The importance of cities in protecting imperiled species

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Abstract

Habitat loss and alteration from urbanization are key threats to biodiversity. Thus, municipal decisions around imperiled species have the potential to affect urban conservation. Using Canada as a case study, we analyzed the distribution of mapped critical habitats and range extents of imperiled species in large cities and metropolitan areas. Our analysis revealed that ~28% of species at risk of extinction in Canada, spanning nine taxonomic groups, had more than 75% of their mapped critical habitat in Canadian metropolitan areas and 14% of species were urban-restricted. To explore municipal engagement in biodiversity conservation, we assessed the consideration of imperiled species in publicly available plans and strategies for 42 of the largest Canadian metropolitan areas. Over half of cities (72%) mentioned imperiled species in biodiversity or official plans and approximately half of cities (52%) outlined actions for these species. While biodiversity conservation is one of many competing priorities in cities, given their significant overlap with critical habitat, cities can play a large role in protecting and increasing public awareness of imperiled species.

Introduction

Urbanization is one of the leading causes of habitat loss globally and is accelerating as human populations increase (Simkin et al., 2022). As many urban areas are biodiversity hotspots (Ives et al., 2016), lands and waters within and around urban boundaries can overlap with habitats deemed critical for species at risk of extinction (hereafter imperiled species; Soanes & Lentini, 2019). For some endemic species, urban boundaries entirely overlap with known range extents or critical habitat areas (Aronson et al., 2014; Lepczyk et al., 2023; Soanes & Lentini, 2019). Consequently, species conservation within urban areas is increasingly imperative.

There is no strict, global definition for the degree of urbanization that constitutes a "city" (United Nations Statistics Division, 2017). Yet, about half of the global human population currently lives in cities and other densely populated urban areas, and that number is expected to continue to increase (Zlotnik, 2004). The effects of urbanization on biodiversity are well-documented (Mcdonald et al., 2008; McKinney, 2006). Nevertheless, urban biodiversity is one of the primary pathways through which people connect with nature and gain conservation awareness (Schwarz et al., 2017). Urban nature also provides important ecosystem services to urban residents. In this context, cities have a critical opportunity to play a pivotal role in the protection of imperiled species by strengthening conservation measures while also increasing public awareness of environmental issues (Simkin et al., 2022). However, because municipal authorities must work to balance infrastructural, environmental, cultural and economic needs within urban areas, integrating biodiversity conservation is one of many competing priorities and can pose a significant challenge.

In Canada, urban areas are concentrated in the most biodiverse regions (Coristine et al., 2018). Cities take up a very small portion of Canada's land mass, and municipal conservation efforts are inconsistent and not integrated across Canadian cities (Olive, 2014). Highly altered urban ecosystems can also be seen as a "lost cause" (Kowarik, 2018). Habitat loss caused by increasing urbanization and residential development has a disproportionately large impact on imperiled species compared to other threats (McCune et al., 2013; Venter et al., 2006).

Over 80% of the Canadian population lives in an urban area (Statistics Canada, 2022b). Evidence from surveys in Toronto and Vancouver in 2013 suggests that urban Canadians have little awareness of endangered species and do not feel responsible for their protection (Olive, 2014). Nevertheless, Canadians in general are strongly committed to conservation in principle (McCune et al., 2017). Thus, we posit that cities in Canada may have underrecognized and undervalued opportunities to improve protection for large numbers of imperiled species and involve Canadian urbanites - over 80% of the Canadian population - in conservation.

Existing federal protection for imperiled species in Canada is granted by the Species at Risk Act (SARA). Once assessed and listed under SARA, the critical habitat of an imperiled species is defined to the extent possible in a recovery strategy (Species at Risk Act [SARA], 2002). Critical habitat is protected on federal lands (SARA, 2002), but these cover on average <8% of the ranges of Canadian imperiled species (Bolliger et al., 2020). Terrestrial critical habitat can also be protected on non-federal lands through an emergency order, though there are only two species with active emergency orders at the time of writing (Western Chorus Frog (*Pseudacris triseriata*) and Greater Sage-Grouse (*Centrocercus urophasianus*); Government of Canada,

2025). Some provinces and territories have additional imperiled species legislation, of varying effectiveness (Gordon et al., 2024; Ray et al., 2021).

In Canada, municipal jurisdiction is strongly influenced by provincial policies. Although addressing environmental issues at local branches of government has been considered to be most effective (Gilbert et al., 1996), municipalities have limited jurisdiction over the protection of species and habitats. Nevertheless, local governments directly influence activities and processes that have significant effects on imperiled species and their habitat (Mallet, 2005) by implementing protection policies (Hodge et al., 2021), and by managing and regulating land-use planning (K. Thompson et al., 2019), infrastructure (e.g., transportation systems, stormwater conveyance), and greenspaces (Lam & Conway, 2018).

The important role of cities and local/regional authorities in preventing biodiversity loss is reinforced in several documents and ratifications of the United Nations, including target 12 of the Kunming-Montreal Global Biodiversity Framework (United Nations Convention on Biological Diversity, 2022). Despite their central role in policy-making, the United Nations does not yet fully recognize cities as stakeholders (Szörényi & Leroy, 2023). In Canada, there is a general lack of research connecting urban areas, municipal conservation policy, and imperiled species (Olive, 2014). To better understand these connections, we explored how frequently or explicitly biodiversity conservation is considered in municipal planning across Canada.

In this data-driven perspective, we used Canada as a case study to assess the importance of cities for conservation of imperiled species and explore how the urgent need to conserve biodiversity

was reflected in municipal biodiversity policies. Our objectives were to: a) determine the degree to which the mapped critical habitat and range extents of Canada's imperiled species overlap with urban areas; and b) quantify the consideration of imperiled species conservation and management in biodiversity plans and official city plans from large Canadian urban centres.

In Canada, habitat for several species at risk of extinction is restricted to urban areas

We assessed the degree to which habitat for imperiled species intersects with Canadian cities by quantifying the overlap between the mapped critical habitat and ranges of federally listed, imperiled species, and census metropolitan areas (hereafter CMAs) and census subdivisions (hereafter cities). We focused our analyses on species that have been assessed as imperiled in Canada (e.g., those assessed as Special Concern, Threatened or Endangered) and listed under SARA. CMAs are defined as an area with at least 100,000 people, comprising one or more cities that surround an urban core with a population of at least 50,000 residents (n = 156, Statistics Canada, 2021, 2023). CMAs often contain rural or non-urban areas that have not yet become urbanized, but are under direct pressure from urban sprawl (Statistics Canada, 2022b). Many cities are contained within CMAs and cities were included to provide spatial layers that contained a higher density of urbanized space (n = 446; Statistics Canada, 2023).

Critical habitat is defined as habitat necessary for the survival or recovery of an imperiled species, and contains areas a species depends on for its life processes (Environment and Climate Change Canada [ECCC], 2023). Mapped critical habitat is only identified for species listed as Endangered or Threatened, and can be based on occupancy data, habitat characteristics and/or functions, biophysical characteristics (ECCC, 2023; Lefebvre et al., 2018). We overlaid the mapped critical habitat of 273 listed species with CMAs and cities using ESRI ArcGIS Pro

158 (3.2.0). We found that for 77 of these imperiled species, >75% of mapped critical habitat
159 overlapped with CMAs (Figure 1). Thirty-eight (14%) species' mapped critical habitats were
160 urban-restricted, overlapping >99% with urban areas (Table 1). The mapped critical habitat of
161 fourteen imperiled species overlapped with cities by >75%, with habitat of four species
162 overlapping by >99% (Figure 2).

163 At the time of writing, critical habitat had not been defined or mapped for 249 species, and
164 SARA does not require mapping of critical habitat for species of Special Concern. Therefore, we
165 also analyzed urban overlap with species' range extents (n = 488 species; ECCC, 2023b). Range
166 extent represents all areas where a species may occur, including potentially unsuitable habitat
167 (see Appendix A). Overlap of these range extents with CMAs and cities in Canada was lower
168 than overlap with critical habitat. Forty-five imperiled species had range extents that overlapped
169 by ≥75% with CMAs, nine of which overlapped by >99% (Figure S1A). Six species' range
170 extents overlapped by >75% with Canadian cities (Figure S1B). None of these range extents
171 overlapped completely with Canadian cities, but the range extents of the silver hair moss
172 (*Fabronia pusilla*), Virginia goat's-rue (*Tephrosia virginiana*) and bird's-foot violet (*Viola*
173 *pedata*) overlapped with Canadian cities by 98%, 97%, and 91%, respectively.
174
175 Thirteen CMAs and seven cities overlapped ≥75% with the critical habitat of at least one
176 imperiled species (Figures 3 and S2). The Victoria CMA was built in the Garry Oak ecosystem
177 in southwestern British Columbia, which has dwindled to less than 5% of its original size within
178 Canada (Garry Oak Ecosystems Recovery Team, n.d.). This ecosystem is home to over 100
179 imperiled species (Garry Oak Ecosystems Recovery Team, n.d.) and much of the remaining

Garry Oak ecosystem occurs within the Victoria CMA. The city of Windsor, Ontario is in the planning stage of creating the first urban national park (Parks Canada Agency, 2024).

