Climate Change, Ecosystem Loss, and Flood Risk: Taking Stock using Burlington as a Case

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Abstract

Extreme weather events, climate change, and biodiversity loss are connected by both cause and solution. The impacts of climate change are already apparent as the frequency and magnitude of extreme weather events are increasing, undermining progress made across the globe toward sustainable development. These impacts are magnified by unsustainable and unplanned development, leading to lost biodiversity and ecosystem services, further reducing the ability of communities to respond and recover. As warming increases, the frequency and intensity of these hazards will also increase while at the same time making it more difficult to adapt to and mitigate disasters—the aftermath of hazards. Nature-based solutions provide opportunities to mitigate and adapt to climate change impacts, reduce the risk of disasters, enhance biodiversity, and build sustainable and resilient communities. They are cost-effective approaches that conserve, restore and enhance the natural environment. Using the 2014 flood event in the City of Burlington (Ontario, Canada), this study takes stock of flood risk in the region and how nature-based solutions provide significant co-benefits toward reducing disaster risks.

Keywords: flood risk, nature-based solutions, climate change, biodiversity loss, disaster risk reduction, Burlington, Ontario, Canada.

Introduction

According to the World Economic Forum's *Global Risk Report* for 2022, the three most damaging risks are environmental and include climate action failure, extreme weather and biodiversity loss (World Economic Forum, 2022). The impacts of climate change are already apparent as the frequency and magnitude of extreme weather events are increasing, undermining progress made across the globe toward sustainable development (United Nations Office for Disaster Risk Reduction [UNDRR], 2021). These impacts are magnified by the loss of biodiversity and ecosystem services, further reducing the ability of communities to respond and recover (United Nations Environment Programme [UNEP], 2021a; Warren et al., 2021). To effectively address these interconnected crises, a comprehensive approach is required—one that aligns goals and targets across sectors in order to maximize co-benefits, minimize trade-offs and reduce compound vulnerabilities (UNEP, 2021a, 2021b). This demands a paradigm shift toward designing a more sustainable economy built in harmony with nature (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES], 2019). This includes steering economic, political, social and technological pathways away from environmental degradation towards restoration (UNEP, 2021b; IPBES, 2019). Nature-based solutions help achieve these goals as they provide opportunities to mitigate and adapt to climate change, reduce the risk of disasters and enhance biodiversity, while providing a robust foundation for sustainable development (Doswald et al., 2021).

Disaster Risk

Climate change is producing more severe floods, droughts and other extreme weather events (Boyd & Markandya, 2021), and the loss of biodiversity and ecosystem services are magnifying the impacts of these hazards, further reducing the ability of communities to respond and recover (UNEP, 2021a; Warren et al., 2021). As warming increases, the frequency and intensity of these events will also increase, while at the same time making it more difficult to adapt to and mitigate disasters (Warren et al., 2021). To effectively reduce risk, the underlying drivers of climate change and ecosystem degradation must be addressed. *The Sendai Framework for Disaster Risk Reduction 2015-2030* is a global framework and set of guiding principles for reducing disaster risk and building resilience. It is a comprehensive framework with four priorities and seven targets to prevent and reduce risk and safeguard development gains from the impacts of disasters (UNDRR, 2015). It addresses the urgency and importance of anticipating, planning and reducing disaster risk to effectively protect individuals and communities, their health, livelihoods, assets and the environment in order to build resilience. This framework, however, assumes that building resilience through risk-reduction approaches is attainable. While some of the current and projected risks of climate change can be managed with adaptation activities, limits to resilience are encountered when climate thresholds or tipping points are triggered (Allen et al., 2012; De Coninck et al., 2018). For instance, the risks associated with 2°C of warming will be greater than those posed by 1.5°C (Hoegh-Guldberg et al., 2018). Addressing escalating risks necessitates innovative approaches that harmonize disaster risk reduction priorities with those of other sectors.

Climate Change

Since the 1950s, unsustainable development has accelerated the burning of fossil fuels and the destruction of natural carbon sinks, increasing greenhouse gas (GHG) concentrations in the atmosphere (UNEP, 2021b). As of 2021, global, human-caused warming has reached approximately 1.11 ± 0.13°C above pre-industrial levels, causing profound changes to both natural and human systems (World Meteorological Organization, 2022). *The Paris Agreement*, signed by 196 Parties in 2015, is a global agreement to reduce GHG emissions in order to limit warming to below 2°C, ideally 1.5°C, compared to pre-industrial levels by 2050 (United Nations

Framework Convention on Climate Change [UNFCCC], 2015). To limit warming to 1.5°C, GHG emissions must be dramatically reduced by 2030 and net zero emissions must be achieved by 2050 (Rogelj et al., 2018). However, based on current pledges under the *Paris Agreement,* warming is expected to reach 2.8°C by the end of this century (UNEP, 2022).

The impacts of climate change are not universal, as warming varies between regions, with the highest increases occurring in high northern latitudes (Bush et al., 2019). For instance, Canada's mean annual temperature has increased by 1.7°C (Bush et al., 2019), significantly higher than the global average (World Meteorological Organization, 2022). Because of this, extreme heat events have already increased across Canada and are expected to occur in greater frequency and magnitude as temperatures continue to rise (Bush et al., 2019). Extreme precipitation events have also increased, with the annual mean precipitation increasing by 18.3% (Zhang et al., 2019). Extreme precipitation is expected to increase further under a high emission scenario across Canada, where, by 2100, a 20-year precipitation event is expected to become a 5-year event (Zhang et al., 2019). Warmer temperatures and changes in precipitation are also expected to increase the risk of wildfires and droughts throughout the country (Bonsal et al., 2019). To effectively address these growing risks, mitigation efforts aimed at preventing or reducing GHG emissions alongside efforts to sequester carbon through conserving and restoring natural sinks, must be integrated with climate change adaptation and risk reduction priorities to minimize warming and secure a future where risks can be managed (Rogelj et al., 2018).

