

Feb
2022

Estimated Annual Expenditures on Invasive Species by Canadian Municipalities: 2021 National Survey Results

BY: RICHARD J. VYN, PHD

FOR: INVASIVE SPECIES CENTRE, SAULT STE. MARIE, ON

This project was led by the Invasive Species Centre and run in collaboration with the Invasive Alien Species National Committee. Funding for this project was provided by Environment and Climate Change Canada.

Table of Contents

Executive Summary.....	iv
1.0 Introduction	1
2.0 Survey Data	2
2.1 Proportion of Municipalities Impacted by Invasive Species	3
2.2 Expenditures on Invasive Species	3
2.2.1 Expenditures by Province or Region	4
2.2.2 Comparison of Reported Expenditures Across Provinces and Regions	7
2.3 Invasive Species of Concern and Expenditures on Individual Species	7
2.4 Invasive Species Funding from Other Sources	11
2.5 Invasive Species Funding Requirements	14
2.6 Data Issues and Limitations	19
2.7 Sample Representativeness	20
2.8 Summary of Survey Results.....	20
3.0 Methods for Estimating Total Expenditure.....	21
3.1 Extrapolation Approaches.....	21
4.0 Results	22
4.1 Extrapolation Results	22
4.2 Limitations and Potential Bias.....	22
4.3 Summary and Discussion of Results.....	22
5.0 Conclusions	26
References	29

List of Tables

Table 1: Number of responding municipalities, by province or territory	2
Table 2: Summary of survey results for expenditures reported by municipalities on invasive species activities	5
Table 3: Summary of reported expenditures by municipalities on invasive species, by category of expenditure.....	5
Table 4: Invasive species reported as a top 5 priority by responding municipalities	8
Table 5: Invasive species reported as a top 5 priority by responding municipalities, by province or region	9
Table 6: Invasive species reported as a number one priority by responding municipalities.....	10

Table 7: Invasive species reported as a number one priority by responding municipalities, by province or region.....	10
Table 8: Species-specific expenditures reported by responding municipalities.....	12
Table 9: Species-specific expenditures, by province or region.....	13
Table 10: Emerging invasive species of concern reported by responding municipalities	13
Table 11: Invasive species funding received from other sources	14
Table 12: Estimated in-kind spending on invasive species	15
Table 13: Municipalities reporting insufficient funding for invasive species	16
Table 14: Amount of additional annual funding requirements reported by municipalities.....	16
Table 15: Summary of extrapolation results for estimated total expenditure on invasive species by all municipalities in Canada	25
Table 16: Estimated expenditures on individual invasive species by all municipalities, based on the three estimates of total annual expenditure in Canada	28

List of Figures

Figure 1: Summary of responses to the question “How would you characterize the impacts of invasive species on your municipal government?”	3
Figure 2: Summary of responses by province/region to the question “How would you characterize the impacts of invasive species on your municipal government?”	4
Figure 3: Summary of reported expenditures by municipalities on invasive species, by category of expenditure.....	6
Figure 4: Estimated increases in costs of invasive species management in the past 5 years	17
Figure 5: Estimated increases in costs of invasive species management in the past 5 years, by province or region.....	17
Figure 6: Estimated increases in costs of invasive species management in the next 5 years	18
Figure 7: Estimated increases in costs of invasive species management in the next 5 years, by province or region.....	18

Executive Summary

An online survey was conducted in 2021, in collaboration with the Invasive Alien Species National Committee, to collect data and information on expenditures in 2020 for invasive species prevention, detection, control and management, habitat restoration, and research and science activities by municipalities across the country. Survey data on reported expenditure amounts were then extrapolated to estimate total annual expenditure on invasive species across all municipalities in Canada. This report builds on similar studies conducted in Ontario between 2017 and 2019 for the Invasive Species Centre (Vyn, 2019). This national municipal expenditures survey is the first of its kind conducted in Canada.

Expenditures on invasive species were reported by 179 of 231 municipalities (77.5%)¹, with an average expenditure across all municipalities of \$142,101. Total expenditures reported by these municipalities summed to \$32,825,232, and per capita expenditures were \$2.42. Average expenditures ranged across provinces and regions from \$250 in the Territories to \$438,823 in Alberta, while per capita expenditures ranged from \$0.09 in the Territories to \$7.54 in Manitoba. The species with the largest share of expenditures reported by responding municipalities was Emerald Ash Borer (32.3%).

The survey results were used to estimate the total annual expenditure on invasive species across the country, based on an extrapolation approach. Extrapolations were conducted for municipalities based on average expenditure across responding municipalities and based on per capita expenditure, which accounts for the influence of population on reported expenditure amounts. **To account for observed variation in expenditures across provinces and regions, extrapolations were conducted to the provincial level prior to aggregation to the national level.** Note that all expenditures in this report are annual expenditures that were incurred in 2020.

The extrapolation based on per capita expenditure generated an estimate of total annual expenditure of \$95.8 million, while the extrapolation based on average expenditure generated an estimate of \$400.0 million. Since the sample of responding municipalities is weighted toward higher populated municipalities, the estimate based on average expenditure is likely an overestimate of total expenditure, whereas the extrapolation based on per capita expenditure may address this issue. However, based on comparisons to the results of prior surveys conducted in Ontario and based on feedback from government organizations involved in invasive species management, the estimate based on per capita expenditure is likely much too low. The relatively low response rate in many of the provinces may have negatively impacted the accuracy of this estimate. A potentially more accurate estimate could be the average of these two estimates, or \$247.9 million. **As a result, this report presents three scenarios for the estimated total annual expenditure by municipalities in Canada, ranging from \$95.8 million to \$400.0 million, with a midpoint of \$247.9 million.** While this midpoint may be the best approximation, the relatively low numbers of responses in many of the provinces make it difficult to determine the most accurate estimate or to generate a more specific estimate.

The estimated total expenditure accounts only for expenditures by municipalities, and does not include expenditures on invasive species by provincial governments, territorial governments, or the federal government. This survey does not include expenditures from parks, Indigenous communities or

¹ It is possible that other municipalities with no expenditures chose not to participate in the survey.

conservation authorities. In addition, it is important to note that 140 municipalities (60.6% of respondents) indicated that insufficient funding was received for combating invasive species, and the average amount of additional funding required indicated by responding municipalities was \$578,093. This implies that considerably more could be spent on invasive species management in Canada.

1.0 Introduction

A survey of municipalities across Canada was conducted in 2021, on behalf of the FPT Invasive Alien Species National Committee, by the Invasive Species Centre (ISC) to estimate annual expenditures incurred by municipalities related to invasive species management. This survey involved collecting information from municipalities across Canada on the types of invasive species that were of concern within their jurisdictions and the amounts and types of expenditures that were incurred on invasive species management activities. The expenditure amounts provided by the surveyed municipalities were then extrapolated to estimate the total annual expenditure across all municipalities in Canada on invasive species activities.

Similar surveys had previously been conducted by the ISC for municipalities and conservation authorities in the province of Ontario in 2017, 2018, and 2019. The results of these surveys generated interest in conducting a national survey to estimate expenditures on invasive species by municipalities all across Canada. This survey was primarily conducted online, with a link to this survey distributed by email to municipalities across Canada. In some cases, municipalities were contacted by phone to let them know about the survey. The survey was initially targeted to municipalities with a population of at least 10,000, with the intention to reach out to enough municipalities to achieve representation of at least 80% of the population within each province or territory. However, in some provinces and territories, too many of the municipalities were below this population threshold to achieve the 80% representation. As a result, in these provinces and territories, the population threshold of 10,000 was reduced in order to ensure that the survey was distributed to municipalities that represented at least 80% of the population. In Ontario, British Columbia, and Alberta, the survey was distributed to all municipalities with a population of at least 10,000. In Quebec and Nova Scotia, the survey was distributed to municipalities with a population of at least 5,000. This population threshold was reduced to 1,000 in Manitoba and to 500 in Saskatchewan. For the remaining provinces and territories, the survey was distributed to as many municipalities as could be contacted.

The purpose of this report is to summarize the survey results and to generate a national estimate of total annual expenditure on invasive species by municipalities across Canada. The survey responses are summarized in Section 2 for all responding municipalities across Canada as well as for each province or region. The extrapolation methods used to estimate total expenditure by municipalities across Canada are described in Section 3, the results of which are provided in Section 4. Section 5 provides a discussion of the conclusions of this report.

2.0 Survey Data

Survey respondents were asked to provide information on amounts and types of expenditures related to invasive species management activities as well as information on species of concern. The survey results are described below, both in aggregate for all responding municipalities across Canada as well as by province or region to examine for similarities and differences between provinces and regions.

A total of 231 responses were received from municipalities across the country, which represent 6.5% of the 3,530 municipalities in Canada. The numbers of responses are broken down by province in Table 1. The province with the most responses was Quebec, with surveys completed by 64 municipalities, followed by British Columbia with 36 and Alberta with 35. The fewest responses were received from the Territories, with 1 response each from Northwest Territories and Nunavut and 2 responses from Yukon Territory. Due to the relatively low number of responses in the Territories as well as in the Atlantic Provinces, the survey results in each of these two regions were aggregated and summarized at the regional level. After aggregation, there were four responses for the Territories and 22 for the Atlantic Provinces.

Table 1 also indicates the approximate numbers of municipalities in each province contacted to complete the survey, the total numbers of municipalities, and the response rates based on both the number of municipalities contacted and the total number of municipalities. The response rates for municipalities that were contacted ranged from 2.7% in Newfoundland & Labrador and 4.2% in Northwest Territories to 45.5% in Alberta and 45.6% in British Columbia. The response rates based on the total number of municipalities ranged from 2.5% in Newfoundland & Labrador and 3.4% in Saskatchewan to 16.1% in Manitoba and 22.2% in British Columbia.