High overlap between an imperiled species' habitat and a city or CMA does not indicate that this species occurs or has critical habitat within a downtown core or urban matrix. However, it does indicate significant responsibility for a city (or cities) to support that species' recovery. For example, Blanding's turtles (*Emydoidea blandingii*), occur in cities in Ontario such as Ottawa, Pickering, Barrie, and Brantford (ECCC, 2018). The most heavily urbanized parts of these municipalities are not used directly by turtles, but they live within city boundaries, and thus rely on local governments to institute much-needed protection against threats such as development and transportation corridors (ECCC, 2018). In another example, nugget moss (*Microbryum vlassovii*) has two mapped critical habitats in Canada that fall completely within the boundaries of Penticton and Kamloops, British Columbia. Roadway maintenance, a municipal responsibility, is a potential threat to *M. vlassovii* in both cities (City of Kamloops, 2025; City of Penticton, 2025; COSEWIC, 2006). While *M. vlassovii* does not depend on urban structures for its survival (ECCC, 2012), the cities of Penticton and Kamloops maintain direct jurisdictional influence over the natural areas that support this species, and can therefore directly influence the species' persistence and recovery.

Planning for imperiled species management is limited in Canadian cities

Few Canadian cities have a dedicated strategy with detailed goals to protect biodiversity and address related environmental issues (hereafter biodiversity strategy) (ICLEI Canada, 2018). We searched for biodiversity strategies for 42 Canadian core cities (the municipalities with the

highest population within each CMA; Statistics Canada, 2022a). We conducted a Google search using the names of each city and the following terms: “biodiversity strategy,” “biodiversity plan,” “conservation strategy,” “conservation plan,” “environmental plan,” or “environmental strategy”. If the strategy did not appear in Google searches, we then searched on the city’s website. If the city did not have a publicly accessible biodiversity plan, we used Google searches using the city name AND “official plan” to access the official city plan, which are comprehensive documents focusing on multiple aspects within the city (policy, transit, land use, infrastructure, etc.). For cities in Québec, we translated these search terms to French. We then reviewed each biodiversity plan or official city plan for the following information: a) mention of imperiled species or SARA, b) a list or number of imperiled species in the city, or examples of imperiled species in the city, and c) implemented or anticipated actions to protect imperiled species in the city. For the plans that identified anticipated actions, we assigned standardized categories to the actions using the IUCN-CMP categories, version 2.0 (IUCN-CMP, 2016).

Seventeen core cities (40.5%) had a dedicated biodiversity strategy, and 12 (70.6%) of these strategies listed or mentioned imperiled species. These cities were generally more populous than those whose biodiversity strategies don’t mention imperiled species (Figure S3), suggesting that resource availability in smaller cities may limit the development of biodiversity planning for imperiled species. Six cities (35.3%) identified actions within their biodiversity strategies. Twenty-five cities (59.5%) did not have a dedicated biodiversity strategy, but 24 of these cities (96%) included biodiversity-related policies and actions within their city’s official plan.Of these 24 cities, 19 (79.2%) listed or mentioned imperiled species. Thirteen official plans (66.6%) described actions for imperiled species conservation.

Of the six cities (Calgary, Ottawa, Toronto, Vancouver, Hamilton, and Windsor) with biodiversity strategies that described actions to protect imperiled species, the level of detail in those actions varied. Some actions were broad and ambitious, for example, Calgary's "Our BiodiverCity" plan states: "Develop and implement management plans for all status species in Calgary parks and open space" (City of Calgary, 2015). Similarly, Windsor's Environmental Master Plan states: "Continue to implement Species at Risk protection measures in all areas of Windsor and develop strategies to improve their status" (City of Windsor, 2017). Other actions were more detailed, such as Hamilton's Five-Year Biodiversity Action Plan, with actions such as "Preserve and enhance City managed dune habitat along the Lake Ontario shoreline by reducing erosion through maintaining dedicated beach access, leaving deadwood and developing a Dune Management Plan" (City of Hamilton, 2024).

The median number of actions identified in official plans was five, while the median number of actions for biodiversity strategies was 32. Types of actions identified in dedicated biodiversity strategies were more varied than those identified in official city plans (Figure 4). Actions identified in official plans were often policies, zoning, standards, or by-laws. Biodiversity strategies often included actions involving community engagement and awareness, research and monitoring, training for conservation and municipal professionals, and direct land/water management, including removing invasive species and/or planting vegetation. All of these actions are important for protecting and recovering imperiled species (Binley et al., 2025), and biodiversity strategies included a broader scope of actions for cities to implement. Nonetheless, specific actions are an important component of effective conservation of imperiled species

(Green et al., 2019; Possingham et al., 2000), so cities can maximize their impacts by considering both broad strategies and specific actions when planning for biodiversity.

We note that these summaries of conservation plans do not fully represent what happens in practice (i.e., implementation), and imperiled species conservation may be included in other government documents, regulations, and policies, as well as initiatives led by other types of organizations (e.g. environmental non-governmental organizations). For example, in the official plan for Victoria, British Columbia, one action is to "Develop and maintain an Urban Forest Master Plan to enhance the urban forest on public and private land" (City of Victoria, 2013). The Urban Forest Master Plan details many actions intended to protect and improve the urban forest in Victoria (City of Victoria, 2013), which were not captured in this case study.

We also note that the policies included in official plans are based on provincial policies. For example, cities in Ontario are required to implement policies identified in the Ontario Provincial Planning Statement (hereafter OPPS; Government of Ontario, 2024) developed for Natural Heritage Systems. While all policies set out in the OPPS set a required minimum standard, they must be considered in complement with each other (Government of Ontario, 2024), which can allow cities to prioritize aspects of the OPPS as long as the city policy does not conflict with policies in the OPPS. Therefore, even though the actions identified in official plans have regulatory power, they may not be tailored to the municipality and the local ecology. It is unclear whether this approach may limit the efficacy of protection for imperiled species within these jurisdictions.

At the time of writing, three additional cities in Canada (Gatineau, Kingston, and Québec City) have committed to creating biodiversity strategies in accordance with Kunming-Montreal Global Biodiversity Framework target goals. Kingston will release its Biodiversity Conservation Strategy in 2026 (City of Kingston, 2023), and Gatineau has published a preliminary version of its biodiversity strategy (Ville de Gatineau, 2023). The development of specific biodiversity strategies, with detailed actions and timelines, could improve the ability of municipalities to protect wildlife in their city, and can increase accountability for those actions.

Conclusion

Our analysis revealed that critical habitat and range extents for imperilled species in Canada (i.e., those listed as Special Concern, Threatened, or Endangered under the federal Species at Risk Act) overlaps substantially with Canadian CMAs and cities. Given cities only comprise 0.14% of Canada's land area (Statistics Canada, n.d.; World Bank, n.d.), municipal and regional governments have a disproportionately large responsibility for imperilled species conservation and protection in relation to their land area. Despite their importance in protecting imperiled species, we found that municipal strategies and planning for conservation are still limited. We found 20 cities had municipal strategies that outlined specific actions for imperiled species. Since the federal and provincial governments are often limited in their capacity to protect imperiled species due to land tenure issues (Scheele et al., 2018), municipal governments could fill this gap in protection. Of course, cities often have competing priorities, and conserving imperiled species cannot be their highest priority. Supporting municipalities in developing and implementing plans has the potential to improve protection initiatives for the 14% of species whose critical habitats

294 are limited to urban areas. Adequate funding from provincial/state and federal agencies is
295 required to provide capacity and resources for urban biodiversity conservation.
296
297 Non-governmental organizations and other community and volunteer-based programs are also
298 crucial for imperiled species conservation in urban areas (Olive & Penton, 2018). For example,
299 the conservation of a population of Jefferson Salamanders (*Ambystoma jeffersonianum*) in
300 Kitchener, Ontario, illustrates how community leadership can result in political engagement and
301 action. Jefferson salamanders experienced high road mortality along Stauffer Road in Kitchener,
302 which they must cross during the breeding season to lay their eggs in vernal pools (C.
303 Thompson, 2015). Local grassroots organizations, concerned citizens and environmental groups
304 spearheaded an operation to close this road during the spring, to protect the salamanders when
305 they are most vulnerable (C. Thompson, 2015). The municipal government then agreed to
306 temporarily close this road once a year during the migration. Another example is the Bird-
307 Friendly Cities certification program, funded by the federal government, which unites concerned
308 community groups and municipalities to reduce threats to birds in urban environments (Nature
309 Canada, n.d.).
310
311 Many aspects of our Canadian case study are applicable on a global scale. A similarly high
312 proportion of imperiled species were restricted to urban areas in Australia (Soanes & Lentini,
313 2019). As the global population increases, so does the proportion of people living in urban areas
314 worldwide (Cohen, 2006; Montgomery, 2008). As such, it is more important than ever for
315 municipal and regional governments to know which species' habitats fall within their
316 jurisdiction, and to implement imperilled species protection into urban planning and expansion.

