between land use, biodiversity and ecosystem services that you are developing?**

Our framework begins with land use, especially its spatial pattern, and how changes in the configuration of land use types affects the maintenance of biodiversity and the provision of ecosystem services. There is a wealth of science showing that landscape structure can influence both biodiversity and ecosystem function. Landscape structure relates to both composition – the different types of habitat present and their relative proportions, and configuration – the spatial arrangement of these habitats. Likewise, there is a great deal of science indicating that biodiversity and ecosystem function influence the provision of ecosystem services. Our framework combines these notions, leading to the idea that the management of the spatial structure of the landscape, such as protecting or establishing habitat corridors, can maintain the functional links between biodiversity and ecosystems services required for human wellbeing.

**How will your approach help to improve the delivery and provision of data to communities managing ecosystem services?**

There are two issues in play here – the provision of data and the appreciation of how to use data to develop and evaluate alternative planning scenarios. Acquiring, vetting and making data readily available that is relevant to landscape management is expensive – individual towns depend on government investments in monitoring climate, water quality, soils, hydrology, land use, etc. There is, and probably always will be, too little site-specific data for certain variables relevant to landscape management but on the other hand there is enough to support objective analysis of alternative planning scenarios.



The more pressing deficiencies are in the level of knowledge about ecosystem health and ecosystem services and in the availability of tools for analysis of the impacts of planning decisions on each of these. The Montérégie Connection initiative seeks to increase awareness of ecosystem services and to begin to develop tools that can be used by decision makers involved in landscape management at the municipal and regional level. Related to this, our approach of involving communities in developing the questions and generating the answers is key to improving the use of relevant information. This makes it a true collaboration among scientists and stakeholders, and less of a delivery of data approach.

**What have been the biggest accomplishments in this work to date?**

First, we have established broad partnerships with local and regional stakeholders, and are especially proud of the way we have incorporated them into the process of developing knowledge. Second, we have developed a new conceptual framework linking the structure of the landscape through biodiversity with the provision of ecosystem services. Third, an important step is the consideration of multiple ecosystem services in a model framework so that communities can consider trade-offs and synergies in decision-

making. Finally, training a large team of post-doctoral collaborators, students and technicians to work more directly with stakeholders is something we are very proud of.

**How do you see the project developing in the future?**

We hope we will make a substantial contribution to the design and implementation of a green corridor surrounding Montreal, and we have been in contact the Montreal Metropolitan Committee about their plans to develop a greenbelt for Montreal. Our vision of an ecological network and the science that we are developing might be able to help plan what this greenbelt could look like. We currently have projects on green networks (forests), and blue networks (waterways). In the future, we hope to develop networks that incorporate both blue and green corridors and take into account interactions among the two. We also hope to further develop the historical aspects of the project. Understanding how long-term legacies of past land use affect the services provided by landscapes today is key and has not yet been conducted scientifically. We will work with other scientific groups internationally, who are interested in the next generation of ecosystem services models designed to make optimal decisions about landscape management for ecological and social benefits.



# Innovative scenario-based **land use models**

**McGill University** researchers are pioneering land planning tools to support improved decision-making in peri-urban and agricultural environments to encourage effective strategies for sustainable landscape management by paying attention to the links between biodiversity and ecosystem services

**BIODIVERSITY AND ECOSYSTEMS** have a wide range of functions and deliver services that are essential for human wellbeing. Many ecosystem services directly benefit people, such as the provision of food and fresh water, while other benefits are indirect, such as the capture of carbon dioxide by plants or the prevention of soil erosion. As landscapes around the world are transformed and modified, both biodiversity and ecosystem services are placed under growing pressure. The Montérégie Connection initiative arose in response to the increasing awareness that a dual focus on biodiversity and ecosystem services can promote sustainable landscape management.