Table 1: Number of responding municipalities, by province or territory

Province/Territory	Respondents		# of Municipalities		Response Rate	
	#	% of Total	Contacted	Total	% of Contacted	% of Total
British Columbia	36	15.6%	79	162	45.6%	22.2%
Alberta	35	15.2%	77	344	45.5%	10.2%
Saskatchewan	26	11.3%	253	774	10.3%	3.4%
Manitoba	22	9.5%	119	137	18.5%	16.1%
Ontario	22	9.5%	178	444	12.4%	5.0%
Quebec	64	27.7%	187	1,108	34.2%	5.8%
New Brunswick	7	3.0%	98	104	7.1%	6.7%
Nova Scotia	3	1.3%	24	49	12.5%	6.1%
Prince Edward Island	5	2.2%	61	63	8.2%	7.9%
Newfoundland & Labrador	7	3.0%	258	278	2.7%	2.5%
Nunavut	1	0.4%	14	25	7.1%	4.0%
Northwest Territories	1	0.4%	24	24	4.2%	4.2%
Yukon	2	0.9%	14	18	14.3%	11.1%
Total	231	100.0%	1,386	3,530	16.7%	6.5%

2.1 Proportion of Municipalities Impacted by Invasive Species

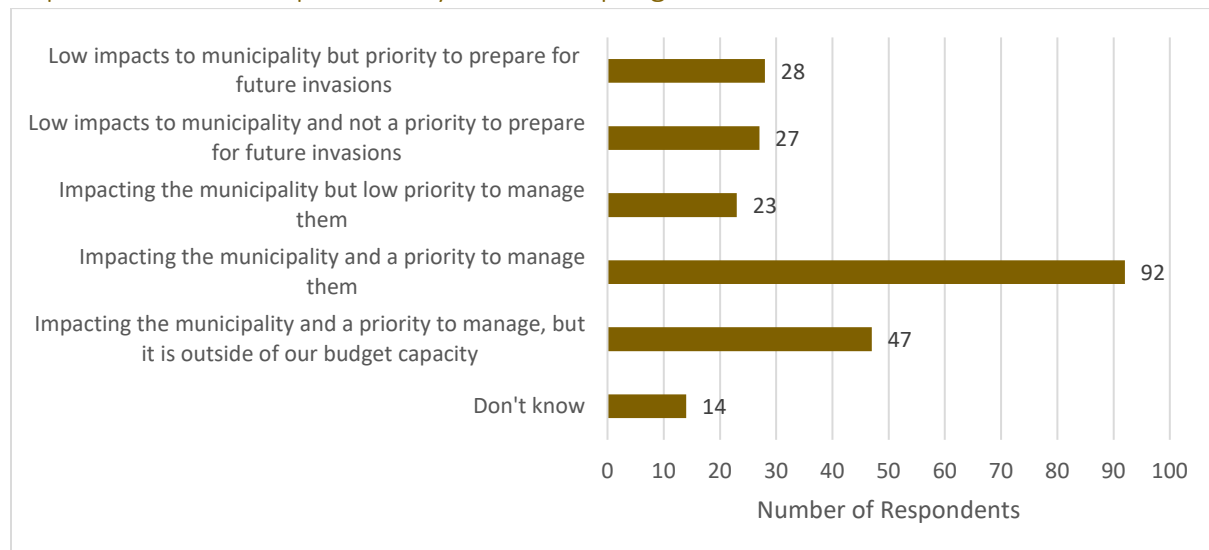
Of the 231 responses, only 27 (11.7%) indicated that invasive species had low or no impacts on their municipality and that it was not a priority to prepare for future invasions. The majority of respondents (139, or 60.2%) indicated that invasive species were currently impacting their municipality and that it was a priority to manage them, while another 28 (12.1%) indicated that it was a priority to prepare for future invasions (see Figure 1). Some variation was observed in these responses across provinces and regions (see Figure 2). For example, the proportion of municipalities that indicated that invasive species were currently impacting their municipalities and that it was a priority to manage them ranged from 0% in the Territories and 27.2% in the Atlantic Provinces to 88.9% in British Columbia and 90.9% in Ontario.

2.2 Expenditures on Invasive Species

The survey results for expenditures on invasive species reported by responding municipalities is provided in Tables 2 and 3. Table 2 provides statistics on the expenditures reported by each province or region, while Table 3 reports the proportional allocations of expenditures for each province or region among the five categories of activities: prevention, detection, control and management, habitat restoration, and research and science.

Expenditures on invasive species in 2020 were reported by 179 of the 231 responding municipalities (77.5%), with total reported expenditures of \$32,825,232 (see Table 2).² Expenditures by individual municipalities ranged from \$100 to \$2,900,000, with an average across the 231 responding municipalities of \$142,101. The per capita expenditure across all responding municipalities was \$2.42. As evident in Table 3 and Figure 3, the majority of expenditures were incurred for control and management activities (61.6%). Expenditures allocated to other categories included 14.7% for detection activities, 13.6% for prevention activities, 6.1% for habitat restoration, and 4.0% for research and science.

Figure 1: Summary of responses to the question “How would you characterize the impacts of invasive species on your municipal government?”



² Expenditures on invasive species in 2020 may have been negatively impacted by Covid-19 (see Section 2.6).

Figure 2: Summary of responses by province/region to the question “How would you characterize the impacts of invasive species on your municipal government?”



2.2.1 Expenditures by Province or Region

In British Columbia, expenditures on invasive species were reported by 33 of the 36 responding municipalities (91.7%), with total reported expenditures of \$6,011,555. Expenditures ranged from \$4,000 to \$982,740, with an average across the 36 responding municipalities of \$166,988. The per capita expenditure for responding municipalities in British Columbia was \$1.19.

In Alberta, expenditures on invasive species were reported by 29 of the 35 responding municipalities (82.9%), with total reported expenditures of \$15,358,811. Expenditures ranged from \$10,500 to \$2,900,000, with an average across the 35 responding municipalities of \$438,823. The per capita expenditure for responding municipalities in Alberta was \$5.45.

In Saskatchewan, expenditures on invasive species were reported by 22 of the 26 responding municipalities (84.6%), with total reported expenditures of \$1,712,778. Expenditures ranged from \$100 to \$1,266,288, with an average across the 26 responding municipalities of \$65,876. The per capita expenditure for responding municipalities in Saskatchewan was \$3.46.

Table 2: Summary of survey results for expenditures reported by municipalities on invasive species activities

Province/Region	Responses	Expenditures Reported		Expenditures on Invasive Species Activities				
	#	#	%	Total	Minimum	Average ^a	Maximum	Per Capita
British Columbia	36	33	91.7%	\$6,011,555	\$4,000	\$166,988	\$982,740	\$1.19
Alberta	35	29	82.9%	\$15,358,811	\$10,500	\$438,823	\$2,900,000	\$5.45
Saskatchewan	26	22	84.6%	\$1,712,778	\$100	\$65,876	\$1,266,288	\$3.46
Manitoba	22	18	81.8%	\$773,662	\$100	\$35,166	\$180,000	\$7.54
Ontario ^b	22	21	95.5%	\$3,177,454	\$3,000	\$144,430	\$970,000	\$1.07
Quebec	64	50	78.1%	\$5,434,472	\$100	\$84,914	\$2,050,000	\$4.83
Atlantic Provinces	22	5	22.7%	\$355,500	\$2,500	\$16,159	\$250,000	\$0.35
Territories	4	1	25.0%	\$1,000	\$1,000	\$250	\$1,000	\$0.09
Total	231	179	77.5%	\$32,825,232	\$100	\$142,101	\$2,900,000	\$2.42

^a The average expenditure is calculated as the average across all responding municipalities rather than the average across municipalities that reported expenditures.

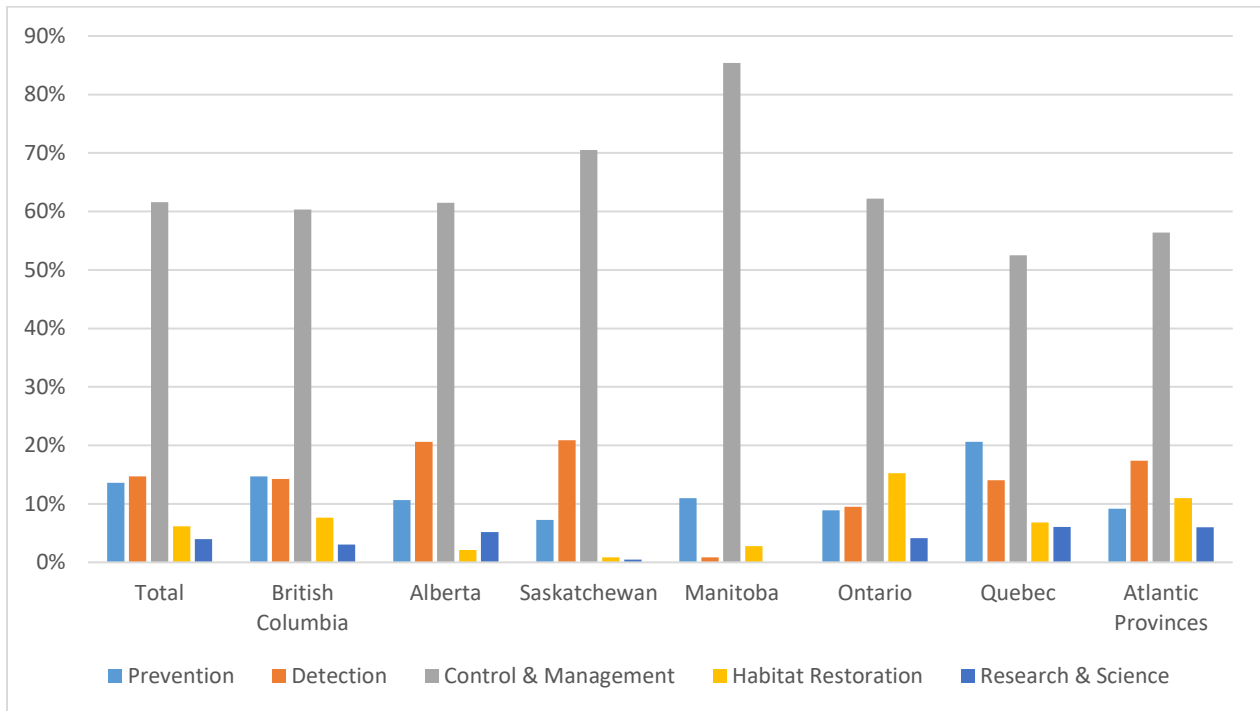
^b The results of a previous survey of municipality expenditures on invasive species in Ontario (Vyn, 2019) indicated a much higher average expenditure (\$218,148). Since the 2019 survey had a much larger sample size (147), it is most likely more representative of actual expenditures.