317 More studies on urban, imperilled species, spanning developed and developing regions, and
318 considering the overlapping needs to people and biodiversity, can inform policies to improve
319 biodiversity conservation and human well-being in urban areas worldwide. Moreover, additional
320 efforts to recognize and further develop the role of urban and regional planners and managers in
321 conservation are required (e.g., formal training, sharing of successes and failures), given their
322 potential to serve as key actors in protecting and restoring biodiversity.

References

Aronson, M. F. J., La Sorte, F. A., Nilon, C. H., Katti, M., Goddard, M. A., Lepczyk, C. A., Warren, P. S., Williams, N. S. G., Cilliers, S., Clarkson, B., Dobbs, C., Dolan, R., Hedblom, M., Klotz, S., Kooijmans, J. L., Kühn, I., MacGregor-Fors, I., McDonnell, M., Mörtberg, U., … Winter, M. (2014). A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. *Proceedings of the Royal Society B: Biological Sciences*, *281*(1780), 20133330. https://doi.org/10.1098/rspb.2013.3330

Binley, A. D., Haddaway, L., Buxton, R., Lalla, K. M., Lesbarreres, D., Smith, P. A., & Bennett, J. R. (2025). Endangered species lack research on the outcomes of conservation action. *Conservation Science and Practice*, *n/a*(n/a), e13304. https://doi.org/10.1111/csp2.13304

Bolliger, C. S., Raymond, C. V., Schuster, R., & Bennett, J. R. (2020). Spatial coverage of protection for terrestrial species under the Canadian Species at Risk Act. *Écoscience*, *27*(2), 141–147. https://doi.org/10.1080/11956860.2020.1741497

City of Calgary. (2015). *Our BiodiverCity*. https://www.calgary.ca/parks/wildlife/biodiversity.html

City of Hamilton. (2024). *A Five-Year Biodiversity Action Plan for Hamilton, 2024*. https://pub-hamilton.escribemeetings.com/filestream.ashx?DocumentId=431784

City of Kamloops. (2025). *Road Maintenance*. https://www.kamloops.ca/city-services/transportation-roads/road-maintenance

City of Kingston. (2023). *Kingston's Strategic Plan 2023-2026*. https://www.cityofkingston.ca/media/as5a2uyc/council_plan_strategicplan2023-2026.pdf

City of Penticton. (2025). *Road Repair & Maintenance*. https://www.penticton.ca/city-

346 services/roadwork-construction/road-repair-and-maintenance
347 City of Victoria. (2013, February). *Urban Forest Master Plan*.
348 https://www.victoria.ca/media/file/urban-forest-master-planpdf
349 City of Windsor. (2017). *Environmental Master Plan*.
350 https://www.citywindsor.ca/Documents/residents/environment/EMP%20Final%20Copy
351 %20January%2018.pdf
352 Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and
353 key challenges for sustainability. *Technology in Society*, *28*(1), 63–80.
354 https://doi.org/10.1016/j.techsoc.2005.10.005
355 Coristine, L. E., Jacob, A. L., Schuster, R., Otto, S. P., Baron, N. E., Bennett, N. J., Bittick, S. J.,
356 Dey, C., Favaro, B., Ford, A., Nowlan, L., Orihel, D., Palen, W. J., Polfus, J. L.,
357 Shiffman, D. S., Venter, O., & Woodley, S. (2018). Informing Canada's commitment to
358 biodiversity conservation: A science-based framework to help guide protected areas
359 designation through Target 1 and beyond. *FACETS*, *3*(1), 531–562.
360 https://doi.org/10.1139/facets-2017-0102
361 COSEWIC. (2006). *Nugget moss (Microbryum vlassovii) COSEWIC assessment and status*
362 *report*. https://www.canada.ca/en/environment-climate-change/services/species-risk-
363 public-registry/cosewic-assessments-status-reports/nugget-moss.html
364 Environment and Climate Change Canada. (2012, September 20). *Nugget moss (Microbryum*
365 *vlassovii): Recovery strategy 2012* [Program descriptions;research].
366 https://www.canada.ca/en/environment-climate-change/services/species-risk-public-
367 registry/recovery-strategies/nugget-moss-2012.html
368 Environment and Climate Change Canada. (2018, December 20). *Blanding's Turtle (Emydoidea*

blandingii): Recovery strategy 2018. https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/recovery-strategies/blandings-turtle-2018.html

Environment and Climate Change Canada. (2023a). *Critical Habitat for Species at Risk National Dataset* [Dataset]. https://data-donnees.az.ec.gc.ca/data/species/protectrestore/critical-habitat-species-at-risk-canada/

Environment and Climate Change Canada. (2023b). *Range Map extents—Species at Risk—Canada—Open Government Portal* [Dataset]. https://open.canada.ca/data/en/dataset/d00f8e8c-40c4-435a-b790-980339ce3121

Garry Oak Ecosystems Recovery Team. (n.d.). *Species at Risk*. Retrieved February 7, 2025, from https://goert.ca/about/species-at-risk/

Gilbert, R., Stevenson, D., Girardet, H., & Stren, R. (1996). Making Cities Work: The Role of Local Authorities in the Urban Environment. In *Making Cities Work: Role of Local Authorities in the Urban Environment*. Routledge. https://doi.org/10.4324/9781315066431

Gordon, S. C. C., Duchesne, A. G., Dusevic, M. R., Galán-Acedo, C., Haddaway, L., Meister, S., Olive, A., Warren, M., Vincent, J. G., Cooke, S. J., & Bennett, J. R. (2024). Assessing species at risk legislation across Canadian provinces and territories. *FACETS*, *9*, 1–18. https://doi.org/10.1139/facets-2023-0229

Government of Canada. (2025). *Species at risk public registry* [Dataset]. https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

Government of Ontario. (2024). *Provincial Planning Statement, 2024*.

https://www.ontario.ca/files/2024-10/mmah-provincial-planning-statement-en-2024-10-23.pdf

Green, E. J., Buchanan, G. M., Butchart, S. H. M., Chandler, G. M., Burgess, N. D., Hill, S. L. L., & Gregory, R. D. (2019). Relating characteristics of global biodiversity targets to reported progress. *Conservation Biology*, *33*(6), 1360–1369. https://doi.org/10.1111/cobi.13322

Hodge, G., Gordon, D. L. A., & Shaw, P. (2021). *Planning Canadian communities: An introduction to the principles, practices, and participants in the 21st century* (Seventh edition.). Nelson.

ICLEI Canada. (2018). *Canada Target 4 2018 Survey of Municipalities Report*. https://chm.cbd.int/api/v2013/documents/52B10DCA-2774-188E-8214-AE0456E231F5/attachments/204953/Canada%20Target%204%202018%20Survey%20of%20Municipalities%20Report.pdf

IUCN-CMP. (2016). *Unified Classification of Conservation Actions, Version 2.0*. https://docs.google.com/spreadsheets/d/1i25GTaEA80HwMvsTiYkdOoXRPWiVPZ5l6KioWx9g2zM/edit?usp=embed_facebook

Ives, C. D., Lentini, P. E., Threlfall, C. G., Ikin, K., Shanahan, D. F., Garrard, G. E., Bekessy, S. A., Fuller, R. A., Mumaw, L., Rayner, L., Rowe, R., Valentine, L. E., & Kendal, D. (2016). Cities are hotspots for threatened species. *Global Ecology and Biogeography*, *25*(1), 117–126. https://doi.org/10.1111/geb.12404

Kowarik, I. (2018). Urban wilderness: Supply, demand, and access. *Urban Forestry & Urban Greening*, *29*, 336–347. https://doi.org/10.1016/j.ufug.2017.05.017

Lam, S. T., & Conway, T. M. (2018). Ecosystem services in urban land use planning policies: A

415 case study of Ontario municipalities. *Land Use Policy*, *77*, 641–651.
416 https://doi.org/10.1016/j.landusepol.2018.06.020
417 Lefebvre, S. L., Landry-Cuerrier, M., & Humphries, M. M. (2018). Identifying the critical
418 habitat of Canadian vertebrate species at risk. *Canadian Journal of Zoology*, *96*(4), 297–
419 304. https://doi.org/10.1139/cjz-2016-0304
420 Lepczyk, C. A., Aronson, M. F., & La Sorte, F. A. (2023). Cities as sanctuaries. *Frontiers in*
421 *Ecology and the Environment*, *21*(5), 251–259. https://doi.org/10.1002/fee.2637
422 Mallet, J. S. (2005). *Municipal Powers, Land Use Planning, and the Environment:*
423 *Understanding the Public's Role*.
424 https://www.canlii.org/en/commentary/doc/2005CanLIIDocs209#!fragment//BQCwhgzi
425 BcwMYgK4DsDWszIQewE4BUBTADwBdoByCgSgBpltTCIBFRQ3AT0otokLC4EbDt
426 yp8BQkAGU8pAELcASgFEAMioBqAQQByAYRW1SYAEbRS2ONWpA
427 McCune, J. L., Carlsson, A. M., Colla, S., Davy, C., Favaro, B., Ford, A. T., Fraser, K. C., &
428 Martins, E. G. (2017). Assessing public commitment to endangered species protection: A
429 Canadian case study. *FACETS*, *2*, 178–194. https://doi.org/10.1139/facets-2016-0054
430 McCune, J. L., Harrower, W. L., Avery-Gomm, S., Brogan, J. M., Csergő, A.-M., Davidson, L.
431 N. K., Garani, A., Halpin, L. R., Lipsen, L. P. J., Lee, C., Nelson, J. C., Prugh, L. R.,
432 Stinson, C. M., Whitney, C. K., & Whitton, J. (2013). Threats to Canadian species at risk:
433 An analysis of finalized recovery strategies. *Biological Conservation*, *166*, 254–265.
434 https://doi.org/10.1016/j.biocon.2013.07.006
435 Mcdonald, R. I., Kareiva, P., & Forman, R. T. T. (2008). The implications of current and future
436 urbanization for global protected areas and biodiversity conservation. *Biological*
437 *Conservation*, *141*(6), 1695–1703. https://doi.org/10.1016/j.biocon.2008.04.025