Biodiversity and Ecosystem Loss

Changes in landscape and seascape, climate change, ecosystem degradation, escalating pollution and the influx of invasive species have led to the rapid decline of ecosystems and biodiversity (IPBES, 2019). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services states that approximately one million of the world's eight million species are facing extinction, and despite current action, biodiversity and ecosystem services continue to deteriorate (2019). Modelling projects warming temperatures to further impair ecosystem function and biodiversity (IPBES, 2019). The Intergovernmental Panel on Climate Change (IPCC) estimates that approximately 18% of species are at risk of extinction if warming reaches 2°C by 2100, and if warming reaches 4°C, it is estimated that 50% of species will be threatened (2023). In high northern latitude countries such as Canada, where warming is expected to outpace the global average, biodiversity is at increased risk (Lemieux et al., 2021). As indicated by World Wildlife Fund Canada, at-risk species have already declined on average by 59% from 1970–2016, as reported by the Committee on the Status of Endangered Wildlife in Canada, and those considered threatened according to the International Union for Conservation of Nature Red List of Threatened Species have declined on average by 42% over the same time period (World Wildlife Fund Canada, 2020). To reverse these trends, it is imperative that environmental degradation and increased warming be avoided. The United Nations Biodiversity Conference (COP15) culminated in the adoption of the *Kunming-Montreal Global Biodiversity Framework,* comprising four goals and 23 targets aimed at halting and ultimately reversing biodiversity loss by 2030. The successful implementation of this framework is key as biodiversity plays a critical role in maintaining the functionality and resilience of ecosystems, serving as the very foundation for the delivery of essential ecosystem services (UNEP, 2021b).

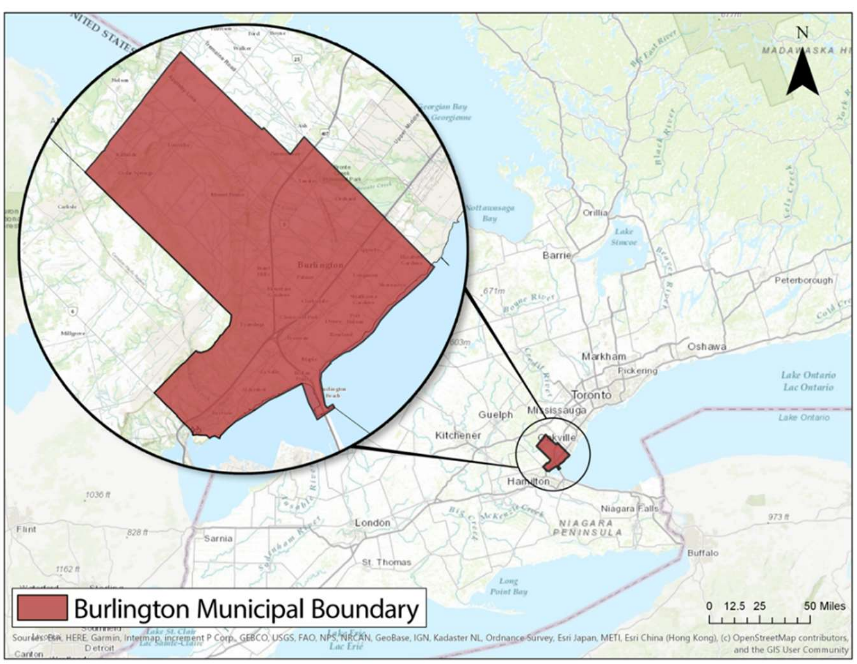
Ecosystems provide a range of services valued at $3.6 trillion per year in Canada, such as carbon sequestration, climate regulation, food, water and air purification, and habitat for flora and fauna, while also protecting communities from natural disasters (Molnar et al., 2021). Healthy ecosystems are, therefore, critical for human life and for enhancing the adaptive capacity of communities during extreme weather events (Kapos et al., 2021; Molnar et al., 2021). They also sequester about half of human-caused emissions in both terrestrial and aquatic ecosystems, playing a critical part in mitigating climate change (UNEP, 2021a). Currently, only about 16% of global lands and 8% of oceans are protected (UNEP-WCMC & IUCN, 2021). While momentum is growing, as over 60 countries have joined the *High Ambition Coalition for Nature and People* in committing to protecting 30% of all land and seas by 2030, governments must broaden their ambitions (High Ambition Coalition for Nature and People, n.d.). Conservation scientists state that optimum outcomes for biodiversity arise somewhere between 30–70% of protection, with 50% considered an agreeable mid-point (Woodley et al., 2019). While protecting ecosystems is critical to halting biodiversity loss, it also must be done in a way that prioritizes connectivity (Lemieux et al., 2021; UNEP, 2021a), an essential feature for ecological and evolutionary processes such as species migration and adaptation (Lemieux et al., 2021). Only 4% of Canadian lands are considered adequately protected *and* connected (Saura et al., 2018), but by reconnecting fragmented landscapes with forests, wetlands and grasslands, species can disperse throughout the landscape (Lemieux et al., 2021) while sequestering carbon, mitigating floods and increasing community resilience (UNEP, 2021b). Halting biodiversity and ecosystem loss, therefore, provides a pathway for a more sustainable future and must be considered in parallel with climate change and disaster risk reduction priorities to ensure ecosystems continue to provide essential goods and services critical for human life (IPBES, 2019; UNEP, 2021b).