Table 3: Summary of reported expenditures by municipalities on invasive species, by category of expenditure

Province/Region	Prevention	Detection	Control & Management	Habitat Restoration	Research & Science
British Columbia	14.7%	14.3%	60.3%	7.6%	3.1%
Alberta	10.7%	20.6%	61.5%	2.1%	5.2%
Saskatchewan	7.3%	20.9%	70.5%	0.8%	0.5%
Manitoba	11.0%	0.8%	85.4%	2.8%	0.0%
Ontario	8.9%	9.5%	62.2%	15.2%	4.2%
Quebec	20.6%	14.0%	52.5%	6.8%	6.1%
Atlantic Provinces	9.2%	17.4%	56.4%	11.0%	6.0%
Territories ^a	-	-	-	-	-
Total	13.6%	14.7%	61.6%	6.1%	4.0%

^a None of the respondents from the Territories provided breakdowns of expenditures across these categories.

Figure 3: Summary of reported expenditures by municipalities on invasive species, by category of expenditure



In Manitoba, expenditures on invasive species were reported by 18 of the 22 responding municipalities (81.8%), with total reported expenditures of \$773,662. Expenditures ranged from \$100 to \$180,000, with an average across the 22 responding municipalities of \$35,166. The per capita expenditure for responding municipalities in Manitoba was \$7.54.

In Ontario, expenditures on invasive species were reported by 21 of the 22 responding municipalities (95.5%), with total reported expenditures of \$3,177,454. Expenditures ranged from \$3,000 to \$970,000, with an average across the 22 responding municipalities of \$144,430. The per capita expenditure for responding municipalities in Ontario was \$1.07.

In Quebec, expenditures on invasive species were reported by 50 of the 64 responding municipalities (78.1%), with total reported expenditures of \$5,434,472. Expenditures ranged from \$100 to \$2,050,000, with an average across the 64 responding municipalities of \$84,914. The per capita expenditure for responding municipalities in Quebec was \$4.83.

In the Atlantic Provinces, expenditures on invasive species were reported by only 5 of the 22 responding municipalities (22.7%), with total reported expenditures of \$355,500. Expenditures ranged from \$2,500 to \$250,000, with an average across the 22 responding municipalities of \$16,159. The per capita expenditure for responding municipalities in the Atlantic Provinces was \$0.35.

In the Territories, expenditures on invasive species were reported by only one of the four responding municipalities (25.0%), with an expenditure of \$1,000. This worked out to an average of \$250 across the four responding municipalities. The per capita expenditure for responding municipalities in the Territories was \$0.09.

2.2.2 Comparison of Reported Expenditures Across Provinces and Regions

Considerable variation in reported expenditures by municipalities was observed across provinces and regions within Canada. The percentage of municipalities reporting expenditures was highest in Ontario (95.5%) and British Columbia (91.7%), and was lowest in the Atlantic Provinces (22.7%) and the Territories (25.0%). The average expenditure by responding municipalities was highest in Alberta (\$438,823) and British Columbia (\$166,988), and was lowest in the Territories (\$250) and the Atlantic Provinces (\$16,159). Three provinces (Alberta, Quebec, and Saskatchewan) had municipalities that reported expenditures of more than \$1,000,000. Per capita expenditures were highest in Manitoba (\$7.54) and Alberta (\$5.45), and were lowest in the Territories (\$0.09) and the Atlantic Provinces (\$0.35).

The proportion of reported expenditures allocated for control and management activities was highest among the five categories for all provinces and regions, ranging from 52.5% in Quebec to 85.4% in Manitoba (see Table 3 and Figure 3). The allocation of expenditures for detection activities ranged from 0.8% in Manitoba to 20.9% in Saskatchewan. The allocation of expenditures for prevention activities ranged from 7.3% in Saskatchewan to 20.6% in Quebec. The allocation of expenditures for habitat restoration ranged from 0.8% in Saskatchewan to 15.2% in Ontario. The allocation of expenditures for research and science ranged from 0.0% in Manitoba to 6.1% in Quebec.

2.3 Invasive Species of Concern and Expenditures on Individual Species

Survey respondents were asked to list up to five priority invasive species of concern in their municipality, and to provide the expenditure incurred on each of these species. Of the 231 responding municipalities, 181 provided at least one priority invasive species of concern. The species of concern reported by at least five municipalities are listed in Table 4, which includes 31 different species. The top five reported species of concern were Japanese knotweed (57 municipalities), giant hogweed (43), emerald ash borer (42), leafy spurge (29), and phragmites (29).

When broken down by province or region, differences can be observed in the invasive species that were most frequently listed as priority species of concern by responding municipalities. Table 5 provides the five most frequently reported species of concern by municipalities in each province or region. Japanese knotweed was the most frequently reported species of concern by municipalities in British Columbia and Quebec, scentless chamomile was the most frequently reported species of concern in Alberta, leafy spurge in Saskatchewan, Dutch elm disease in Manitoba, phragmites in Ontario, and emerald ash borer in the Atlantic Provinces.

The invasive species listed as the number one priority species of concern most frequently by responding municipalities was emerald ash borer, which was at the top of the list for 20 municipalities (see Table 6). This was followed by Dutch elm disease (18), Japanese knotweed (17), Eurasian watermilfoil (14), and giant hogweed (14). The most frequently reported number one priority species of concern is broken down by province or region in Table 7, where Dutch elm disease was reported most frequently as the number one priority species in Saskatchewan, Manitoba, and the Atlantic Provinces.

Table 4: Invasive species reported as a top 5 priority by responding municipalities

Species (Common Name)	Number Reporting	% of Respondents
Japanese Knotweed	57	24.7%
Giant Hogweed	43	18.6%
Emerald Ash Borer	42	18.2%
Leafy Spurge	29	12.6%
Phragmites	29	12.6%
Eurasian Watermilfoil	28	12.1%
Dutch Elm Disease	23	10.0%
Scentless Chamomile	22	9.5%
Zebra/Quagga Mussels	16	6.9%
Buckthorn (all spp.)	15	6.5%
Canada Thistle	14	6.1%
Spongy Moth ^a	12	5.2%
Norway Rat	12	5.2%
Yellow Toadflax	12	5.2%
Common Tansy	11	4.8%
Wild Parsnip	11	4.8%
Himalayan Blackberry	9	3.9%
Noxious Weeds ^b	9	3.9%
Common Burdock	8	3.5%
English Ivy	7	3.0%
Poison Hemlock	7	3.0%
Scotch Broom	7	3.0%
Dog Strangling Vine	6	2.6%
Garlic Mustard	6	2.6%
Himalayan Balsam	6	2.6%
Purple Loosestrife	6	2.6%
Spotted Knapweed	6	2.6%
Absinth	5	2.2%
Blueweed	5	2.2%
Goldfish	5	2.2%

^a In July 2021, the Entomological Society of America removed “gypsy moth” as a recognized common name for *Lymantria dispar*. The Entomological Society of America launched a new program to review and replace insect common names that may be inappropriate or offensive because they perpetuate negative ethnic or racial stereotypes. Spongy moth is the new common name for *Lymantria dispar*.

^b For the purpose of these results, ‘Noxious Weeds’ is a general category of invasive species rather than the name of a specific invasive species. This category includes many of the weed species listed in this table.