McKinney, M. L. (2006). Urbanization as a major cause of biotic homogenization. *Biological Conservation*, *127*(3), 247–260. https://doi.org/10.1016/j.biocon.2005.09.005

Montgomery, M. R. (2008). The Urban Transformation of the Developing World. *Science*, *319*(5864), 761–764. https://doi.org/10.1126/science.1153012

Nature Canada. (n.d.). *Bird Friendly City: A Certification Program—Nature Canada*. Retrieved January 24, 2025, from https://naturecanada.ca/defend-nature/how-you-help-us-take-action/bfc/

Olive, A. (2014). Urban awareness and attitudes toward conservation: A first look at Canada's cities. *Applied Geography*, *54*, 160–168. https://doi.org/10.1016/j.apgeog.2014.08.002

Olive, A., & Penton, G. (2018). Species at risk in Ontario: An examination of environmental non-governmental organizations. *Canadian Geographies / Géographies Canadiennes*, *62*(4), 562–574. https://doi.org/10.1111/cag.12483

Parks Canada Agency. (2024, December 23). *Pre-feasibility report for Windsor, Ontario*. https://parks.canada.ca/pun-nup/potentiels-candidates/windsor/faisabilite-feasbility

Possingham, H. P., Andelman, S. J., Noon, B. R., Trombulak, S., & Pulliam, H. R. (2000). Making Smart Conservation Decisions. In *Conservation biology: Research priorities for nature conservation*.

Ray, J. C., Grimm, J., & Olive, A. (2021). The biodiversity crisis in Canada: Failures and challenges of federal and sub-national strategic and legal frameworks. *FACETS*, *6*, 1044–1068. https://doi.org/10.1139/facets-2020-0075

Scheele, B. C., Legge, S., Armstrong, D. P., Copley, P., Robinson, N., Southwell, D., Westgate, M. J., & Lindenmayer, D. B. (2018). How to improve threatened species management: An Australian perspective. *Journal of Environmental Management*, *223*, 668–675.

https://doi.org/10.1016/J.JENVMAN.2018.06.084

Schwarz, N., Moretti, M., Bugalho, M. N., Davies, Z. G., Haase, D., Hack, J., Hof, A., Melero, Y., Pett, T. J., & Knapp, S. (2017). Understanding biodiversity-ecosystem service relationships in urban areas: A comprehensive literature review. *Ecosystem Services*, *27*, 161–171. https://doi.org/10.1016/j.ecoser.2017.08.014

Simkin, R. D., Seto, K. C., McDonald, R. I., & Jetz, W. (2022). Biodiversity impacts and conservation implications of urban land expansion projected to 2050. *Susutainability Science*, *119*(12). https://doi.org/10.1073/pnas.2117297119

Soanes, K., & Lentini, P. E. (2019). When cities are the last chance for saving species. *Frontiers in Ecology and the Environment*, *17*(4), 225–231. https://doi.org/10.1002/fee.2032

Species at Risk Act (2002). https://www.canada.ca/en/environment-climate-change/services/species-risk-act-accord-funding/listing-process/act.html

Statistics Canada. (n.d.). *Geography*. Retrieved February 7, 2025, from https://www150.statcan.gc.ca/n1/pub/11-402-x/2011000/chap/geo/geo-eng.htm

Statistics Canada. (2021, November 17). *Dictionary, Census of Population, 2021 – Census metropolitan area (CMA) and census agglomeration (CA)*. https://www12.statcan.gc.ca/census-recensement/2021/ref/dict/az/Definition-eng.cfm?ID=geo009

Statistics Canada. (2022a, February 9). *Population and population growth rate of census metropolitan areas in Canada, 2011 to 2016 and 2016 to 2021, ranked by percentage of growth in 2021*. https://www150.statcan.gc.ca/n1/daily-quotidien/220209/t002a-eng.htm

Statistics Canada. (2022b, February 9). *The Daily—Canada's large urban centres continue to grow and spread*. https://www150.statcan.gc.ca/n1/daily-quotidien/220209/dq220209b-

484 eng.htm
485 Statistics Canada. (2023). *2021 Census Boundary files* (No. Census metropolitan areas and
486 census agglomerations, Census subdivisions) [Dataset].
487 https://www12.statcan.gc.ca/census-recensement/2021/geo/sip-pis/boundary-
488 limites/index2021-eng.cfm?year=21
489 Szörényi, A., & Leroy, P. (2023, February 1). *Why cities should be fully recognized stakeholders*
490 *within the UN system*. World Economic Forum.
491 https://www.weforum.org/stories/2023/02/cities-should-play-stronger-role-within-the-un-
492 system/
493 Thompson, C. (2015, March 4). *Salamander love closes Kitchener road each spring*. The
494 Waterloo Region Record. https://www.therecord.com/news/waterloo-region/salamander-
495 love-closes-kitchener-road-each-spring/article_7621ac14-09bd-5e1d-8a6b-
496 4f9ca75158e8.html
497 Thompson, K., Sherren, K., & Duinker, P. N. (2019). The use of ecosystem services concepts in
498 Canadian municipal plans. *Ecosystem Services*, *38*, 100950.
499 https://doi.org/10.1016/j.ecoser.2019.100950
500 United Nations Convention on Biological Diversity. (2022). *Kunming-Montreal Global*
501 *Biodiversity Framework*.
502 https://www.cbd.int/doc/c/e6d3/cd1d/daf663719a03902a9b116c34/cop-15-l-25-en.pdf
503 United Nations Statistics Division. (2017). *Population density and urbanization*.
504 https://unstats.un.org/unsd/demographic/sconcerns/densurb/densurbmethods.htm
505 Venter, O., Brodeur, N. N., Nemiroff, L., Belland, B., Dolinsek, I. J., & Grant, J. W. A. (2006).
506 Threats to Endangered Species in Canada. *BioScience*, *56*(11), 903–910.

https://doi.org/10.1641/0006-3568(2006)56[903:TTESIC]2.0.CO;2

Ville de Gatineau. (2023). *Plan d'action de la biodiversité et Plan de gestion de l'eau*. https://www.gatineau.ca/portail/default.aspx?p=guichet_municipal/participation_citoyenne/consultations_publiques/consultations_publiques_2023/plan_action_biodiversite_plan_gestion_eau

World Bank. (n.d.). *Urban land area (sq. Km)—Canada*. World Bank Open Data. Retrieved February 7, 2025, from https://data.worldbank.org

Zlotnik, H. (2004). World Urbanization: Trends and Prospects. In *New Forms of Urbanization*. Routledge.

517 **Tables**

518 Table 1. Species with mapped critical habitats overlapping >99% with Canadian Metropolitan

519 Areas (CMA).

Common Name	Scientific Name	Taxonomic Group	% Overlap
Poor Pocket Moss	*Fissidens pauperculus*	Lichens & Mosses	100
Western Harvest Mouse (*dychei* subspecies)	*Reithrodontomys megalotis dychei*	Mammals	100
Dwarf Sandwort	*Minuartia pusilla*	Vascular Plants	100
Fragrant Popcornflower	*Plagiobothrys figuratus*	Vascular Plants	100
Muhlenberg's Centaury	*Centaurium muehlenbergii*	Vascular Plants	100
Prairie Lupine	*Lupinus lepidus*	Vascular Plants	100
Tall Bugbane	*Actaea elata*	Vascular Plants	100
Round-leaved Greenbrier (Great Lakes Plains population)	*Smilax rotundifolia*	Vascular Plants	100
Nugget Moss	*Microbryum vlassovii*	Lichens & Mosses	100
Colicroot	*Aletris farinosa*	Vascular Plants	100
Dense Spike-primrose	*Epilobium*	Vascular Plants	100

	densiflorum		
Deltoid Balsamroot	*Balsamorhiza deltoidea*	Vascular Plants	99.99
Vesper Sparrow (*affinis* subspecies)	*Pooecetes gramineus affinis*	Birds	99.99
Streambank Lupine	*Lupinus rivularis*	Vascular Plants	99.99
Kellogg's Rush	*Juncus kelloggii*	Vascular Plants	99.99
Brook Spike-primrose	*Epilobium torreyi*	Vascular Plants	99.99
Rayless Goldfields	*Lasthenia glaberrima*	Vascular Plants	99.99
Tall Woolly-heads	*Psilocarphus elatior*	Vascular Plants	99.99
Rosy Owl-clover	*Orthocarpus bracteosus*	Vascular Plants	99.99
Howell's Triteleia	*Triteleia howellii*	Vascular Plants	99.99
Taylor's Checkerspot	*Euphydryas editha taylori*	Arthropods & Molluscs	99.99
Coast Microseris	*Microseris bigelovii*	Vascular Plants	99.99
Blue-grey Taildropper	*Prophysaon coeruleum*	Arthropods & Molluscs	99.99
Ord's Kangaroo Rat	*Dipodomys ordii*	Mammals	99.99
Seaside Bone	*Hypogymnia heterophylla*	Lichens & Mosses	99.98
Horsetail Spike-rush	*Eleocharis*	Vascular Plants	99.98