The Montérégie Connection is a research initiative based in the region around Montréal in southern Québec, Canada that is under pressure from urban sprawl as well as climate change. Agriculture, urbanisation and road development have greatly fragmented the region, driven biodiversity loss, and diminished the supply of many ecosystem services. Three researchers at McGill University came together to develop novel approaches to land planning in the Montérégie: Dr Elena Bennett, Associate Professor at the McGill School of Environment and the Department of Natural Resource Sciences; Dr Andrew Gonzalez, Director of the Quebec Centre for Biodiversity Science and Professor of Biology; and Dr Martin Lechowicz, Director of the university's Gault

Nature Reserve and Professor of Biology. Dr Jeff Cardille of the Department of Natural Resource Sciences and Dr Jeanine Rhemtulla of the Department of Geography completed the team. Using the Montérégie as a test bed, these biologists and geographers are collaborating to develop approaches and tools that can improve regional landscape planning for sustainability in metropolitan regions.

## MANAGING CONNECTIVITY FOR SUSTAINABLE LANDSCAPES

Their approach is rooted in the hypothesis that changes to landscape configuration, and in particular the connectivity of forest patches, not only affect biodiversity but also the processes underpinning the ecosystem services that people depend upon in the Montérégie. The team is characterising forest fragmentation and mapping the spatial distribution of biodiversity and diverse ecosystem services on this regional landscape. Mathematical models, field surveys and experiments demonstrate that connectivity is a key component of the landscape that maintains biodiversity and ecosystem services. They are drawing on these results to design an ecological network composed of forest patches and corridors that can be embedded within a proposed greenbelt around Montréal. As Gonzalez summarises: "The forest connectivity re-established by this ecological network is expected to improve the resilience of the

landscape by maintaining biodiversity, helping populations to adapt, and ecosystems to reorganise under climate change".

The inspiration for the Montérégie Connection started in the late-1990s when the ecological integrity of a forest system under the stewardship of McGill University, the Gault Nature Reserve on Mont St-Hilaire, was beginning to be threatened by urban expansion. Through the efforts of the Mont St-

Hilaire Nature Centre, an NGO with which the university closely collaborates, local towns gradually became open to a more proactive decision-making and management process for regional land use. The need for scientifically sound models that could help communities explicitly consider biodiversity, recreation, carbon storage, nutrient cycling, and related factors in their planning soon became apparent. "The Montérégie Connection arose as a research collaboration to develop interactive models that could help communities incorporate biodiversity and ecosystem services into their planning, to ensure they were resilient to the challenges to be faced in the future, including climate change and global economic changes," explains Bennett.

Because the future of the Montérégie will be determined by a wide array of organisations across a large area, it was clear to the collaborators that effective sustainable management would require input and action from all the regional stakeholders. "Scientifically, we came from a view of managing and protecting landscapes. In this particular region, we were seeing forest loss, fragmentation, changing landscapes, alongside a growing interest in environment," elaborates Lechowicz. "The situation seemed ripe for science that could make a difference." Their initial work, which investigated ways to reconnect isolated pockets of forest, helped to create new perspectives on land use policy and an innovative ecological corridor concept in the region. Grants were sought for three projects that together laid the foundation for the Montérégie Connection – one focused on healthy aquatic ecosystems, another on forest corridors and climate change, and the last on the ecosystem service implications of maintaining healthy and connected aquatic and forest ecosystems in this peri-urban agricultural landscape.



SAMPLING POLLINATION SERVICES © ALEX TRAN



**ADDRESSING 'GREEN' AND 'BLUE' CORRIDORS**

The project entitled 'Designing Ecological Networks for Climate Change' seeks to prioritise and implement forested 'green' corridors in the St-Lawrence River valley around greater Montreal. Using a scenario-based approach, the research team is investigating how different corridor designs improve resilience to climate change, which could have wide-ranging implications, as Gonzalez outlines: "We are designing an ecological network that will sustain biodiversity and ecosystem services for a region of 4 million people. It is unique and path-breaking science that can have a remarkable effect on the wellbeing of the local people". The notion behind the project is that improving connectivity between forest fragments can strengthen biotic exchange, and so maintain biodiversity and ecosystem services. This ecological network will also serve the purpose of facilitating migration of biota in response to climate change by addressing several significant questions: can present day fragmented landscapes be modified to maintain biodiversity and critical ecological processes under a changing climate? How do we design and implement corridor networks in the most economically effective and sustainable manner? Can we design climate-proof landscapes that maintain the connectivity and permeability required to assist large-scale northward migration whilst maintaining local biodiversity, ecosystem processes and ecosystem services?