Case Study: Flooding in Burlington, Ontario

Flooding is the most destructive natural hazard in Ontario as it accounts for the most damages and interruptions to society (Government of Ontario, 2020). Globally, it is also the most frequent disaster, comprising 44% of all international disasters between 2000 and 2019 (UNDRR, 2020). The IPCC has identified Ontario as one of many regions that will experience the largest growth in heavy precipitation events (Hoegh-Guldberg et al., 2018). The annual mean precipitation has already increased by 9.7%, and is expected to increase by the end of the century by 5.3% for a low emission scenario or 17.3% for a high emission scenario, highlighting two very different futures based on emission pathways (Zhang et al., 2019). The City of Burlington, the case study of focus, is also projected to experience increased precipitation. Under a high emission scenario, Burlington's annual precipitation is projected to increase by 10% by 2051, with a 17% increase in the spring and an 18% increase in the winter (City of Burlington, 2022). Conservation Halton, the local watershed management agency, has identified riverine flooding as one of Burlington's major determinants of flood risk (Harris & Doherty, 2015). The main causes of riverine flooding in Ontario include excess precipitation, snowmelt, rain-on-snow, and ice jams (Bonsal et al., 2019). This case study presents the 2014 flood event in the City of Burlington, highlights some of the conditions that exacerbated the impacts of the storm and where nature-based solutions can be successfully implemented to mitigate risk and provide significant co-benefits.

Figure 1

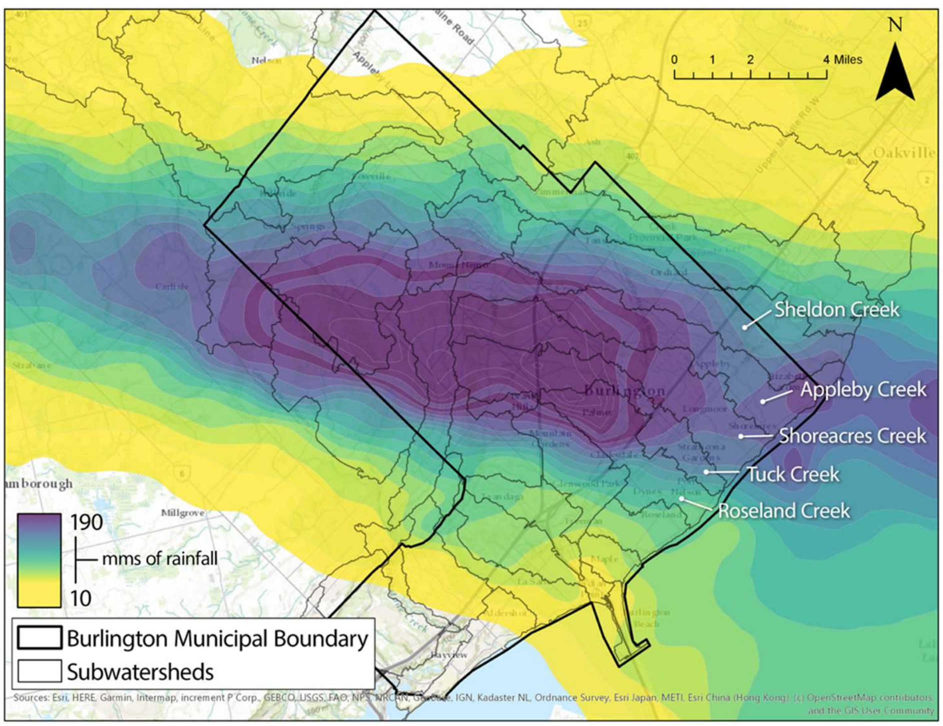
Map of Burlington, Ontario



Burlington is located within Ontario's Golden Horseshoe, bounded by Ontario's Greenbelt to its north and Lake Ontario to its south (Figure 1). On the afternoon of August 4, 2014, heavy rain fell on Burlington, generating significant runoff and flooding over 6,000 properties (Harris & Doherty, 2015). Rainfall reached up to 196 mm over seven hours, producing rainfall depths that exceeded the 100-year record of regional storm events and causing over $90 million in insured damages (Figure 2) (Amec Foster Wheeler, 2017; Harris & Doherty, 2015).

Figure 2

Precipitation Isohyets from August 4, 2014 Storm

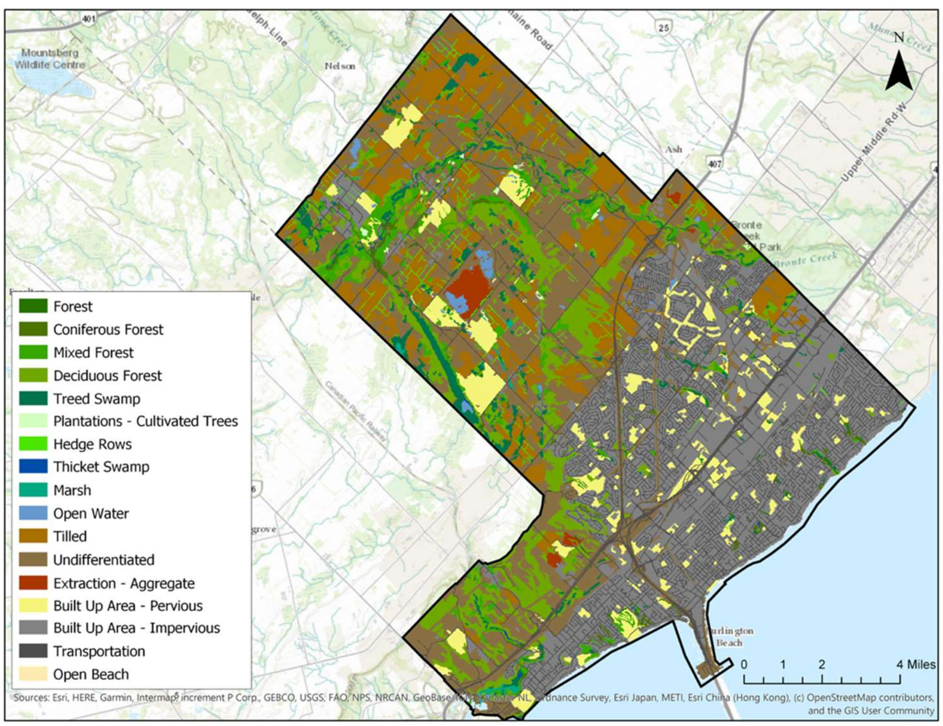


Note. This displays the estimated total precipitation amounts in 10 mm intervals developed from local rainfall gauges incorporated with Buffalo's NexRAD radar data in the study area. Data source: Conservation Halton.