	equisetoides		
Hine's Emerald	*Somatochlora hineana*	Arthropods & Molluscs	99.97
Seaside Birds-foot Lotus	*Lotus formosissimus*	Vascular Plants	99.97
Bearded Owl-clover	*Triphysaria versicolor*	Vascular Plants	99.97
Townsend's Mole	*Scapanus townsendii*	Mammals	99.97
Bear's-foot Sanicle	*Sanicula arctopoides*	Vascular Plants	99.97
Golden Paintbrush	*Castilleja levisecta*	Vascular Plants	99.96
California Buttercup	*Ranunculus californicus*	Vascular Plants	99.94
Spotted Wintergreen	*Chimaphila maculata*	Vascular Plants	99.93
Coastal Giant Salamander	*Dicamptodon tenebrosus*	Amphibians	99.76
Slender Bush-clover	*Lespedeza virginica*	Vascular Plants	99.41
Willowleaf Aster	*Symphyotrichum praealtum*	Vascular Plants	99.29
Prothonotary Warbler	*Protonotaria citrea*	Birds	99.07

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Figures

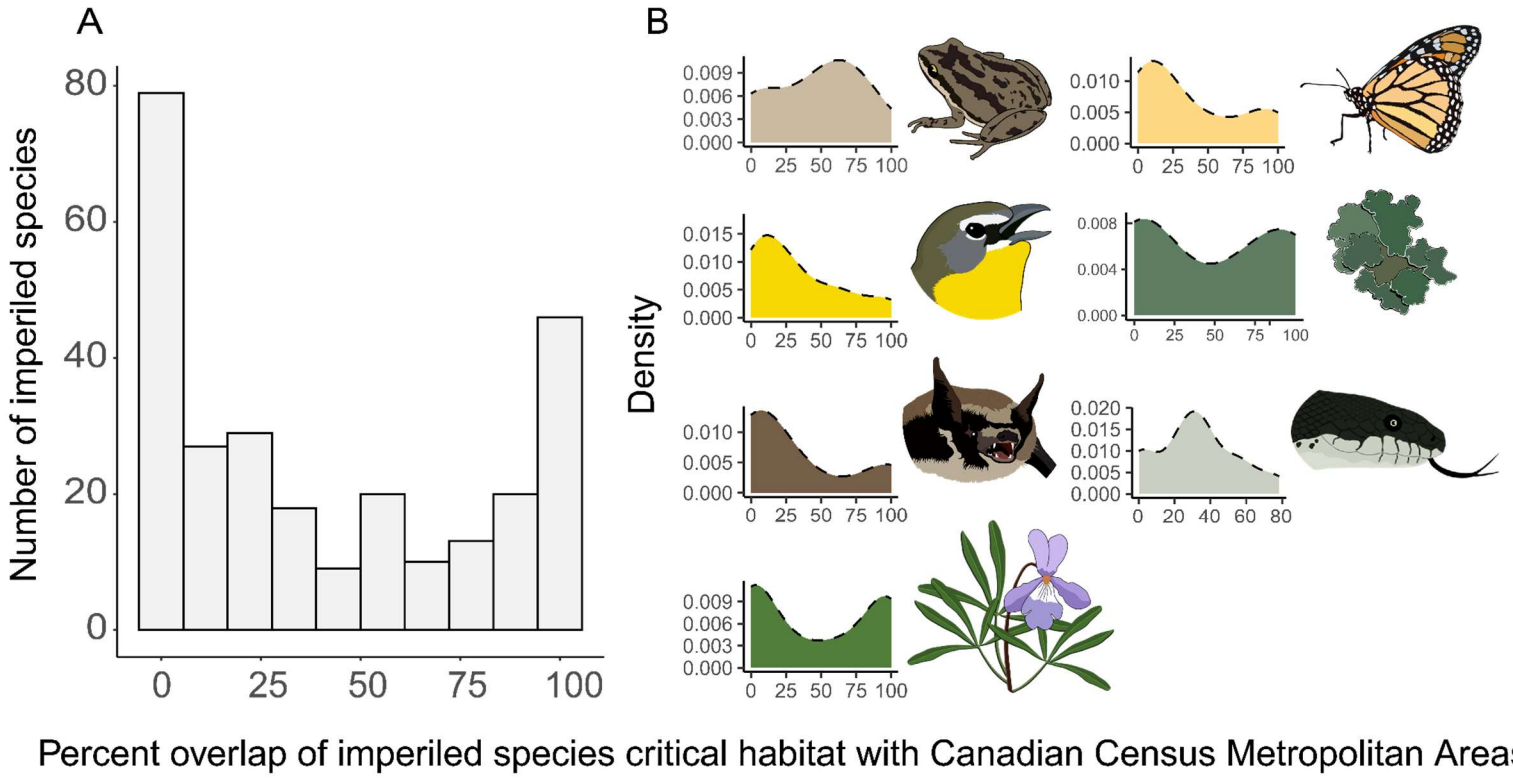


Figure 1. **A.** Frequency distribution of percent overlap between mapped critical habitat for imperiled Canadian species and Canadian Metropolitan Areas (CMAs - areas with at least 100,000 people comprising one or more cities, surrounding a core city) across 7 taxonomic groupings. **B.** Density plots of percent overlap between imperiled species critical habitat and CMAs across 7 taxonomic groups (clockwise from top-left: Amphibians, Arthropods & Molluscs, Birds, Lichens & Mosses, Mammals, Reptiles, and Vascular Plants. Note: illustrations of Yellow-breasted Chat, Boreal Forest Lichen, Little Brown Myotis, Gray Ratsnake, and Bird's Foot Violet adapted with permission from photographs by: Guy Babineau, Robert Cameron, the US Fish & Wildlife Service, Robert Tervo, and the US National Park Service, respectively.