Table 5: Invasive species reported as a top 5 priority by responding municipalities, by province or region

British Columbia

Species (Common Name)	Number Reporting	% of Respondents
Japanese Knotweed	22	61.1%
Giant Hogweed	9	25.0%
Himalayan Blackberry	9	25.0%
English Ivy	7	19.4%
Scotch Broom	7	19.4%

Alberta

Species (Common Name)	Number Reporting	% of Respondents
Scentless Chamomile	14	40.0%
Yellow Toadflax	10	28.6%
Canada Thistle	9	25.7%
Leafy Spurge	9	25.7%
Noxious Weeds	6	17.1%

Saskatchewan

Species (Common Name)	Number Reporting	% of Respondents
Leafy Spurge	14	53.8%
Norway Rat	8	30.8%
Scentless Chamomile	8	30.8%
Dutch Elm Disease	7	26.9%
Common Tansy	5	19.2%

Manitoba

Species (Common Name)	Number Reporting	% of Respondents
Dutch Elm Disease	8	36.4%
Emerald Ash Borer	3	13.6%
Leafy Spurge	3	13.6%
Zebra/Quagga Mussels	3	13.6%
Noxious Weeds	2	9.1%

Ontario

Species (Common Name)	Number Reporting	% of Respondents
Phragmites	13	59.1%
Spongy Moth	12	54.5%
Emerald Ash Borer	11	50.0%
Giant Hogweed	9	40.9%
Wild Parsnip	6	27.3%

Quebec

Species (Common Name)	Number Reporting	% of Respondents
Japanese Knotweed	27	42.2%
Eurasian Watermilfoil	22	34.4%
Giant Hogweed	22	34.4%
Emerald Ash Borer	19	29.7%
Phragmites	16	25.0%

Atlantic Provinces

Species (Common Name)	Number Reporting	% of Respondents
Emerald Ash Borer	4	18.2%
Dutch Elm Disease	3	13.6%
Giant Hogweed	3	13.6%
Japanese Knotweed	3	13.6%
Buckthorn (all spp.)	1	4.5%

Table 6: Invasive species reported as a number one priority by responding municipalities

Species (Common Name)	Number Reporting	% of Respondents
Emerald Ash Borer	20	8.7%
Dutch Elm Disease	18	7.8%
Japanese Knotweed	17	7.4%
Eurasian Watermilfoil	14	6.1%
Giant Hogweed	14	6.1%
Leafy Spurge	8	3.5%
Noxious Weeds	7	3.0%
Phragmites	7	3.0%
Zebra/Quagga Mussels	6	2.6%
Norway Rat	5	2.2%

Table 7: Invasive species reported as a number one priority by responding municipalities, by province or region

British Columbia

Species (Common Name)	Number Reporting	% of Respondents
Japanese Knotweed	9	25.0%
Giant Hogweed	2	5.6%
Zebra/Quagga Mussels	2	5.6%

Alberta

Species (Common Name)	Number Reporting	% of Respondents
Noxious Weeds	5	14.3%
Canada Thistle	4	11.4%
Dutch Elm Disease	3	8.6%

Saskatchewan

Species (Common Name)	Number Reporting	% of Respondents
Dutch Elm Disease	5	19.2%
Leafy Spurge	5	19.2%
Norway Rat	4	15.4%

Manitoba

Species (Common Name)	Number Reporting	% of Respondents
Dutch Elm Disease	7	31.8%
Noxious Weeds	2	9.1%
Zebra/Quagga Mussels	2	9.1%

Ontario

Species (Common Name)	Number Reporting	% of Respondents
Emerald Ash Borer	8	36.4%
Phragmites	5	22.7%
Spongy Moth	4	18.2%

Quebec

Species (Common Name)	Number Reporting	% of Respondents
Eurasian Watermilfoil	11	17.2%
Emerald Ash Borer	10	15.6%
Giant Hogweed	10	15.6%

Atlantic Provinces

Species (Common Name)	Number Reporting	% of Respondents
Dutch Elm Disease	3	13.6%
Emerald Ash Borer	1	4.5%
Eurasian Watermilfoil	1	4.5%

Many of the municipalities provided expenditure amounts for the individual species listed in their top five priority species of concern. Expenditures on specific invasive species reported by responding municipalities are provided in Table 8. The species with the highest total expenditure was emerald ash borer, which totaled \$4,849,715, or 32.3% of all reported species-specific expenditures. This was followed by Eurasian watermilfoil (\$1,292,600, or 8.6%) and Dutch elm disease (\$1,157,257, or 7.7%). Japanese knotweed, which was reported as a priority invasive species of concern by the highest number of municipalities, had the fourth-highest total expenditure (\$925,937, or 6.2%). Expenditures on noxious weeds accounted for \$860,000, or 5.7% of total species-specific expenditures, but it was unclear from the survey responses how these expenditures were distributed among the different invasive species that comprise this category. This implies that expenditures for some individual species within this category, such as Japanese knotweed, Canada thistle, leafy spurge, etc., may actually have been higher than is indicated in Table 8.

In some provinces, the majority of the reported expenditures were incurred for one invasive species (see Table 9). For example, expenditures on Dutch elm disease accounted for 71.1% of reported species-specific expenditures in the Atlantic Provinces and 65.0% of expenditures in Saskatchewan, while emerald ash borer accounted for 68.7% of species-specific expenditures in Quebec and 66.4% in Ontario. Species-specific expenditures were highest for Eurasian watermilfoil in British Columbia (37.2% of total), for Canada thistle in Alberta (21.4%), and for Dutch elm disease in Manitoba (32.0%).

Survey respondents were also asked to identify emerging invasive species of concern, which include species not currently found within the municipality but that may need to be addressed in the near future. Invasive species that were reported as emerging species of concern by at least five municipalities are listed in Table 10. The top reported emerging species of concern are zebra/quagga mussels (55 municipalities), wild boar (30), emerald ash borer (29), Asian longhorned beetle (17), and giant hogweed (17).

2.4 Invasive Species Funding from Other Sources

Respondents were asked to indicate whether they received other funding for invasive species activities, such as federal, provincial, municipal, or grant funding, as well as the amount of funding. Provincial funding was most commonly reported, with 43 municipalities across the country indicating receipt of these funds (see Table 11). Among the other sources of funding, grant funding was received by 17 municipalities, federal funding by 12 municipalities, and municipal funding by 8 municipalities. The average funding amounts received from the three levels of government were quite similar, with averages of \$63,955 for federal, \$65,548 for provincial, and \$62,425 from municipal. The average amount of grant funding was much lower, at \$26,369.

Considerable variation was observed across provinces and regions, and not all types of funding were received in each province or region. Respondents from the Territories did not report funding from any of these sources. Respondents from the Atlantic Provinces reported only federal funding, while respondents from Manitoba reported only provincial funding. The average amount of federal funding reported by municipalities ranged from \$1,300 in Saskatchewan to \$145,647 in British Columbia. The average amount of provincial funding ranged from \$22,473 in Quebec to \$108,817 in Alberta. The average amount of municipal funding ranged from \$4,100 in Saskatchewan to \$143,433 in British Columbia. The average amount of grant funding ranged from \$2,730 in Saskatchewan to \$72,200 in Ontario.

Table 8: Species-specific expenditures reported by responding municipalities

Species (Common Name)	Expenditure	% of Total
Emerald Ash Borer	\$4,849,715	32.3%
Eurasian Watermilfoil	\$1,292,600	8.6%
Dutch Elm Disease	\$1,157,257	7.7%
Japanese Knotweed	\$925,937	6.2%
Noxious Weeds	\$860,000	5.7%
Canada Thistle	\$721,500	4.8%
Phragmites	\$700,000	4.7%
Himalayan Blackberry	\$626,906	4.2%
Leafy Spurge	\$457,099	3.0%
Parrot's Feather	\$341,192	2.3%
Yellow Toadflax	\$310,000	2.1%
Spotted Knapweed	\$265,000	1.8%
Buckthorn (all spp.)	\$240,193	1.6%
Zebra/Quagga Mussels	\$220,100	1.5%
Giant Hogweed	\$206,400	1.4%
Scentless Chamomile	\$180,539	1.2%
Spongy Moth	\$120,598	0.8%
Norway Rat	\$113,956	0.8%
Wild Parsnip	\$105,190	0.7%
Absinth	\$102,500	0.7%
Clubroot	\$100,000	0.7%
Common Tansy	\$93,105	0.6%
Chafer Beetle	\$85,000	0.6%
Nodding Thistle	\$85,000	0.6%
Tall Buttercup	\$65,000	0.4%
Garlic Mustard	\$64,946	0.4%
English Ivy	\$60,000	0.4%
White Cockle	\$60,000	0.4%
European Elm Scale	\$46,600	0.3%
Dog Strangling Vine	\$40,300	0.3%
Invasive Pests (insects)	\$40,000	0.3%
Sow Thistle	\$39,000	0.3%
Lamium	\$30,000	0.2%
Blueweed	\$27,500	0.2%
Himalayan Balsam	\$26,669	0.2%
Common Burdock	\$25,239	0.2%
Puncturevine	\$25,171	0.2%
Scotch Broom	\$24,000	0.2%
Baby's Breath	\$20,500	0.1%
Ox-Eye Daisy	\$20,000	0.1%
Purple Loosestrife	\$20,000	0.1%
Smooth Brome	\$20,000	0.1%
Thistle	\$20,000	0.1%
Other	\$168,086	1.1%
Total	\$15,002,798	100.0%

Table 9: Species-specific expenditures reported by responding municipalities, by province or region

British Columbia

Species (Common Name)	Expenditure	% of Total
Eurasian Watermilfoil	\$1,042,000	37.2%
Himalayan Blackberry	\$626,906	22.4%
Parrot's Feather	\$341,192	12.2%
Japanese Knotweed	\$294,637	10.5%
Zebra/Quagga Mussels	\$138,000	4.9%
Total	\$2,802,382	100.0%

Alberta

Species (Common Name)	Expenditure	% of Total
Canada Thistle	\$720,000	21.4%
Noxious Weeds	\$710,000	21.1%
Leafy Spurge	\$351,000	10.4%
Yellow Toadflax	\$285,000	8.5%
Spotted Knapweed	\$265,000	7.9%
Total	\$3,371,600	100.0%

Saskatchewan

Species (Common Name)	Expenditure	% of Total
Dutch Elm Disease	\$815,900	65.0%
Emerald Ash Borer	\$120,000	9.6%
Leafy Spurge	\$80,599	6.4%
Norway Rat	\$68,956	5.5%
Common Tansy	\$42,000	3.3%
Total	\$1,254,784	100.0%