Other factors exacerbated the impacts of the storm including urban development which increases impervious surfaces. These surfaces, such as roads and buildings, produce higher peak-flows and increase the volume and rate of runoff (Moudrak et al., 2017). Watersheds with high impervious land and low forest cover only absorb about 20% of rainfall during precipitation events (Moudrak et al., 2017). Burlington is half rural and half urban, as illustrated in the land cover assessment in Figure 3. Burlington's urban subwatersheds are high in impervious land and low in forest cover (Figure 4), causing excess precipitation to overwhelm the stormwater management infrastructure and increasing the risk of flooding.

Figure 3

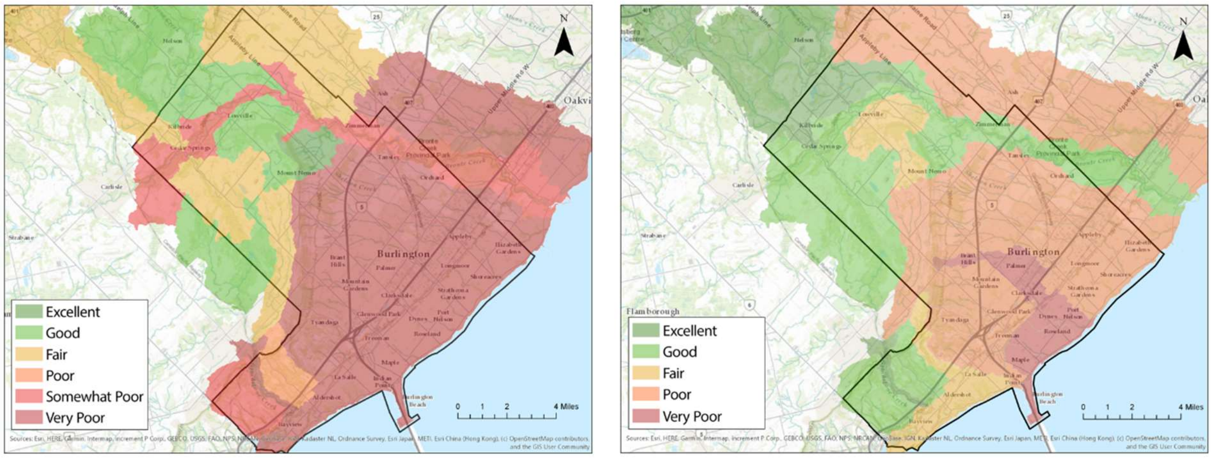
Landscape of Burlington



Note. The southern half is largely impervious surfaces and the northern rural area is a combination of agricultural and green space. Data source: Land Information Ontario.

Figure 4

Impervious Land Grades (left) and Forest Cover Grades (right)

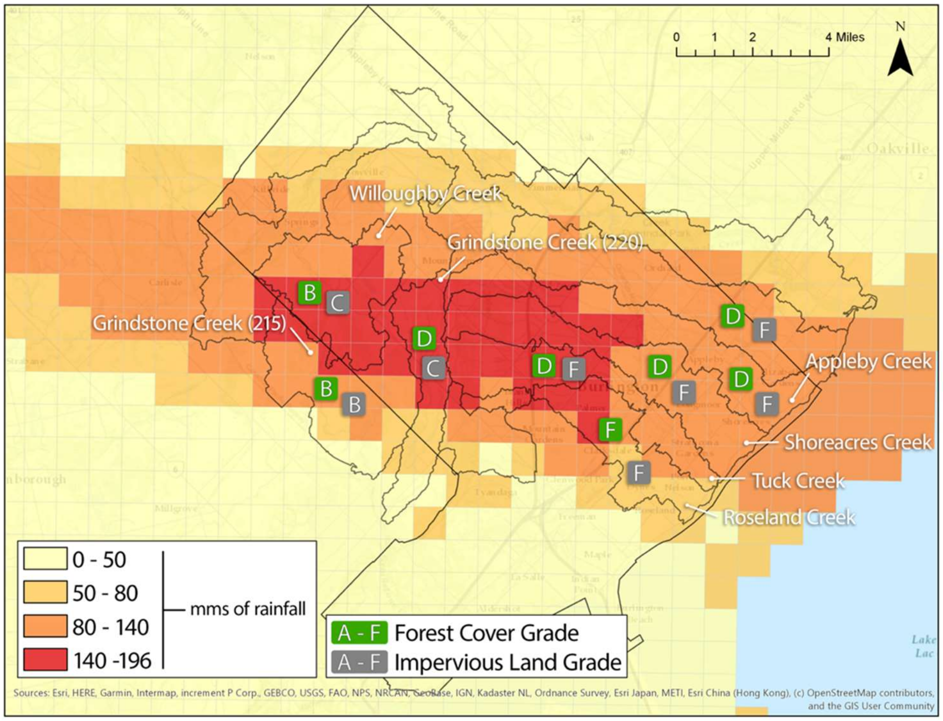


Note. Data Source: Conservation Halton.