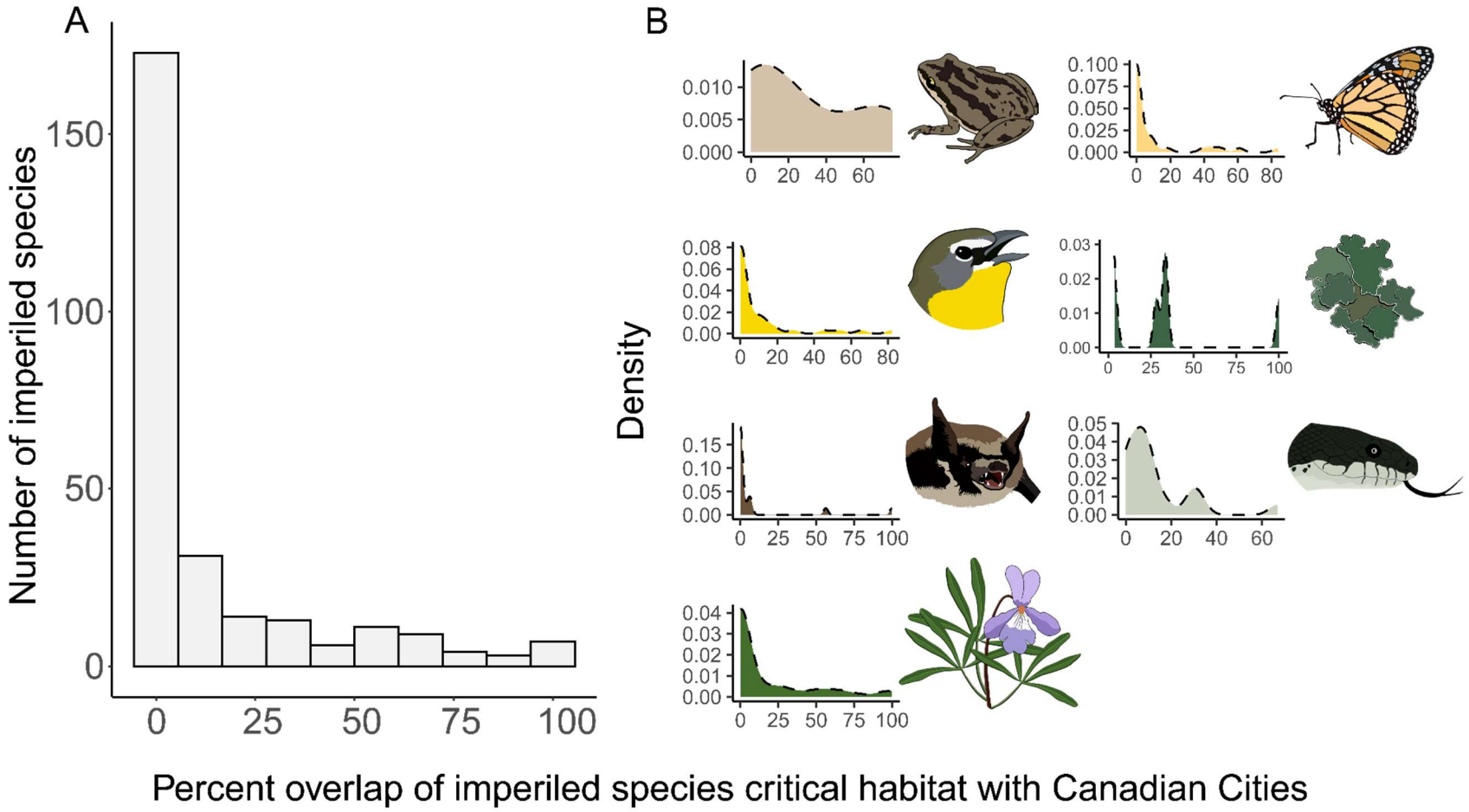


Figure 2. **A.** Frequency distribution of percent overlap between imperiled species critical habitat and Canadian cities across 7 taxonomic groupings. **B.** Density plots of percent overlap between imperiled species critical habitat and Canadian cities across 7 taxonomic groups (clockwise from top-left: Amphibians, Arthropods & Molluscs, Birds, Lichens & Mosses, Mammals, Reptiles, and Vascular Plants. Note: illustrations of Yellow-breasted Chat, Boreal Forest Lichen, Little Brown Myotis, Gray Ratsnake, and Bird's Foot Violet adapted with permission from photographs by: Guy Babineau, Robert Cameron, the US Fish & Wildlife Service, Robert Tervo, and the US National Park Service, respectively.

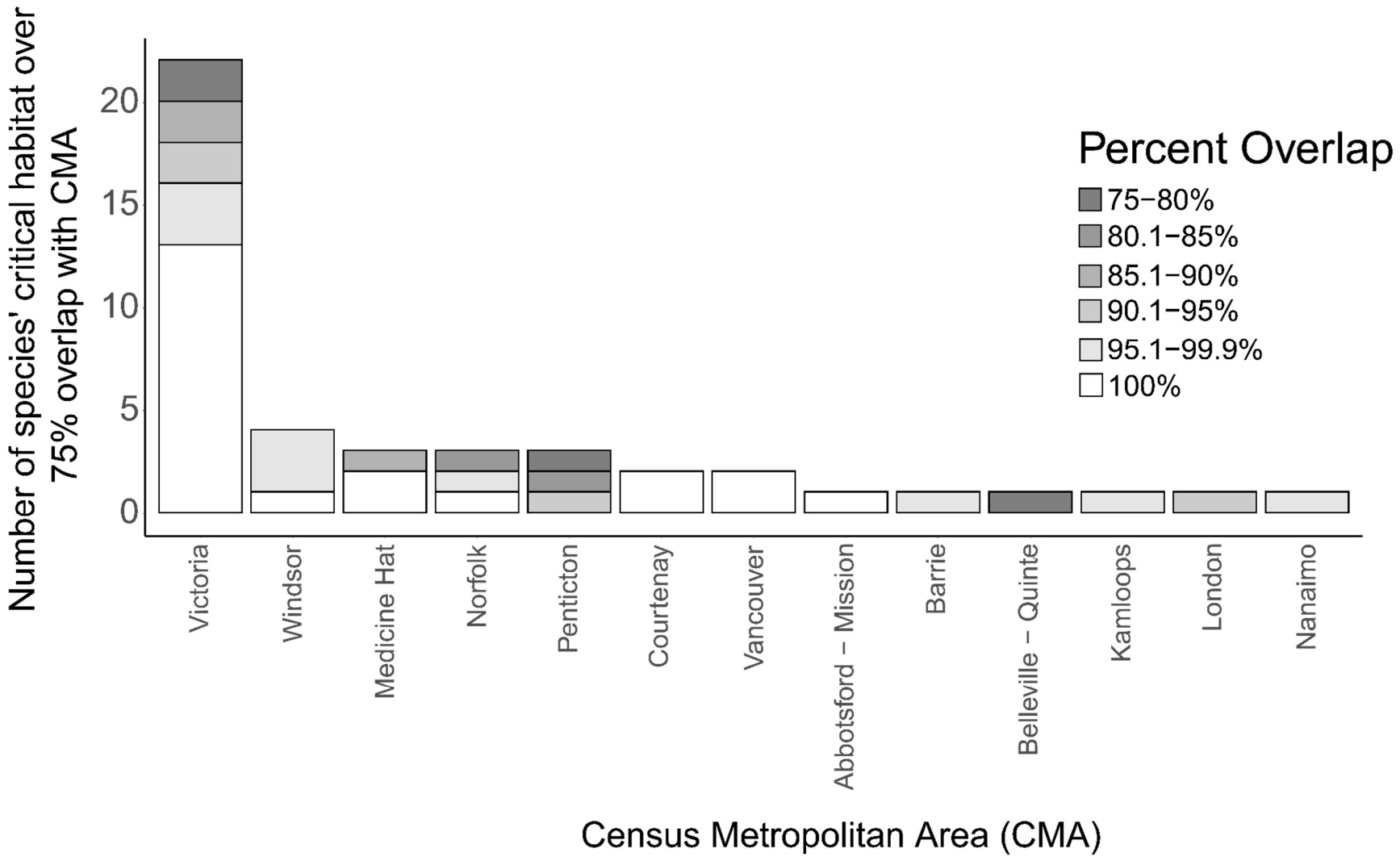
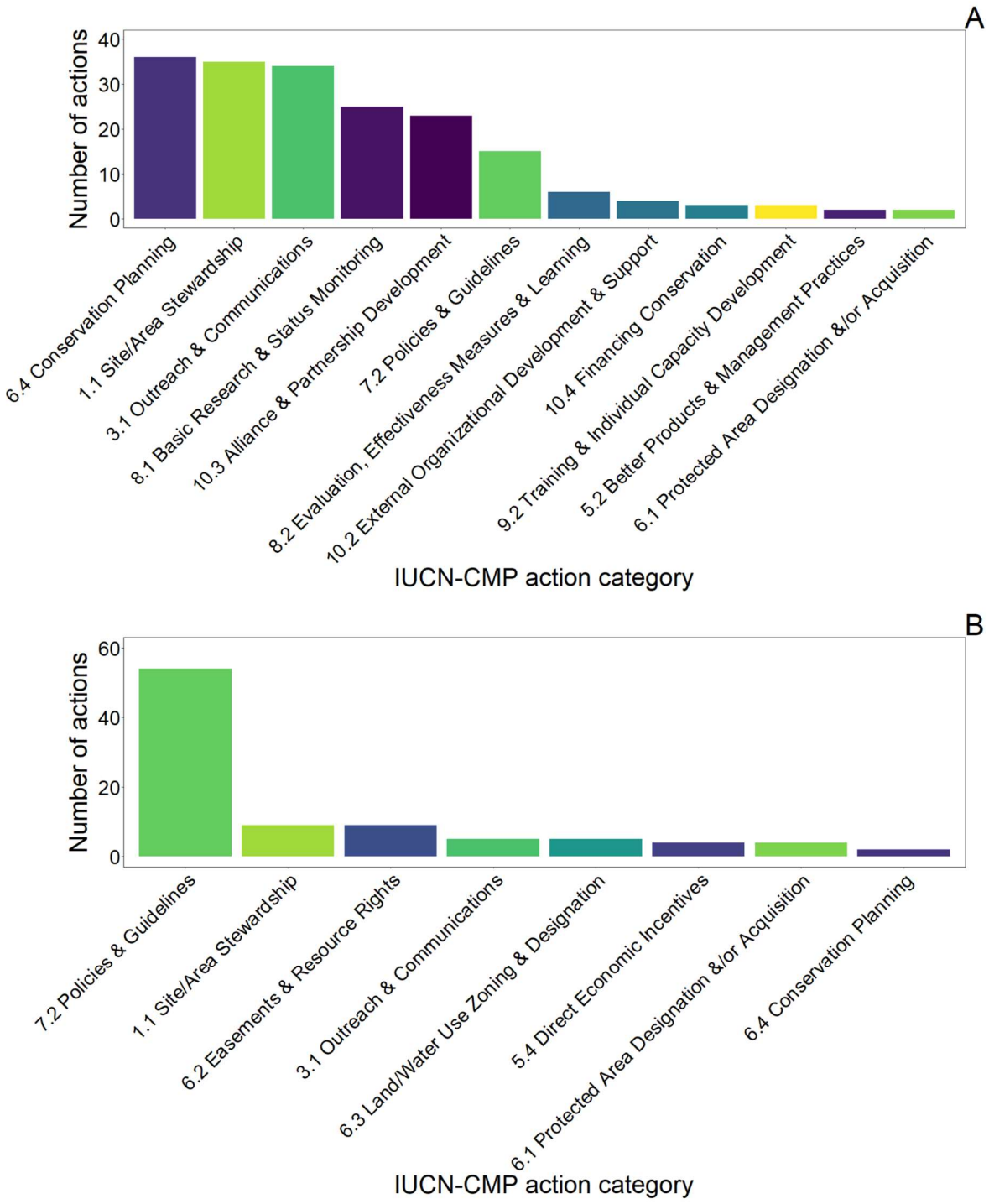


Figure 3. Canadian census metropolitan areas that overlap >75% with the mapped critical habitat of Canadian imperiled species and the number of mapped critical habitats by percentage.