Manitoba

Species (Common Name)	Expenditure	% of Total
Dutch Elm Disease	\$174,357	32.0%
Noxious Weeds	\$145,000	26.6%
Eurasian Watermilfoil	\$100,000	18.3%
Zebra/Quagga Mussels	\$60,000	11.0%
Leafy Spurge	\$25,500	4.7%
Total	\$545,457	100.0%

Ontario

Species (Common Name)	Expenditure	% of Total
Emerald Ash Borer	\$1,346,815	66.4%
Phragmites	\$189,000	9.3%
Spongy Moth	\$120,598	5.9%
Wild Parsnip	\$97,000	4.8%
Buckthorn (all spp.)	\$84,693	4.2%
Total	\$2,027,025	100.0%

Quebec

Species (Common Name)	Expenditure	% of Total
Emerald Ash Borer	\$3,322,800	68.7%
Japanese Knotweed	\$617,700	12.8%
Phragmites	\$511,000	10.6%
Giant Hogweed	\$179,400	3.7%
Eurasian Watermilfoil	\$150,600	3.1%
Total	\$4,836,550	100.0%

Atlantic Provinces

Species (Common Name)	Expenditure	% of Total
Dutch Elm Disease	\$135,000	71.1%
Emerald Ash Borer	\$50,000	26.3%
Buckthorn (all spp.)	\$5,000	2.6%
Total	\$190,000	100.0%

Table 10: Emerging invasive species of concern reported by responding municipalities

Species (Common Name)	Number Reporting	Species (Common Name)	Number Reporting
Zebra/Quagga Mussels	55	Knapweed	9
Wild Boar	30	Japanese Beetle	8
Emerald Ash Borer	29	Asian Giant Hornet	7
Asian Longhorned Beetle	17	Hemlock Woolly Adelgid	7
Giant Hogweed	17	Japanese Knotweed	7
Oak Wilt	15	Rusty Crayfish	7
Spongy Moth	15	Leafy Spurge	6
Dutch Elm Disease	14	Purple Loosestrife	6
Norway Rat	14	Red-Spotted Crayfish	6
Clubroot	13	Whirling Disease	6
Goldfish	13	Chronic Wasting Disease	5
Asian Carp	12	Flowering Rush	5
Carp ^a	10	Garlic Mustard	5
Hawkweed	10	Mountain Pine Beetle	5
Phragmites	10	Red-Eared Slider	5
Buckthorn (all spp.)	9	Spiny Water Flea	5
Eurasian Watermilfoil	9	Wild Parsnip	5

^a Type not specified.

A number of municipalities also reported in-kind spending on invasive species activities, primarily through volunteer hours. In-kind spending was reported by 58 municipalities, with an average value of \$22,180 (see Table 12). Municipalities in all provinces and regions, except for the Territories, reported in-kind spending, with the average value ranging from \$1,733 in the Atlantic Provinces to \$47,891 in British Columbia.

2.5 Invasive Species Funding Requirements

Respondents were asked whether the 2020 funding for invasive species activities in their municipality was sufficient. Of the 231 responding municipalities, 140, or 60.6%, indicated that funding was not sufficient (see Table 13). The proportion of municipalities that indicated insufficient funding varied across provinces and regions, ranging from 25.0% in the Territories and 36.4% in the Atlantic Provinces to 80.6% in British Columbia and 90.9% in Ontario.

A follow-up question asked respondents to estimate the additional annual funding required. Of the 140 municipalities that indicated insufficient funding, 94 provided estimates of the additional funding required, with an average estimate of \$578,093 (see Table 14). The average additional funding requirement ranged across provinces and regions from \$50,857 in Manitoba to \$1,274,712 in Quebec.³ This implies that considerably more funding is required across Canada to adequately manage invasive species.

³ This average is skewed by a response from one municipality of \$30 million. Omitting this response results in an average of \$125,700.

Table 11: Invasive species funding received from other sources^a

	Funding Type	Number Reported	Average of Reported	Average of Total
All Respondents	Federal	12	\$63,955	\$3,322
	Provincial	43	\$65,548	\$12,202
	Municipal	8	\$62,425	\$2,162
	Grant	17	\$26,369	\$1,941
British Columbia	Federal	4	\$145,647	\$16,183
	Provincial	6	\$58,667	\$9,778
	Municipal	3	\$143,433	\$11,953
	Grant	5	\$14,840	\$2,061
Alberta	Federal	3	\$55,148	\$4,727
	Provincial	18	\$108,817	\$55,963
	Grant	2	\$65,000	\$3,714
Saskatchewan	Federal	2	\$1,300	\$100
	Provincial	9	\$22,601	\$7,823
	Municipal	1	\$4,100	\$158
	Grant	4	\$2,730	\$420
Manitoba	Provincial	7	\$33,861	\$10,774
Ontario	Federal	1	\$7,000	\$318
	Municipal	3	\$20,000	\$2,727
	Grant	2	\$72,200	\$6,564
Quebec	Federal	1	\$7,336	\$115
	Provincial	3	\$22,473	\$1,053
	Municipal	1	\$5,000	\$78
	Grant	4	\$22,189	\$1,387
Atlantic Provinces	Federal	1	\$2,500	\$625

^a Not all funding types were reported by municipalities in each province; only reported types are included in this table.

Table 12: Estimated in-kind spending on invasive species

	Number Reported	Average of Reported	Average of Total
British Columbia	11	\$47,891	\$14,633
Alberta	14	\$42,896	\$17,159
Saskatchewan	4	\$1,825	\$281
Manitoba	1	\$5,000	\$227
Ontario	6	\$6,000	\$1,636
Quebec	19	\$5,558	\$1,650
Atlantic Provinces	3	\$1,733	\$236
Total	58	\$22,180	\$5,569

Survey respondents were asked to indicate the percentage increase in the costs of invasive species management that occurred in the past five years, as well as the estimated percentage increase that will occur in the next five years. The responses for the percentage increase over the past five years are displayed in Figure 4 for all respondents, and are broken down by province and region in Figure 5. It is evident from Figure 4 that, aside from the 60 respondents that did not know how much costs had increased, the majority of municipalities estimated that costs increased by less than 50%, with 59 municipalities (33.7%) reporting an increase of 0-25% and 33 municipalities (18.9%) reporting an increase of 25-50%. There were 10 municipalities (5.7%) that reported an increase in costs of invasive species management of over 100%. Similar trends were observed across most provinces and regions (see Figure 5). As displayed in Figure 6, the majority of municipalities that provided estimates of the expected increase in costs of invasive species management indicated that costs were expected to increase by less than 25% (69 municipalities, or 48.3%) or by 25-50% (43 municipalities, or 30.1%). There were 13 municipalities (9.1%) that estimated an increase in costs of over 100%. The majority of municipalities in each province and region estimated cost increases to be less than 50% (see Figure 7).

Table 13: Municipalities reporting insufficient funding for invasive species

	Number Reported	% of Respondents
British Columbia	29	80.6%
Alberta	22	62.9%
Saskatchewan	11	42.3%
Manitoba	9	40.9%
Ontario	20	90.9%
Quebec	40	62.5%
Atlantic Provinces	8	36.4%
Territories	1	25.0%
Total	140	60.6%

Table 14: Amount of additional annual funding requirements reported by municipalities

	Number Reported	Average of Reported
British Columbia	21	\$370,969
Alberta	18	\$374,117
Saskatchewan	8	\$68,788
Manitoba	7	\$50,857
Ontario	11	\$477,273
Quebec	26	\$1,274,712
Atlantic Provinces	3	\$172,500
Total	94	\$578,093

Figure 4: Estimated increases in costs of invasive species management in the past 5 years

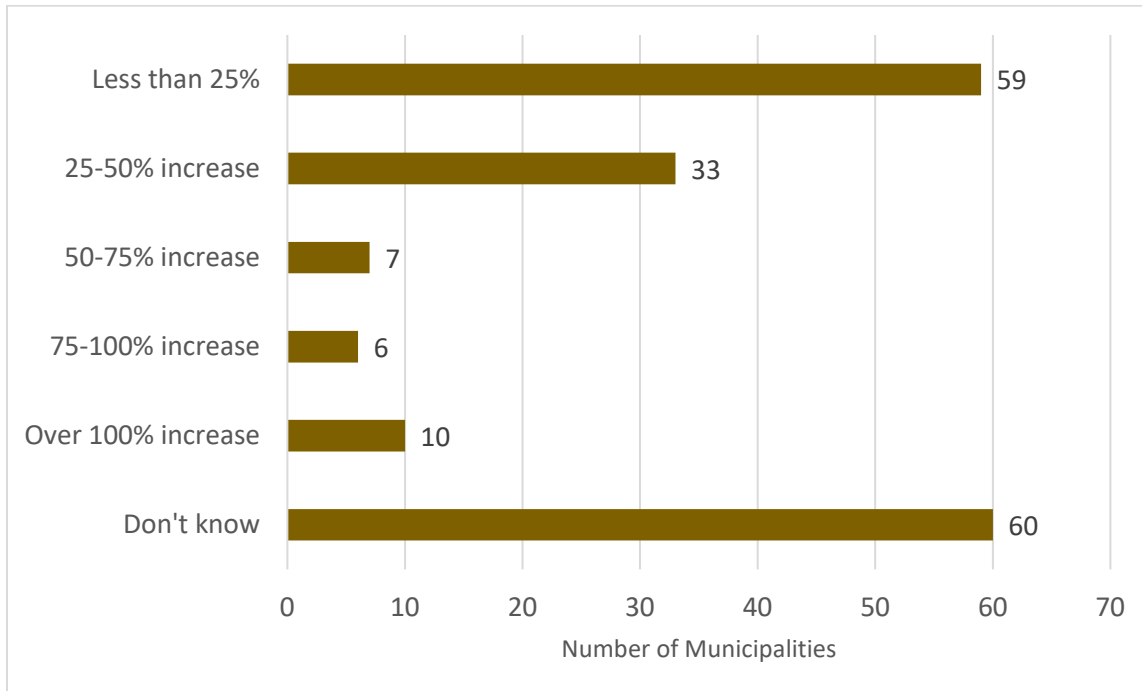


Figure 5: Estimated increases in costs of invasive species management in the past 5 years, by province or region