Following the 2014 precipitation event, significant rainfall levels were recorded in seven of Burlington's subwatersheds, but damages were largely constrained to the four urban subwatersheds (Appleby Creek, Shoreacres Creek, Tuck Creek and Roseland Creek), with the rural subwatersheds (Willoughby Creek and Grindstone Creek subwatersheds, 215 and 220) not mentioned within the after action damage reports (Figure 5) (Amec Foster Wheeler, 2017; Harris & Doherty, 2015). This suggests that those watersheds with better impervious and forest cover grades resulted in fewer damages due to their ability to absorb more water.

Figure 5

Rainfall Estimates for the August 4th, 2014 Event in 1 km × 1 km Grids



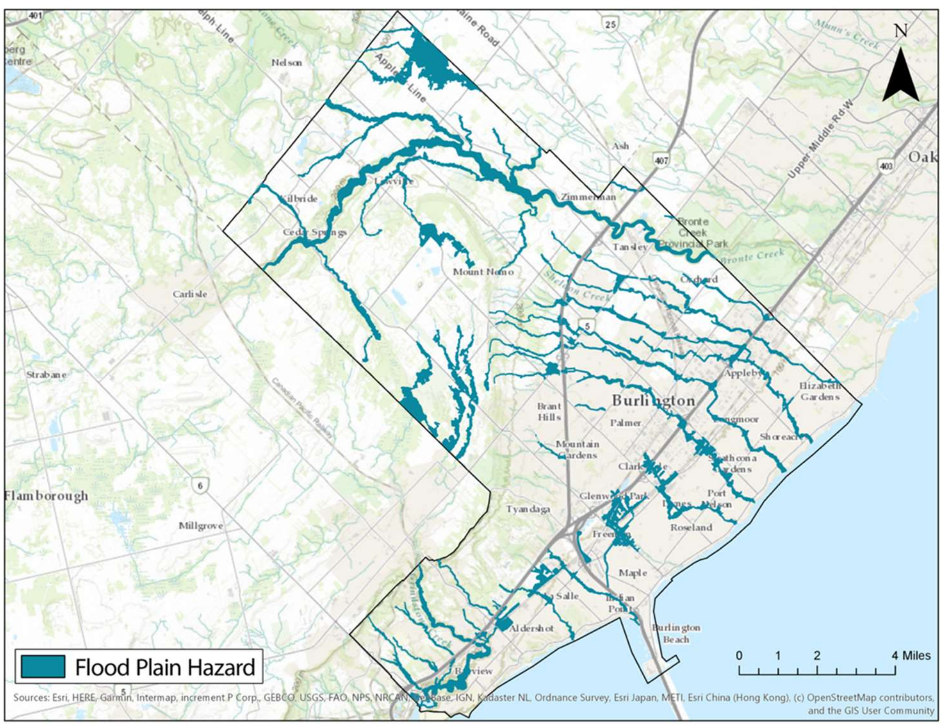
Note. The impervious and forest cover gradings have been added for comparison. Data source: Conservation Halton.

Disaster risk is not only characterized by the severity of the hazard but by the level of exposure, vulnerability, and coping capacity of a community (Public Safety Canada, 2019) based on structural and non-structural inequalities (Allen et al., 2012). For instance, households located within floodplains face increased exposure to flood hazards. At the local level, Conservation Halton is responsible for managing the risks associated with natural hazards, including riverine flooding. To determine flood risk areas, hydraulic models are used and incorporated with hydrology models and topographic considerations. Figure 6 represents Burlington's floodplains based on water surface elevation generated from multiple hydraulic models for the Regulatory Storm (a design storm based on 1954 Hurricane Hazel) (Toronto and Region Conservation

Authority [TRCA], n.d.). Figure 7 displays approximate flood vulnerable clusters where communities are located within the floodplain hazard limit. This is the result of many communities being established in high-risk areas prior to the implementation of the Provincial and Conservation Authority floodplain planning policies which regulate development in hazard limits (Amec Foster Wheeler, 2017; Harris & Doherty, 2015), and because flood hazards can migrate over time based on changes in land use and topography (TRCA, n.d.). Advancements in tools and technology have also improved flood risk projection capabilities, leading to refinements in flood hazard mapping over time (TRCA, n.d.).

Figure 6

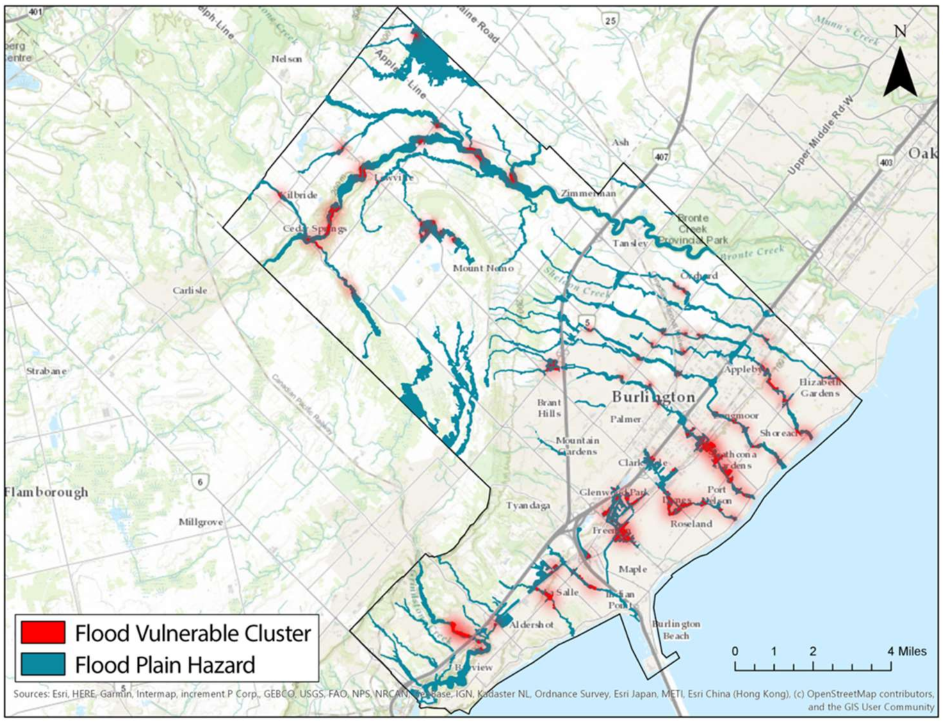
Floodplain Map of Burlington, Ontario



Note. Data source: Conservation Halton.