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539 Figure 4. Distribution of action categories identified in municipal biodiversity strategies (A) and official city plans

540 (B). Action categories were assigned using IUCN-CMP standardized action categories, version 2.0 (IUCN-CMP,

541 2016).

Appendix A

Critical Habitat: distinctions and limitations

It is important that we consider our results within the context of the current state of range and critical habitat mapping for Canada's imperiled wildlife, and how this is reflected in the data used in our analysis.

Canada's Species at Risk Act (hereafter the Act) defines critical habitat as "the habitat [...] necessary for the survival or recovery of a listed wildlife species [...]" (Species at Risk Act, 2002, c 29, s 2.1). The Act requires that critical habitat be designated, "to the extent possible", in the recovery strategies for all threatened, endangered, and extirpated species listed (Species at Risk Act, 2002, s 11(2d). The process of defining and mapping critical habitat is complex, and has been criticized for its procedural inefficiency and ineffectiveness in supporting the conservation of imperiled species in Canada (Lefebvre et al., 2018; Bird & Hodges, 2017). Most egregious is the fact that many threatened, endangered and extirpated species remain without any designated critical habitat. In a review conducted by Bird & Hodges (2017), it was found that, as of 2015, 37.1% of threatened, endangered, or extirpated species (including aquatic species), had any form of mapped critical habitat. Furthermore, only 11.8% of these species maintained *fully* mapped critical habitat in their recovery strategy, with the remaining 25.3% of species' mapped critical habitat being considered *partial* and needing further study (Bird & Hodges, 2017).

In addition to the limited extent of current critical habitat designations, the way critical habitat is mapped spatially must also be considered. For example, many critical habitats are mapped as large, landscape-level polygons (e.g. 100 x 100km) that, using available data on the species in

question, have been determined to include some habitat(s) known to be occupied and/or suitable for its recovery or survival. While these large polygons do contain occupied and suitable habitat for the species in question, the exact location of these habitats is not known, and instead indicate "the general geographic area within which critical habitat is found" (ECCC, 2016b, Figure 4., sec. 6.3). This broad-scale approach to critical habitat mapping is used when species are known to be sparsely distributed, or abundant only at a very local-scale, over a relatively large area (ECCC, 2016b). By their nature, critical habitat designations mapped as large polygons contain significant amounts of land that are unoccupied or unsuitable for the species in question, rather than having occupied or suitable habitat over its entire span (ECCC, 2016b). In contrast, some critical habitats are mapped as small, site-level polygons (1 x 1km), defined as a parcel or patch of occupied and suitable habitat with a small surrounding area (ECCC, 2016b).

The current state of critical habitat designations in Canada impacts how we interpret our results. The most important impact is the fact that the extent of spatial overlap between currently mapped critical habitats and urban boundaries does not reflect the true overlap, and is likely quite conservative. As such, the inclusion of currently mapped critical habitat for threatened, endangered, and extirpated species in our analysis is especially illustrative since we found that the critical habitat of several species maintain high percent overlap (>75%) with urban cities (CMAs) and cities, 77 and 14, respectively. With less than 40% of listed species in Canada having any mapped critical habitat, only 11.8% of which are considered full rather than partial, it is very likely that the true overlap between urban cities and Canadian imperiled species is significantly higher than what was discovered during our analysis (Bird & Hodges, 2015).

We must also be mindful of what percent overlap between mapped critical habitat and urban areas can actually tell us about the relationship between urban areas and imperiled species. This is especially important since the land included inside mapped critical habitat polygons is not entirely composed of habitat suitable or necessary for each species' recovery (ECCC, 2016b). For example, a 92% overlap between an endangered species' mapped critical habitat and a City does not explicitly mean that 92% of that species' critical habitat is overlapped by an urban boundary, especially if said species' critical habitat is mapped at a landscape-level scale. However, such a high percent overlap does indicate that critical habitat is very likely to occur within that city's boundaries. Furthermore, since many critical habitat designations are based on occupancy data (Lefebvre et al., 2018), we can also consider high percent overlap between mapped critical habitat and urban boundaries as being indicative that both the imperiled species and its critical habitat occurs on lands under the jurisdiction of cities.

Range extent data is important to include in our analysis for several reasons. Firstly, it provides spatial data for a much more exhaustive list of imperiled species in Canada compared to mapped critical habitat (488 vs. 273 species, respectively). For instance, range extent data includes species that are not currently listed as threatened, endangered, or extirpated, such as those listed as species of special concern or not at risk, or those with no status. Despite being more exhaustive in its coverage of imperiled wildlife, range extent data is much more broad that that of critical habitat. Much of the data used to define these range extents are drawn from NatureServe's Ecosystem-based automated range maps (EBAR maps), which "combine biodiversity data with expert knowledge to populate ecoshapes [...] with species presence information" and which "represent the geographic extent where a species *may* occur"

(NatureServe Canada, 2023, para. 1; NatureServe Canada, 2023, para.16). Many range extents cover large geographic areas, limiting our confidence that an overlap between these ranges and urban boundaries represents a legitimate overlap with areas where a species is known to occur.

For our purposes, range extent boundaries can be used in a way that is similar to critical habitat. If the modeled range extent of a threatened species maintains 98% overlap with cities, we can argue that:

a) the species in question likely has a relatively limited range in Canada and/or

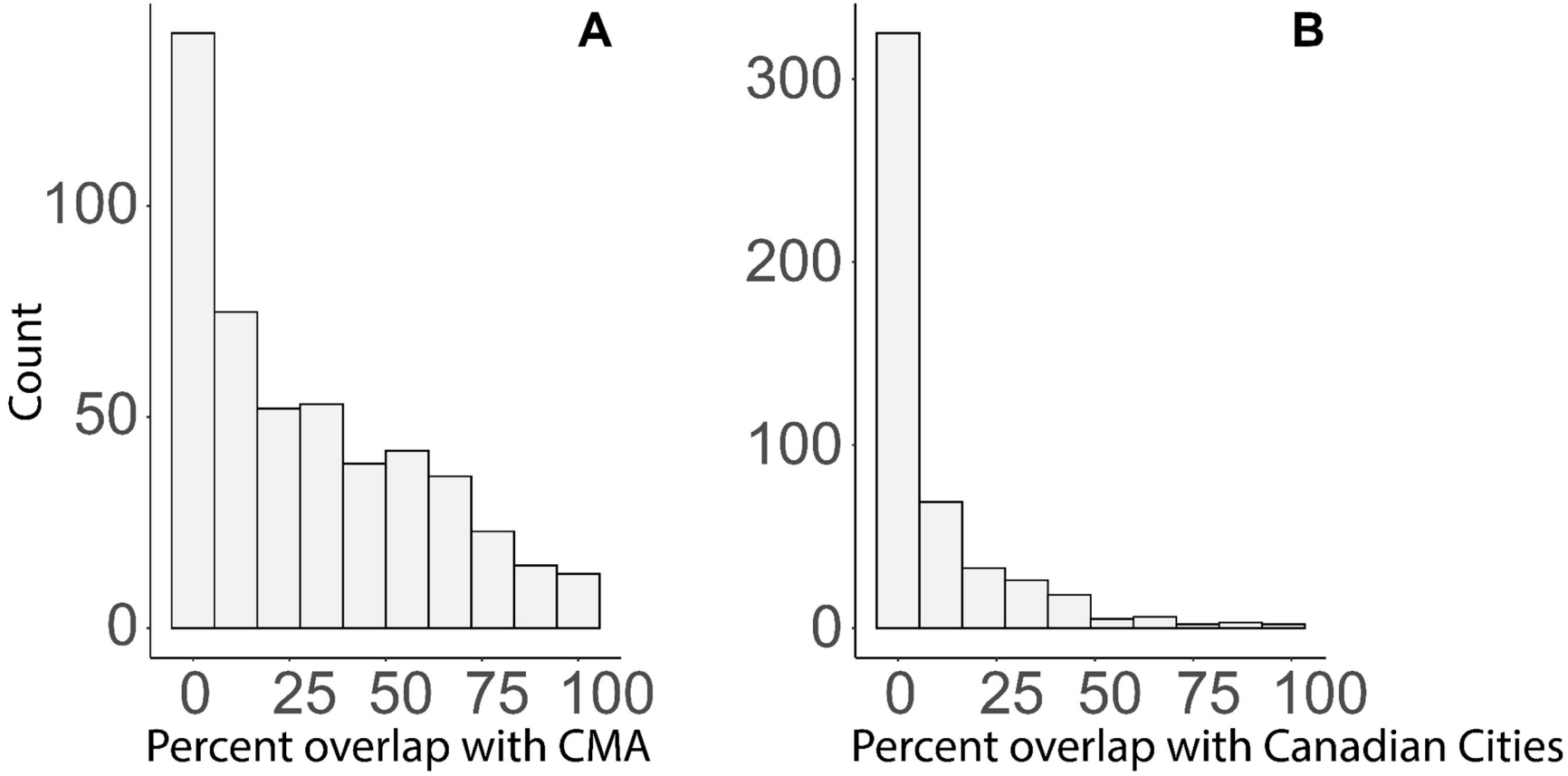
b) much of the area where the species may occur in Canada falls within the jurisdiction of one or several cities.