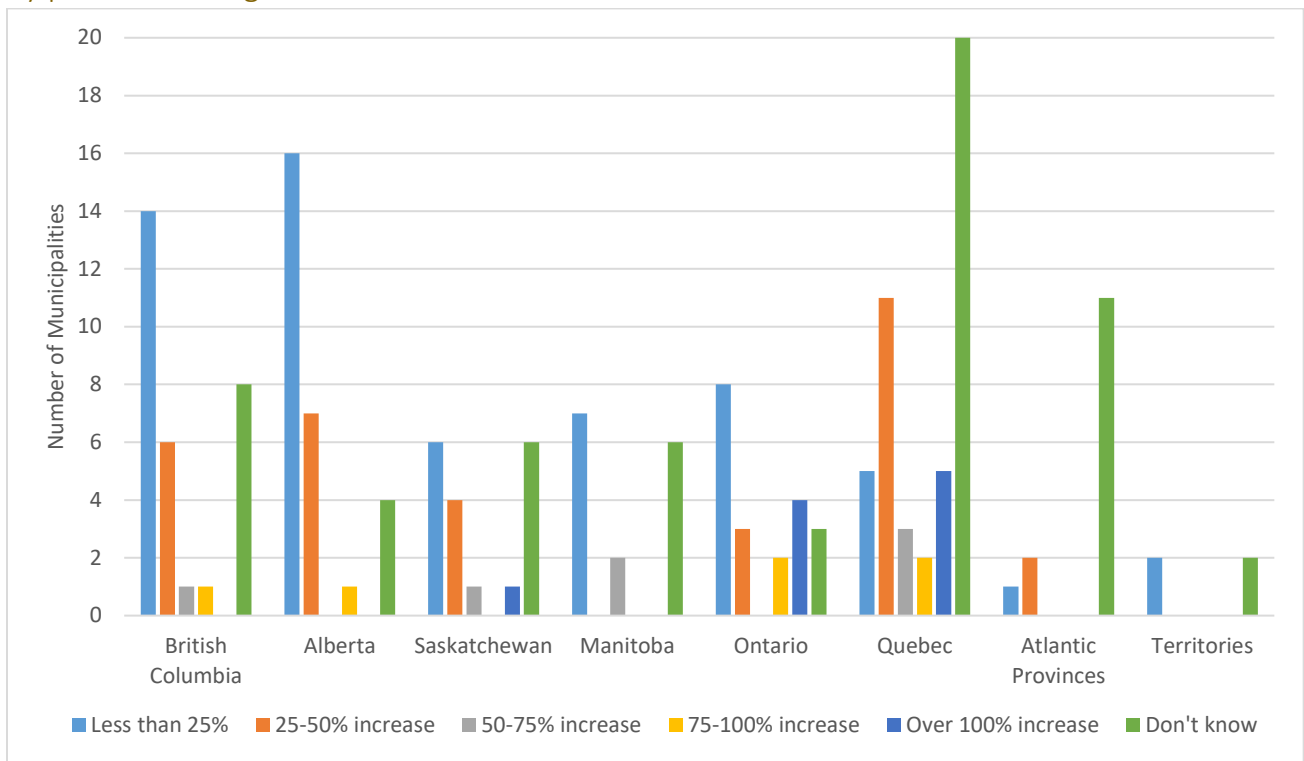


Figure 6: Estimated increases in costs of invasive species management in the next 5 years

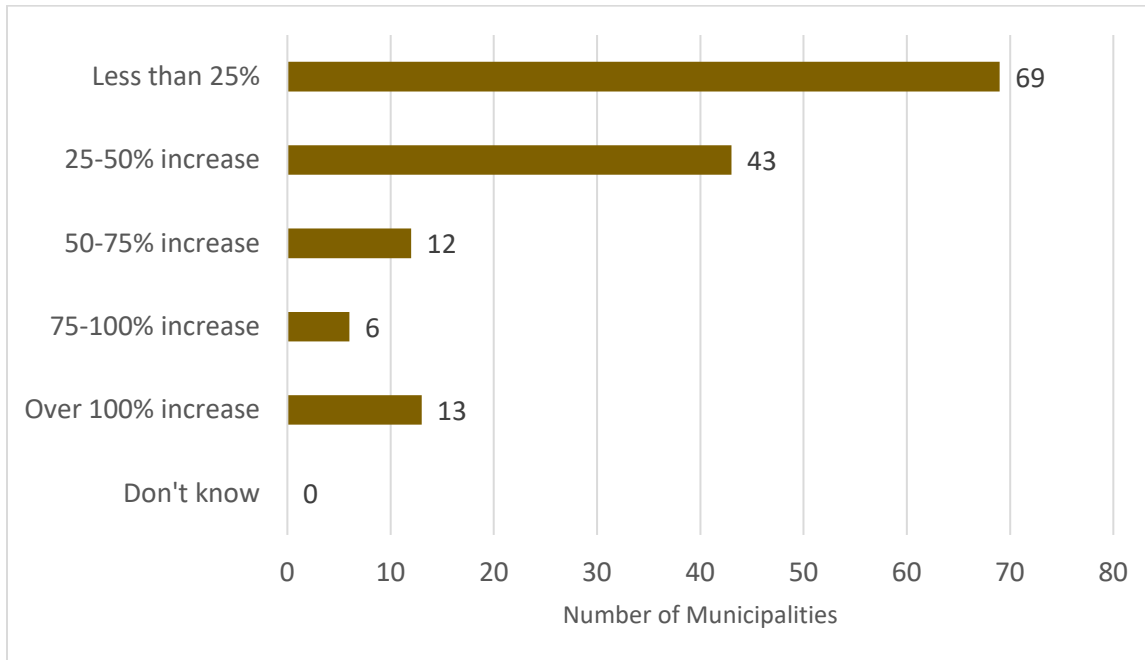
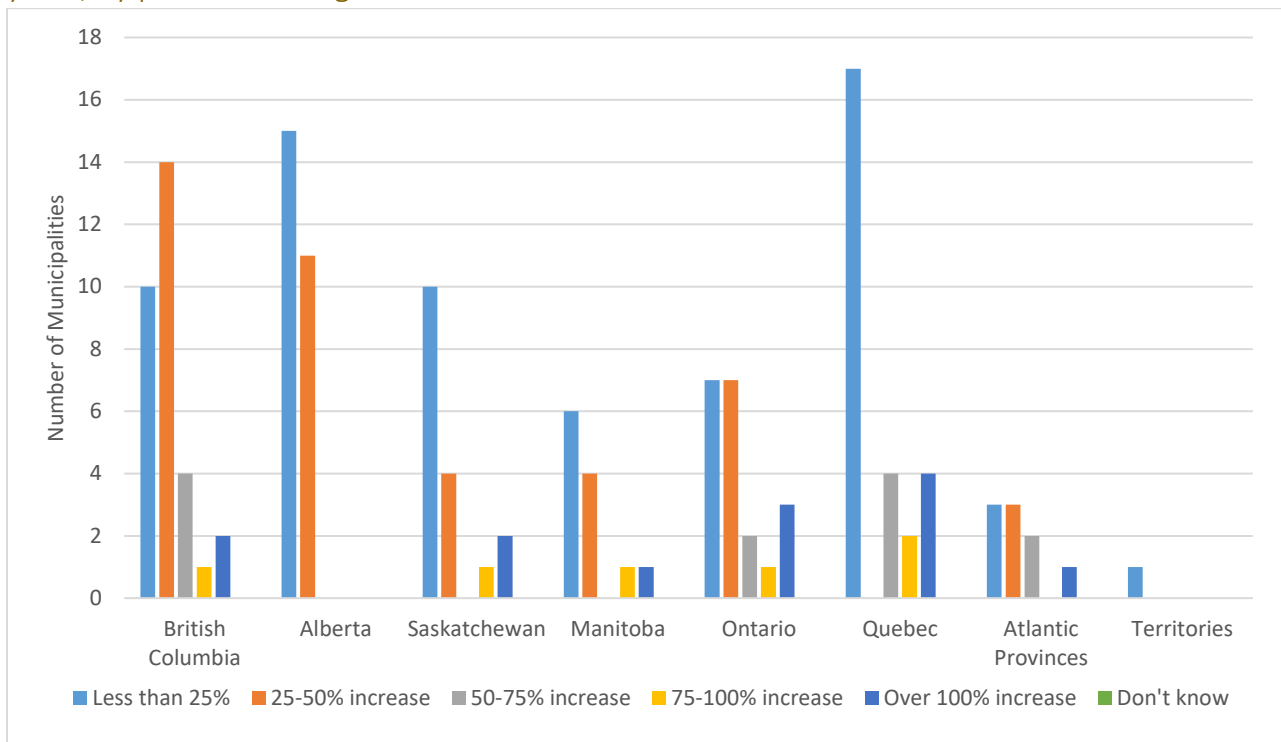


Figure 7: Estimated increases in costs of invasive species management in the next 5 years, by province or region



2.6 Data Issues and Limitations

Survey data reliability is heavily dependent on the accuracy of information provided by respondents. **Hence, it must be acknowledged that the accuracy of the total expenditure on invasive species activities estimated in this report is dependent on the assumption that the information provided through the surveys is accurate.**

Some survey respondents did not provide answers for all questions, and in some cases there were inconsistencies in the answers to different questions. This was addressed in various ways, depending on the nature of the missing or inconsistent information. For example, respondents were asked to provide expenditure amounts for their municipality as well as for their department, but in some cases they only provided an expenditure amount for their department. If an expenditure amount was provided for the department but not for the municipality, the total municipality expenditure was assumed to be equal to that of the department. Among the 72 respondents that provided expenditures for both the municipality and the department, 47 reported equal expenditures for both (the average percentage of total municipality expenditures that were incurred by the department was 83.2%). As such, imposing this assumption in cases where municipality expenditure is not provided may result in a slightly underestimated total expenditure for the municipality.