Figure 7

Flood Vulnerable Clusters

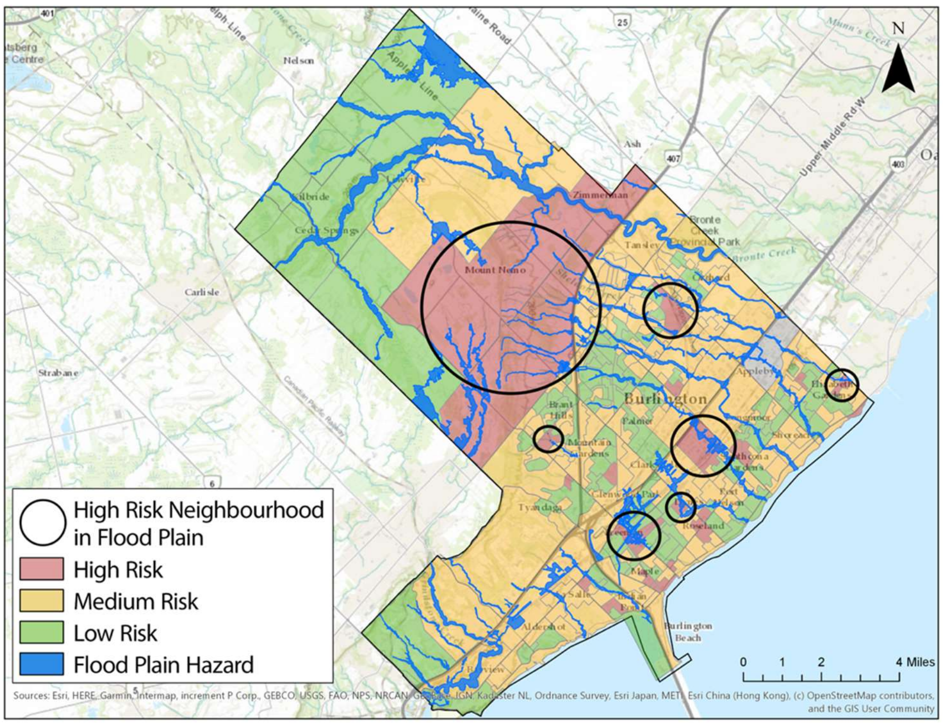


Note. This shows areas where structures are located within the floodplain, identified by overlaying topographic and satellite imagery to the floodplain hazard limit and selecting areas where structures intersected with the hazard limit.

In addition to exposure, inequalities associated with varying levels of wealth and education, health, class, gender and other cultural and social characteristics can increase vulnerability and reduce coping capacity by limiting access to resources (Agrawal, 2018; Armenakis & Nirupama, 2014). Practitioners must consider the socio-economic factors that make particular neighbourhoods more vulnerable in order to prioritize risk reduction strategies. Figure 8 provides an overview of vulnerable neighbourhoods within Burlington based on age, income, language, sex, education, unemployment rate, nationality, minority population, and household size and composition. This is overlaid with the floodplains to further refine those high-risk neighbourhoods located within floodplains.

Figure 8

High-risk Neighbourhoods within Floodplains



Note. Data sources: Environics and Conservation Halton.

Nature-Based Solutions

The most effective risk reduction strategies are those that reduce risk in the short term but also reduce current and projected vulnerabilities (Allen et al., 2012). Nature-based solutions are well suited to this objective as they reduce exposure and vulnerability and enhance the resilience and adaptive capacity of communities by addressing underlying drivers of risk (Allen et al., 2012). Nature-based solutions are approaches that conserve, restore and enhance the natural environment. They are cost-effective and address a range of societal challenges while helping communities adapt to the impacts of climate change, improve biodiversity and increase human health and well-being (Brown et al., 2021; Molnar et al., 2021). The International Union for Conservation of Nature defines nature-based solutions as "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (2020). One-third of climate change mitigation required by 2030 to keep warming below 2°C can be achieved by protecting and restoring natural carbon sinks (UNEP, 2021b). In addition, healthy ecosystems serve as natural buffers and reduce exposure to hazards while simultaneously providing habitat for plants and animals (Brown et al., 2021; Kapos et al., 2021). Nature-based solutions offer tremendous value as they not only address the compounding planetary crises, but provide additional ecological, social and economic co-benefits that increase people's adaptive capacity (Molnar et al., 2021; UNEP, 2021b). For instance, forests and wetlands provide flooding and erosion control, reduce the risk of urban heat island effect, sequester carbon and enhance biodiversity, while providing recreation space and improving water and air quality for human health (UNEP, 2021b). Nature-based solutions are excellent alternatives to traditional infrastructure that produce better outcomes as they are easier to maintain, appreciate over time and have wide-ranging co-benefits (Kapos et al., 2021; Molnar et al., 2021). Conversely, engineered or grey assets (i.e., dams, reservoirs and flood control walls) are expensive to install, require continuous maintenance and depreciate over time (Doswald et al., 2021; Kapos et al., 2021). Initiatives across the globe have demonstrated the value of nature-based solutions. For instance, the Municipal Natural Assets Initiative (MNAI) conducted a pilot project across Canada to assess the value of natural assets in providing municipal stormwater management services (Molnar et al., 2021). The results showed that natural assets provided the same level of stormwater management services as traditional engineered ones in the project areas, meeting the 100-year flood requirements (Molnar et al., 2021).