Including both mapped critical habitat and range extents allows for the most exhaustive analysis possible given the available data on imperiled species in Canada. High percent overlap between a species mapped critical habitat and cities is indicative of said species occurring and maintaining habitat critical to its recovery within urban jurisdictions. Given the limited scope of mapped critical habitat currently in Canada, revealing that a significant number of species' critical habitat are overlapped by urban areas also allows us to project that the true degree of overlap is much higher, since current critical habitat data is limited in the number of species covered, and is only partial for most currently mapped species. Species' range extents, while being broad spatially and not necessarily indicating the occurrence of a species over an entire geographic span, are useful in that they cover a more exhaustive list of imperiled species in Canada. If a species' range extent is highly or even completely overlapped by n cities, we can be confident that the conservation and recovery of that species will depend on the policies and actions of cities,

planners, and non-governmental organizations since said species is very likely to occur on land under their jurisdiction.

Despite the potential limitations of currently mapped range and critical habitat data in Canada, it is highly relevant and illustrative in describing which species are most likely to occupy and maintain suitable habitat within the boundaries of major urban municipalities across Canada, and to show that any estimate of overlap is likely to be much higher as more critical habitats are designated across Canada.

642 **Supplementary figures**



643

644 Figure S1. **A.** Frequency distribution of percent overlap between imperiled species projected range and Canadian census metropolitan areas (CMAs) across 7
645 taxonomic groupings. **B.** Frequency distribution of percent overlap between imperiled species projected range and Canadian cities areas across 7 taxonomic
646 groupings.

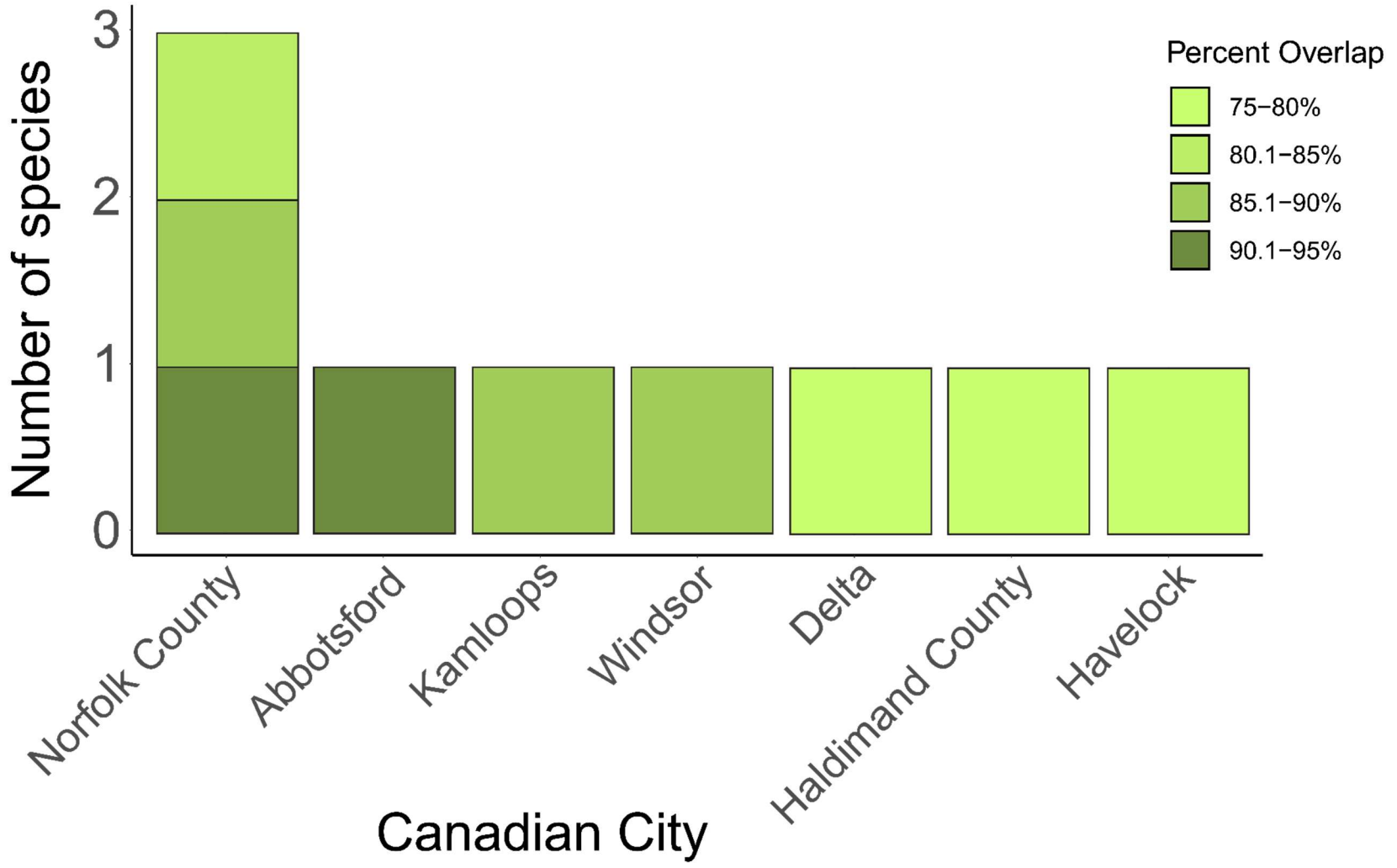
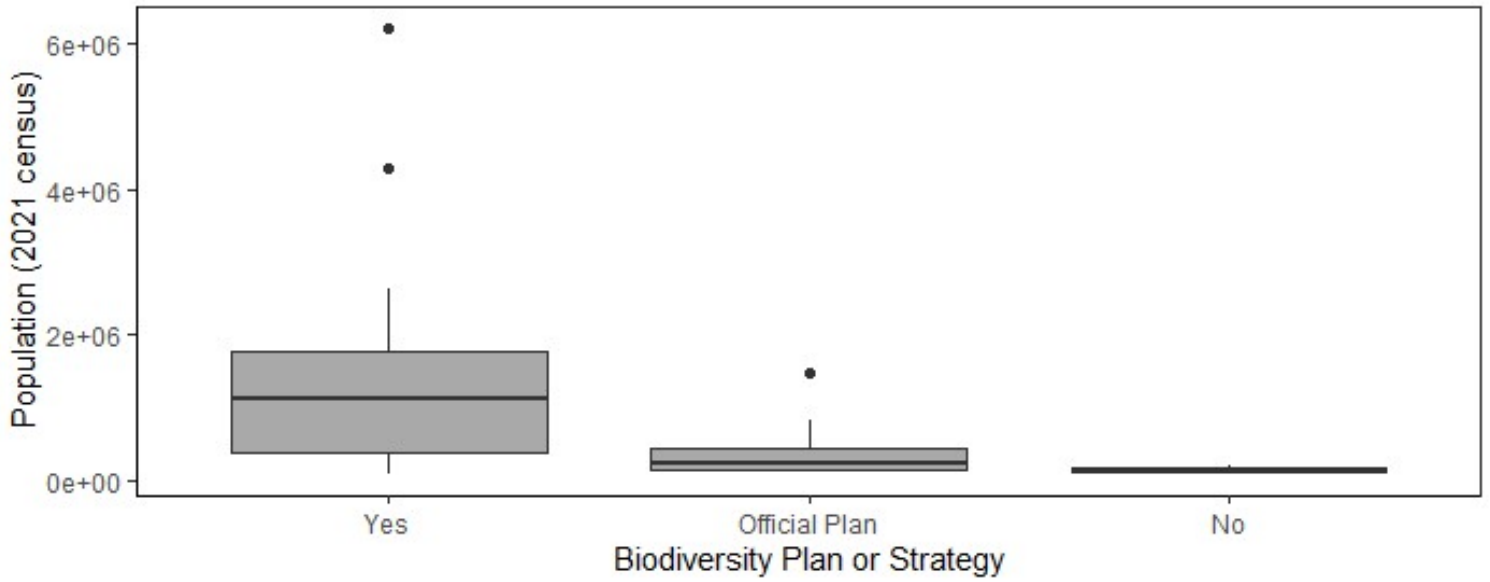


Figure S2. Canadian cities (urban cores) that overlap >75% with the mapped critical habitat of imperiled species and the number of species with mapped critical habitat that overlap >75% for each city.



651

652 Figure S3. City biodiversity strategies or official plans mentioning imperiled species based on population. The population median for cities that mention
653 imperiled species within their biodiversity plan or official plan is 1,126,398; for cities that do not mention imperiled species it is 130,613; for cities with no
654 dedicated biodiversity strategy it is 249,217.