

# EVIDENCE BRIEF

The **Social Sciences and Humanities Research Council** in collaboration with the **Natural Sciences and Engineering Research Council** and the **Canadian Institutes of Health Research**

SSHRC's *Imagining Canada's Future* initiative mobilizes social sciences and humanities research to address emerging economic, societal and knowledge needs for Canada, and help guide decision-making across all sectors toward a better future. This evidence brief addresses the Future Challenge Area of: **Living Within Earth's Carrying Capacity**

## Will smarter forests take us farther? Fostering resilient forest ecosystems in the digital era

### About the project

We sought to advance understanding of the potentially diverse roles of novel and emerging technologies, data and data science techniques for managing forest ecosystems in Canada, centred on the following questions: (1) How are existing data, tools and new technologies (e.g., artificial intelligence, Internet of Things, data analytics, sensors, robotics) being leveraged to measure and assess the resiliency and adaptation potential of socio-cultural-ecological forest systems in rural and urban contexts; and (2) What data integration and linkages are possible within and between forest and urban forest managers and stakeholders, given the use of different measures and indicators to monitor these systems?

We undertook a global scoping review to identify key themes, research foci and practical management applications at the intersection of digital technology, and data science, and forests, as well as determine which countries, agencies and institutions are at the forefront of integrating technology into forest management (e.g., silviculture, community forestry, urban forestry and arboriculture, and sustainable forest management). Initial semi-structured interviews with practitioners complemented the literature review. We identified key use cases for digital technology in forest ecosystem management, and assessed the relevance to Canadian resource, policy and management contexts. Future work will involve developing specific recommendations for forestry stakeholders to anticipate and engage in the use of technology and data science techniques for forest management through partnerships, cross-sector collaboration and capacity-building activities.

### Key findings

- When considering global research output from 2010 to 2020, the country with the highest research output is the United States, followed by China, Finland, Italy, Spain and Canada.
- A strong emphasis was revealed on remote sensing-based innovations for forest monitoring, planning and management, where machine-learning techniques also play an important role in data collection, processing and analysis. Data fusion approaches are also becoming more common, made increasingly accessible by open-source data sets and data-sharing practices.
- Research on technological applications for urban forest ecosystem management did not feature as prominently, although there is uptake in more recent years.
- Arguably, the area of greatest advancement in the forest sector's intersection with digital technology and data is in forest inventory and monitoring. Forest inventorying was a significant use case for technology applications, more specifically for genus/species identification and mapping, forest operations (e.g., harvest planning) and quantification of ecosystem services and benefits (e.g., above-ground biomass estimation, carbon stock assessment).
- Artificial intelligence and machine-learning technologies for data collection, processing and analysis appear to be gaining significant traction in the last three years. They include a range of techniques from classification and segmentation algorithms to convolutional neural networks.

- The rise of unmanned aerial vehicle (UAV) usage over time in forest ecosystem management research indicates increasing interest in flexible and affordable data collection and processing practices.
- Emerging technologies and applications include virtual/augmented environments for understanding human-nature relationships and behaviour patterns, automated workflows for forestry operations and urban green infrastructure mapping and ecosystem services assessments.
- As smartphone usage expands globally, along with better broadband connectivity and data storage capabilities, crowdsourced and citizen science-based forest ecological research may also become more feasible and reliable.
- Key challenges identified by researchers primarily relate to data quality and accuracy; data modelling and assumptions/bias; and capacity, expertise and regulations.
- Many of the opportunities identified by researchers relate to automating resource-intensive data collection, management and analysis practices.

## Policy implications

- Although the forestry sector has often been slow with regard to technological innovation, this literature-based study suggests that digital-based technologies will likely play increasingly prominent roles in monitoring, planning and management.
- Little research explicitly discussed technological applications and methods that apply to both rural and urban forest ecosystem contexts. Thus, there is a need for policy to support this type of research and innovation.
- Gaps appear to exist between research and practice, particularly with regard to forestry operations; vulnerabilities around the pace of technological adoption over traditional methods (and relative affordability of doing so in the short term) are discussed among practitioners but not widely established in the literature. These gaps need to be addressed in future policy and programs.

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## FURTHER INFORMATION

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