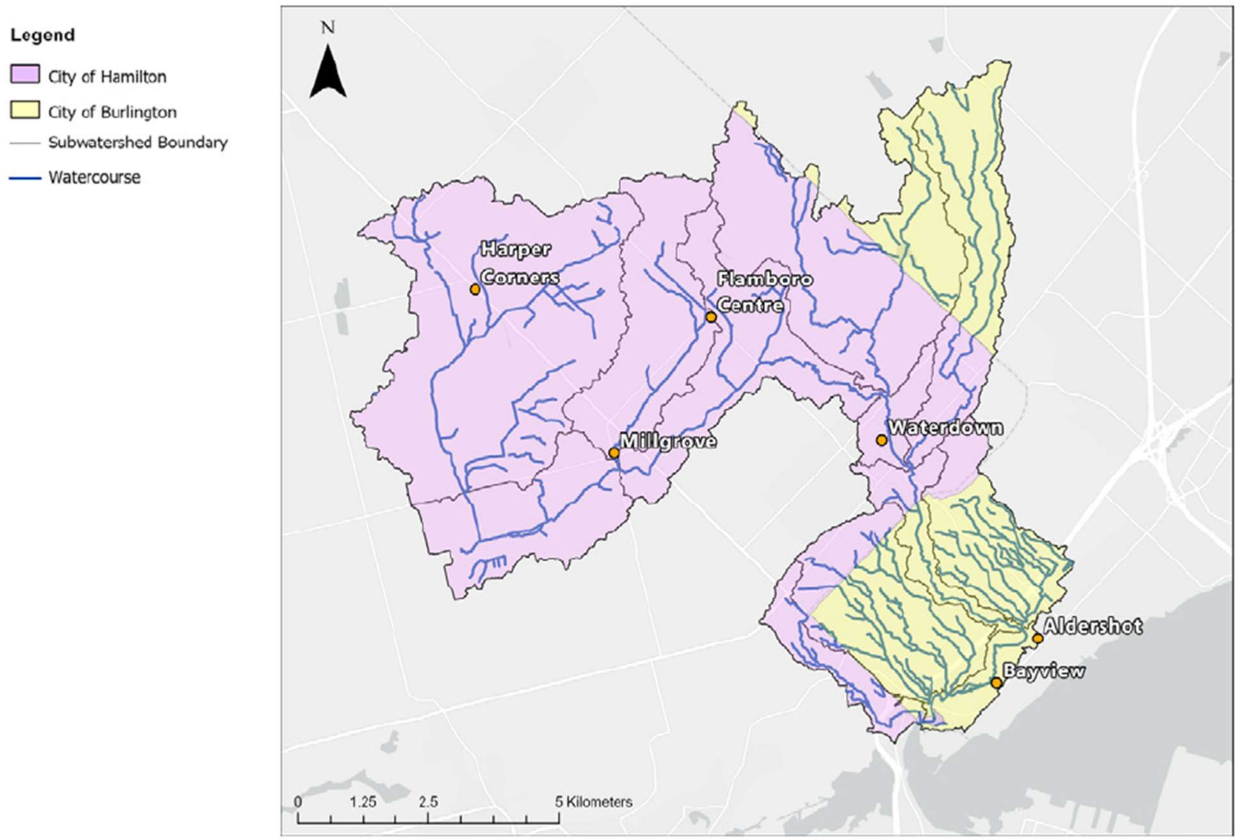
Mitigating Floods with Natural Assets in Burlington, Ontario

Nature-based solutions can help reduce flood risk in Burlington, while providing several co-benefits for people and nature. At the watershed level, floodplain restoration along the waterways would reduce flood and erosion risk while providing multiple co-benefits for biodiversity, carbon sequestration, climate regulation, and water quality and quantity (Naturally Resilient Communities, n.d.). When waterways are narrowed and straightened for urban development, the water runs quickly and increases flood risk downstream, which is further exacerbated in cities like Burlington, with high impervious land and low forest cover (Nirupama & Simonovic, 2007). By restoring the floodplains with alluvial woodlands, deep-rooting riparian vegetation, flood-friendly parks, wetlands and their natural meandering channels, the flow of water during rainfall events can be slowed and the risk of flooding downstream can be reduced (Dixon et al., 2016; Moudrak et al., 2017; Rajabali & Agrawal, 2022), while providing a north/south connectivity corridor for aquatic and terrestrial wildlife. By expanding the embankments and widening the river corridors, the space can be used for flood-friendly activities such as recreation and active transportation (Naturally Resilient Communities, n.d.). Wetlands are also known to reduce flood damage by about 40% by minimizing runoff, increasing groundwater infiltration, and diverting water to streams during precipitation events (Moudrak et al., 2017). Wetlands can be restored upstream in Ontario's Greenbelt to serve as water storage areas to mitigate the amount of runoff entering the city's stormwater infrastructure downstream (Moudrak, 2019).