A related project entitled 'Linking Land Use and Aquatic Biodiversity' encourages local awareness of the importance of 'blue' corridors, the hydrologic networks in and around the Mont St-Hilaire Biosphere Reserve. This project will illustrate how stream water quality – using stream invertebrate communities as an indicator – depends on land cover and land

use in the watershed. The hope is that by placing an emphasis on a local case study with robust scientific data, public policy on key environmental concerns can be effectively influenced. The project is based in part on the idea that changes in stream biota are more easily understood than chemical data on water quality, and also will help raise public awareness of aquatic biodiversity. The Montréal Connection team hopes that this project will encourage local communities and stakeholders to become engaged in the debate about the role of land-water linkages in landscape management, ultimately strengthening efforts to consider land-water, or blue-green, linkages in the design of ecological corridors and the management of watersheds.

A third project brings an historical perspective on landscape management to help develop tools that will foster better land use decisions. This project, entitled 'Managing for Biodiversity and Ecosystem Services', is producing data on regional changes to land use and ecosystem services since the 1930s. "Understanding how multiple ecosystem services change through time will dramatically improve our ability to detect key trade-offs and synergies among ecosystem services and understand how those tradeoffs and synergies change with land use and management," asserts Bennett. This information is being used to develop a novel model that quantifies the long-term effects of changing land use on provision of ecosystem services. The ultimate goal of this project is to provide tools for regional decision-making and land use planning based on our regional model, allowing comparisons of the consequences for sustainability under alternative planning scenarios.

**THE CHALLENGES WITH EXISTING LAND MANAGEMENT TOOLS**

Creating tools that allow policy makers and urban planning professionals to evaluate a range of scenarios from the viewpoint of their impact on ecosystem services is really the 'raison d'être' of the Montréal Connection initiative. The scenario approach can provide an objective framework for discussions about managing landscapes at the local and regional level. The challenge is that, although there is generally a good awareness to broad ecological concepts and a sympathy for the need to address sustainability, there is a limited amount of data and technical expertise available to help support discussions about alternative scenarios



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for landscape management: "Municipalities tend to approach discussions of landscape management in the tradition of urban planning in which concepts of ecosystem services are only weakly integrated," comments Lechowicz. Previously, these discussions tended to focus on environment or agricultural and urban development as an either/or prospect. Modelling a range of ecosystem service outcomes allows communities to choose among an array of options with different spatial patterns of agriculture, urban development, and forested land.

Existing models of ecosystem response to management alternatives generally have been used to promote conservation, primarily in the context of developing countries. These tools are not well equipped to answer many of the critical questions communities in developed countries have when planning for future landscapes, such as how managing for one ecosystem service might cause declines in another, or how communities could arrange land use to obtain synergies that provide several services simultaneously. The Montréal Connection researchers also recognised they needed to create models that work at multiple spatiotemporal scales to help promote good land management decisions in developed countries. "This model will be one of the first to truly take the spatial pattern of land use into account. It is also one of the first built for peri-urban, agricultural, developed world context," highlights Bennett.

**DEVELOPING SCENARIO-BASED PLANNING MODELS**

The Montréal Connection team is working on decision-support tools that will help predict the ecosystem services provided by a landscape under different planning scenarios. This will provide communities with the understanding of the trade-offs that exist in management and allow them to make management decisions in full knowledge of the trade-offs they will incur in the future. "Knowing how urban or peri-



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urban development will affect multiple services allows communities to take into account the trade-offs as they are making decisions," observes Cardille. "Then, the community has the information they need to allow their values to play into the decision while, at the same time, having scientific information forming a base." This scenario approach empowers communities to have a well-informed say in their own future and a clear vision of the full extent and long-term impact of their decisions.

One of the critical challenges to ensuring that the models deliver reliable predictions for the future is being able to accurately quantify changes in the provision of ecosystem services as landscapes change through time. The group has approached this by using a range of resources at different scales across the region. For analysis through time, the researchers are using historical aerial photos to improve understanding of how regional land use has changed since the 1930s. Existing information – such as agricultural census data, reported sightings of rare species, and information sourced from private mapping companies – is being used to quantify a range of ecosystem services over the same time period. This data has been utilised to aggregate the municipal and regional scales and is supplemented by direct measurements in the field by graduate and undergraduate students.