There were a number of cases where the percentages of expenditure amounts spent on different invasive species activities (i.e., prevention, detection, etc.) did not add up to 100%. In these cases, the percentages provided for each activity were adjusted proportionally so that they summed to 100%. For example, if a respondent indicated that 5% was spent on prevention activities and 20% was spent on control and management activities, for a total of 25%, then these percentages would be adjusted to 20% for prevention and 80% for control and management so that the total summed to 100%.

In some cases, total expenditure was stated as \$0 (or no response was recorded), but an amount greater than \$0 was indicated for a specific invasive species. In these cases, the total expenditure was adjusted to be equal to the expenditure on the specific invasive species. In other cases, the sum of expenditures on individual species was greater than the total expenditure reported by the municipality. In these cases, the municipality expenditure amount was increased to be equal to the sum of the expenditures on individual invasive species.

Another limitation of the data could be related to jurisdictional authority for invasive species management, as municipalities in some provinces may have more authority over terrestrial invasive species than over aquatic invasive species. As a result, expenditures on aquatic invasive species may be under-reported in this survey. As evident in Table 8, the majority of species for which expenditures were reported were terrestrial invasive species.

There is also a potential data reliability issue caused by Covid-19. There is the potential that this pandemic led to a reduction in spending, as the restrictions implemented to address the pandemic may have resulted in the elimination or reduction of some invasive species management activities and spending. As a result, the expenditures reported by municipalities for 2020 may be lower than in typical years, which could cause the total expenditure by municipalities in Canada to be underestimated.

2.7 Sample Representativeness

The accuracy of an estimated value for an entire population based on a sample of that population may be affected by the representativeness of the sample, or how well the sample reflects the characteristics of the entire population. For this report, the accuracy of the estimated value for total expenditure on invasive species for all municipalities across Canada may depend on how well the characteristics of the sample municipalities represent those of all municipalities in the country. As a result, it is important to assess the representativeness of the sample. The representativeness is assessed based on a number of factors, including population, household income, and land area.

The sample comprises 231 of the 3,530 municipalities in Canada, or 6.5%. The combined population of the sample municipalities represents 38.6% of the total combined population of all municipalities in the country. The average of the median household income for each of the sample municipalities is 104.2% of the national median household income. The land area covered by the 231 sample municipalities accounts for 7.7% of Canada's land area. As such, the sample is fairly representative of the population based on household income and based on land area. However, the sample does not appear to be very representative in terms of population. As a result, it may be important to account for the influence of population when generating estimates based on this sample. This coincides with the prior surveys conducted in Ontario, where the samples were not found to be very representative based on population. The results of the Ontario surveys also demonstrated the importance of accounting for the influence of population. The methods used for estimating total annual expenditure are described in Section 3.1.

It is evident from the numbers and proportions of sample municipalities for each province that the sample is more heavily weighted toward the provinces of Quebec, British Columbia, and Alberta. These provinces have the highest numbers of municipalities in the sample and the highest response rates based on the total numbers of municipalities in each province.

2.8 Summary of Survey Results

Survey responses were received from 231 municipalities across Canada, which represented 6.5% of all municipalities in the country. The highest number of surveys were received from the province of Quebec (64) and the fewest from Northwest Territories (1) and from Nunavut (1). Expenditures on invasive species were reported by 77.5% of the responding municipalities (179 in total), with this percentage ranging from 22.7% in the Atlantic Provinces to 95.5% in Ontario. The average expenditure across all responding municipalities was \$142,101, ranging from \$250 in the Territories to \$438,823 in Alberta. Per capita expenditure across all responding municipalities was \$2.42, and ranged from \$0.09 in the Territories to \$7.54 in Manitoba. The majority of expenditures were incurred for control and management activities. Reported species-specific expenditures were highest for emerald ash borer, followed by Eurasian watermilfoil, Dutch elm disease, and Japanese knotweed. Species with the highest reported expenditures varied across provinces and regions, as did the identified priority species of concern. The species of concern reported by the highest number of municipalities were Japanese knotweed, giant hogweed, emerald ash borer, leafy spurge, and Eurasian watermilfoil. However, 60.6% of responding municipalities indicated that funding was insufficient for adequately managing invasive species. The average estimated amount of additional annual funding required was \$578,093, and ranged from \$50,857 in Manitoba to \$1,274,212 in Quebec.

3.0 Methods for Estimating Total Expenditure

Total annual expenditure on invasive species activities by municipalities across Canada is estimated using an extrapolation approach. This was the primary estimation approach used for the surveys conducted in Ontario between 2017 and 2019 (Vyn, 2019).

Based on a population of 3,530 municipalities in Canada and a sample size of 231 municipalities, the margin of error is 6.23%.⁴ This margin of error is smaller than those of the previous surveys conducted in Ontario. The smaller the margin of error, the greater confidence that an extrapolation of the survey data will generate an accurate estimate for the entire population.

The extrapolation process is conducted in aggregate for all municipalities across Canada and separately for municipalities within each province or region. The results by province or region are then aggregated to generate an estimate of total annual expenditure on invasive species by all municipalities in Canada.

3.1 Extrapolation Approaches

Two extrapolation approaches are used to estimate total expenditure from the survey results. The first approach is a simple extrapolation based on the average expenditure for the sample municipalities and the total number of municipalities in Canada or in each province or region. Hence, to estimate total expenditure by municipalities across Canada, the average expenditure for the sample municipalities is multiplied by the total number of municipalities in Canada.

The second approach takes into account the influence that the population of municipalities may have on their expenditures and conducts an extrapolation based on per capita expenditure. For the sample municipalities, the expenditure per person is multiplied by the total population of Canada. This extrapolation approach is used because the sample is weighted toward higher populated municipalities, which may influence the level of expenditure. As demonstrated by the discussion of the survey results, as well as by the analyses conducted for the prior surveys in Ontario, population has a significant impact on the level of expenditure, as municipalities in urban areas tend to spend more on invasive species activities than do less-populated jurisdictions. By accounting for the influence of population in the extrapolation process, this may reduce the potential bias inherent in the simple extrapolation approach and potentially generate a more accurate estimate of total expenditure for each province or region as well as for all of Canada.

To account for provincial or regional variation in the sample municipalities or in expenditures on invasive species activities, the two extrapolation approaches described above are also used to conduct extrapolations to the provincial or regional level. The provincial and regional extrapolated amounts are then aggregated to generate an estimated total annual expenditure for all municipalities in Canada. Due to the regional variation in expenditures by municipalities, this approach is expected to generate a more accurate estimate of total expenditure than extrapolation directly to the national level.

⁴ This margin of error is calculated based on a 95% confidence level, using the calculator available at: <https://www.checkmarket.com/sample-size-calculator/>.

4.0 Results

Extrapolations are conducted for the sample municipalities, using the approaches described in the previous section, to generate estimates of total annual expenditure on invasive species across all municipalities in Canada. Considerable variation is evident in the estimates across the different extrapolation approaches, which are described below.

4.1 Extrapolation Results

Two primary extrapolation approaches are used for the sample municipalities, which include a simple extrapolation based on average expenditure and an extrapolation based on per capita expenditure. These extrapolation processes are conducted based on all sample municipalities combined and then by region or province, in order to account for regional variation in expenditures. The results of the extrapolations are summarized in Table 15.

The simple extrapolation approach involves taking the average expenditures for the sample municipalities and extrapolating these amounts across all municipalities in the country. The average estimated expenditure for sample municipalities is \$142,101. Extrapolating this amount across all 3,530 municipalities generates an estimated total expenditure by municipalities in Canada of \$501.6 million.

The second extrapolation approach involves taking the per capita expenditures for the sample municipalities and extrapolating these amounts based on the combined population of all municipalities in Canada. The per capita expenditure on invasive species for the sample municipalities is \$2.42. Extrapolating this amount across the combined population of all municipalities in Canada generates an estimated total expenditure by municipalities of \$85.0 million.

To account for provincial and regional differences in expenditure amounts for municipalities, extrapolations of expenditures up to the provincial or regional level are conducted prior to aggregating up to the national level. The estimated expenditure amounts for sample municipalities within each of the eight provinces and regions are extrapolated using the two approaches described above. The extrapolated amounts for each province and region are then aggregated to generate estimates of total expenditure for municipalities in Canada. The extrapolations based on average expenditures by municipalities within each province or region generate an estimated total expenditure by municipalities in Canada of \$400.0 million. The extrapolations based on per capita expenditures by municipalities within each province or region generate an estimated total annual expenditure of \$95.8 million.