The City of Burlington is already beginning to recognize the role of nature in providing municipal services. An MNAI-led project found that natural assets within the Grindstone Creek watershed (Figure 9) mitigated floods even in stressed climate change scenarios, providing approximately $2 billion in stormwater management services (MNAI, 2022). As a result of this project, the City of Burlington is beginning to identify, value and incorporate natural assets into their Asset Management Plan (MNAI, 2022). This will allow for equal consideration of engineered and natural assets in municipal service delivery. As part of their Climate Adaptation Plan, the municipality also intends to increase its investment in green infrastructure projects to reduce flood risk and enhance other ecosystem services, such as biodiversity which is a fundamental component of healthy ecosystems that deliver a range of functions and services (City of Burlington, 2022). Burlington is located within a crisis ecoregion; identified as an area of high biodiversity and experiencing high threats (Kraus & Hebb, 2020). By 2032, the City of Burlington intends to establish a city-wide Biodiversity Plan that addresses biodiversity loss through habitat restoration and connectivity corridors (City of Burlington, 2022). This can include conserving and restoring natural areas, and developing purpose-based infrastructure, such as natural overpasses and underpasses that reconnect habitats and encourage safe migration (Vartan, 2019). By enhancing and restoring natural areas, habitat can be re-established for plants and animals, while safeguarding the essential goods and services ecosystems provide. The City of Burlington also intends to increase tree canopy cover to 35% by 2041 (City of Burlington, 2022). To do so, they must effectively utilize available planting space within the urban areas using innovative approaches like the Miyawaki urban forest method. By planting native trees, plants, shrubs, and bushes of all sizes and varieties close together within residential parks or along transit corridors (Miyawaki, 1999), these mini forests can increase tree canopy cover significantly faster than traditional forests while providing co-benefits for biodiversity and carbon sequestration (Hewitt, 2021). Increasing urban greenery also allows rainwater to better infiltrate the ground and can reduce urban temperatures by 0.5–2.0°C, preventing heat-related illnesses and deaths (UNEP, 2021b). This will become especially important as the number of days above 30°C is anticipated to increase in Burlington from 16 days per year to 60.9 days in the next 30 to 60 years under a high emission scenario (City of Burlington, 2022).

Figure 9

Grindstone Creek Watershed (MNAI, 2022)



In highly urbanized environments where nature-based solutions may not be feasible to implement due to population density and limited space, engineered assets may incorporate nature-based solutions to enhance their effectiveness (UNEP, 2021c). For example, the introduction of flood-friendly parks, green roofs, rain gardens and bioswales, alongside engineered stormwater management systems such as sewers, pipes, pumps, and outfalls, can reduce the volume and speed at which rainfall enters the municipal stormwater system. In this way, nature-based solutions serve as valuable complements to engineered infrastructure by retaining and filtering excess stormwater while helping recharge aquifers and providing habitat and space for recreation (Brown et al., 2021). Several hybrid approaches are outlined within the City of Burlington's Sustainable Building and Development Guidelines, which identifies sustainable development requirements outlined within Burlington's Official Plan and Zoning By-laws, as well as voluntary measures which are encouraged through incentive programs (City of Burlington, 2021). Specifically, the Guidelines recommend reducing impervious surfaces and stormwater runoff using permeable pavements, bioswales, rain gardens and retention ponds, as well as encouraging the implementation of green roofs and water conservation systems (City of Burlington, 2021). There are also programs available for homeowners to identify and mitigate flood risk in existing structures. For instance, the Home Flood Protection Assessment program provides Burlington residents with a comprehensive report on household flood risks and provides practical, cost-effective measures to alleviate those risks, and Conservation Halton's Enhanced Basement Flooding Prevention Subsidy Program is helping residents undertake home improvements to reduce flood risk. By encouraging the integration of natural assets with engineered ones, the City of Burlington is beginning to harmonize growth and the environment.

Concluding Remarks

The impacts of climate change are becoming increasingly evident as the frequency and magnitude of extreme weather events are rising, and the loss of biodiversity and ecosystem services are magnifying the impacts of disasters, reducing the ability of communities to respond and recover (UNEP, 2021a; Warren et al., 2021). To effectively address these interconnected challenges, this study has presented nature-based solutions as an approach that aligns goals and targets across sectors to mitigate the compounding impacts of climate change, biodiversity loss and increased disaster risk (Doswald et al., 2021). This approach aligns with the Emergency Management Strategy for Canada which seeks to reduce disaster risk and increase resilience by adopting an integrated approach between emergency management partners (Public Safety Canada, 2019).

As warming increases, the frequency and intensity of extreme weather events will also increase, making it more difficult to adapt to and mitigate disasters (Warren et al., 2021). This study has provided evidence of how nature-based solutions reduce risk in the short term but also reduce current and projected vulnerabilities while providing co-benefits for people and nature (Allen et al., 2012). For instance, healthy ecosystems serve as natural buffers, protecting communities from hazards while simultaneously providing habitat for plants and animals (Brown et al., 2021; Kapos et al., 2021). While some climate change risks can be effectively managed using natural assets, limits to resilience are encountered when climate thresholds are surpassed (Allen et al., 2012; De Coninck et al., 2018). Nevertheless, protecting and restoring natural carbon sinks has the potential to accomplish one-third of climate change mitigation required by 2030 to keep warming below 2°C (UNEP, 2021b). In this way, nature-based solutions not only protect communities from existing risks but also mitigate warming, thereby reducing the likelihood of more frequent and intense weather events into the future (Warren et al., 2021).

The Burlington, Ontario example is relevant in the context of this study as the region has experienced increased flood risk due to climate change and ecosystem degradation. The incorporation of nature-based solutions can enhance resilience by supporting stormwater management, temperature regulation, carbon sequestration, and improving biodiversity and ecosystem health. In Canada, there is a growing recognition for the contribution of natural assets in providing municipal services. Since 2016, over 90 local governments have implemented asset management strategies that acknowledge natural assets as essential infrastructure to be safeguarded and sustainably managed for the future (Eyquem et al., 2022). The City of Burlington is taking steps to incorporate natural assets into its Asset Management Plan, ensuring equitable consideration of engineered and natural assets in municipal service delivery (MNAI, 2022). As the region continues to grow and climate impacts intensify, nature's role in providing essential services that protect communities and mitigate hazards will become increasingly important.

Limitations and disclaimer: This report was prepared using the available data cited. Analyses and conclusions may change due to updated datasets and/or incorporating new information. The use of any conclusions drawn in this report is the sole responsibility of the user.

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