### A TRULY COLLABORATIVE EFFORT

The Montérégie Connection initiative has taken the approach of involving local communities and stakeholders in the development of the projects as much as and as soon as possible. The team has been working with many local stakeholders: the Mont St- Hilaire Nature Centre, the town of Mont Saint Hilaire, the government body responsible for the region around Mont St-Hilaire (MRC la Vallée-du-Richelieu), the Regional Committee for the Environment, the Québec Ministry of Environment, Ouranos, the Suzuki Foundation, as well as many individual farmers and land owners. The Montérégie Connection is not intended as simply a data delivery project, but rather as a collaborative effort that will ensure that the information generated is actually useful for decision makers.

This collaborative effort has benefited from the fact that some of the researchers have a long history of working in these communities and developing connections with stakeholders, particularly Lechowicz. Relationships and local knowledge developed over time have meant that the group enjoys a level of trust with the community. "This is important for improving our ability to really gain the interest and support of the community in a more

than superficial way," points out Bennett. Much of the academic research conducted in this discipline to date has not been readily accessible for the relevant communities, as Gonzalez details: "Scientists are often focused on searching for answers to questions that are scientifically interesting, but can have little relevance to communities at any given point in time". It is his opinion that science completed by one person or group of people, with results handed to another group for their use, is not particularly useful. Rather, he believes that by involving the community and stakeholders early



RESEARCH TEAM STUDYING CARBON SEQUESTRATION © ALEX TRAN

and consistently in the research, the results, and their implications for management, will be better understood and more likely to be taken into account during real decision-making. "We started this project by asking the stakeholders what they think are the relevant questions, and inviting them to be involved in many aspects of the research," observes Lechowicz. "Being part of developing the knowledge is key to ensuring that communities will ultimately use it." The work has demonstrated the success of the team's approach and proved that the model they are developing can enhance decision-making in peri-urban and agricultural environments. The research thus far is a clear indicator that the innovative approach adopted in the Montérégie Connection initiative can play a fundamental role in the sustainable management of ecosystem health and services, which will have a considerable impact on biodiversity and human wellbeing for some time to come.



APHID LARVA ON SOYBEAN LEAF AND BACKGROUND IMAGE © MATTHEW MITCHELL

## INTELLIGENCE

### ECOSYSTEM SERVICES, BIODIVERSITY, AND LANDSCAPE CONNECTIVITY

#### OBJECTIVES

To develop practical decision-support tools based on a new conceptual framework about the interactions between land use, biodiversity and ecosystem services.

#### KEY COLLABORATORS

**Professor Andrew Gonzalez • Professor Martin Lechowicz • Professor Jeff Cardille • Professor Jeanine Rhemtulla**

#### FUNDING

Natural Sciences and Engineering Research Council of Canada • Ouranos • Max Bell Foundation

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**ELENA BENNETT** attended Oberlin College as an undergraduate, where she studied Biology and Environmental Studies. She earned her MSc in Land Resources from the University of Wisconsin in 1999, and her PhD in Limnology and Marine Sciences in 2002. As a postdoc, she helped coordinate the Scenarios Working Group for the Millennium Ecosystem Assessment. Dr Bennett started working at McGill in 2005.

**ANDREW GONZALEZ** is Professor and Canada Research Chair in Biodiversity Science, and Director of the Quebec Centre for Biodiversity Science at McGill University. Prior to joining McGill University he spent four years as an Assistant Professor at the University of Paris VI, France.

**MARTIN J LECHOWICZ** is Professor of Biology at McGill University, and has been Director of the Gault Nature Reserve, where he was responsible for a variety of academic and outreach activities that raised public awareness of conservation issues in and around the Mont St Hilaire Biosphere Reserve. He took a bachelor's degree in Humanities at Michigan State University in 1969, a Master's degree in Botany in 1973 and a PhD in Plant Ecology at Wisconsin in 1976.



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