4.2 Limitations and Potential Bias

There are limitations associated with this study that may be a source of bias for the estimated total annual expenditure on invasive species. The sample used to estimate total expenditure is not a randomized sample, as municipalities chose to respond to the surveys. With voluntary response samples, bias is more likely to be an issue. Bias may also arise if there is correlation between the decision to respond to the survey and the level of expenditure. For example, municipalities that incur expenditures on invasive species may be more likely to respond to the survey than municipalities that do not incur expenditures,

which could bias the estimated total expenditure upward. In addition, as discussed in Section 2, the potential accuracy of the estimated total expenditure is largely dependent on survey respondents providing accurate and appropriate information in their responses to questions.

Another potential limitation of this study is that for several provinces there are relatively low numbers of responses. For example, the survey was completed by only 22 out of 494 municipalities (4.5%) in the Atlantic Provinces and only 26 out of 774 municipalities (3.4%) in Saskatchewan. The relatively small numbers of respondents can reduce the degree to which the sample is representative of the full population. This can negatively impact the accuracy of the estimated expenditures for each province, as the reliability of the extrapolation approach depends heavily on sample representativeness. While the representativeness of the samples was examined based on factors such as population, household income, and land area, it is unknown how well each provincial sample is representative of the full population of municipalities within each province in terms of expenditures on invasive species. Overall, with smaller samples, there is a greater likelihood of bias occurring due to outliers. The small sample size is the primary reason that it is difficult to narrow down the range of estimates of total expenditure, as discussed below. As such, the results of this study should be viewed with caution.

4.3 Summary and Discussion of Results

Given the observed differences in the nature of municipality expenditures across provinces and regions, the estimates based on extrapolations to the provincial or regional level prior to aggregating to the national level are expected to be more accurate. Table 15 provides the results of these extrapolations, along with the average of the two extrapolation approaches. As evident in this table, the estimates of total annual expenditure on invasive species by municipalities in Canada vary considerably across the two extrapolation approaches. Since the sample of responding municipalities is more heavily weighted toward higher populated municipalities that tend to have greater expenditures on invasive species, it is quite likely that the estimate of \$400.0 million generated by the extrapolation based on average expenditure is an overestimate of total annual expenditure by municipalities in Canada. As a result, the extrapolation based on per capita expenditure, which accounts for the influence of population, may generate a more accurate estimate of total expenditure.

However, based in part on a comparison with the results of previous surveys conducted in Ontario, the estimate of \$95.8 million based on an extrapolation of per capita expenditure is most likely an underestimate of total expenditure. Specifically, the total expenditure estimated in this study is based on a sample of 22 Ontario municipalities, from which the extrapolation based on per capita expenditure generated an estimated total expenditure for Ontario municipalities of \$14.4 million (see Table 15). By comparison, in the most recent report on invasive species expenditures in Ontario (Vyn, 2019), the estimate was based on a sample size of 147 municipalities. In this case, the extrapolation of per capita expenditure resulted in an estimate of total expenditure by municipalities in Ontario of \$42.3 million. Given the much larger sample size, the 2019 estimate is likely more accurate than the estimate based on the 2021 national survey. This implies that the estimated total expenditure of \$95.8 for municipalities across Canada, based on the extrapolation of per capita expenditure, may be much too low. This implication was further reinforced by feedback from government organizations involved in invasive species management, who also believed that this estimate, along with the corresponding estimated expenditures for specific invasive species, is likely too low.

To address these issues with the two extrapolation approaches, a third expenditure scenario is constructed that involves taking the average of the estimates from the two extrapolation approaches. Thus, the results consist of a range of three potential estimates of total expenditure: \$95.8 million based on per capita expenditure, \$400.0 million based on average expenditure, and the average of these two estimates of \$247.9 million. Due to the potential issues identified with the estimates from each of the two extrapolation approaches, where the estimate based on the extrapolation of average expenditure may be too high while the estimate based on the extrapolation of per capita expenditure may be too low, the average of the two extrapolation estimates (\$247.9 million) may be a better approximation of total annual expenditure. In fact, this approach generates an estimate of total expenditure by municipalities in Ontario of \$39.2 million (see Table 15), which is very close to the estimate of \$42.3 million in the 2019 Ontario study. However, due to the limitations associated with the relatively small sample size, it is difficult to determine which of these three estimated total expenditures is most accurate. As such, all three estimates are presented in this report as potential approximations of total annual expenditure on invasive species by municipalities in Canada.

Table 15: Summary of extrapolation results for estimated total expenditure on invasive species by all municipalities in Canada

	Average Expenditure (a)	Total # of Municipalities (b)	Per Capita Expenditure (c)	Population (d)	Estimated Expenditure		
					Simple Extrapolation (a) x (b)	Per Capita Extrapolation (c) x (d)	Average of Extrapolations
Canada	\$142,101	3,530	\$2.42	35,151,728	\$501,616,530	\$84,986,780	\$292,590,399
British Columbia	\$166,988	162	\$1.19	4,648,055	\$27,052,000	\$5,540,256	\$16,296,128
Alberta	\$438,823	344	\$5.45	4,067,175	\$150,955,169	\$22,184,213	\$86,569,691
Saskatchewan	\$65,876	774	\$3.46	1,098,352	\$50,988,098	\$3,798,937	\$27,393,517
Manitoba	\$35,166	137	\$7.54	1,278,365	\$4,817,806	\$9,644,109	\$7,230,958
Ontario	\$144,430	444	\$1.07	13,448,494	\$64,126,790	\$14,350,748	\$39,238,769
Quebec	\$84,914	1,108	\$4.83	8,164,361	\$94,084,294	\$39,397,009	\$66,740,651
Atlantic Provinces	\$16,159	494	\$0.35	2,333,322	\$7,982,591	\$825,353	\$4,403,972
Territories	\$250	67	\$0.09	113,604	\$16,750	\$10,295	\$13,522
Total					\$400,023,497	\$95,750,920	\$247,887,208

5.0 Conclusions

It is evident from the results that estimates of total annual expenditure on invasive species by municipalities in Canada vary considerably between the two extrapolation approaches. The adverse impact that the relatively small sample sizes for many of the provinces has on generating accurate estimates of expenditure contributes to uncertainty regarding the estimate that best represents actual expenditures by municipalities across Canada. The estimate of \$400.0 million generated through the extrapolation of average expenditure is likely an overestimate of expenditure due to the sample being weighted toward higher populated municipalities that tend to have greater expenditures on invasive species. Conversely, the estimate of \$95.8 million generated through the extrapolation of per capita expenditure is likely an underestimate, as explained in the previous section. As a result, a third estimate scenario is constructed based on the average of the two estimates, or \$247.9 million. Due to the issues identified with the accuracy of the first two estimates, the average may be more representative of actual total expenditure by municipalities across Canada. While it may be a better approximation of total expenditure than the first two estimates, without additional survey work or larger sample sizes it is difficult to determine the accuracy of this estimate. **As such, due to the relatively low numbers of survey responses in many of the provinces, all estimates presented in this report should be viewed with considerable caution.** Despite this limitation, it should be pointed out that the survey results provide a considerable amount of useful information on invasive species management by municipalities in Canada, as described in Section 2.

The average estimate of \$247.9 million works out to an estimated per capita annual expenditure of \$7.05, based on the 2016 Census estimate of the Canadian population of 35.2 million. Applying the average expenditure allocations for the five different types of activities reported by municipalities (see Table 3) to the average of the estimated total annual expenditure of \$247.9 million generates annual expenditure estimates of \$152.6 million for control and management activities, \$36.4 million for detection activities, \$33.7 million for prevention activities, \$15.2 million for habitat restoration, and \$9.8 million for research and science. As evident from the survey results, the majority of expenditures are incurred for control activities rather than prevention or detection activities.

Based on the percentages of total reported expenditures for individual invasive species (see Table 8), each of the estimates of total annual expenditure can be broken down by species. The resulting ranges of estimates of total annual expenditures by all municipalities for specific invasive species are provided in Table 16. As evident in this table, based on the average of the estimated total annual expenditures, it is estimated that \$80.0 million was spent annually on emerald ash borer, \$21.3 million on Eurasian watermilfoil, \$19.1 million on Dutch elm disease, \$15.3 million on Japanese knotweed, and \$14.2 million on noxious weeds. Table 16 also indicates the estimated expenditures by species under the other two expenditure estimate scenarios.

It should be noted that the total annual expenditure estimated in this study accounts only for expenditures by municipalities in Canada and not by other government bodies or institutions. Expenditures by provincial and federal government departments on invasive species would not be accounted for in these estimates, which suggests that total expenditure on invasive species incurred across all levels of government likely exceeds the total expenditure estimated in this study.

It is evident from the survey responses that funding for invasive species activities is an issue facing a number of municipalities. Of the 231 responses from municipalities in this survey, 179 indicated that expenditures on invasive species activities were incurred, but 140 of these respondents indicated that funding was not sufficient to cover the costs of managing invasive species. This implies that expenditures incurred by municipalities across Canada could be much higher than the estimated total expenditure if more funding were available. In addition, costs of invasive species management are expected to increase considerably, with the majority of respondents indicating expected increases of 0-25% or 25-50%.

There are substantial economic benefits associated with controlling invasive species. For example, in the prior Ontario studies, the annual economic impacts of invasive species were estimated to be \$3.6 billion (Vyn, 2019). As such, additional funding for controlling invasive species, even a substantial increase over and above the total annual expenditure estimated by this study, could generate a net economic benefit to the country.

Table 16: Estimated expenditures on individual invasive species by all municipalities, based on the three estimates of total annual expenditure in Canada^a

Species (Common Name)	Low	High	Average
Emerald Ash Borer	\$30,951,872	\$129,309,212	\$80,130,542
Eurasian Watermilfoil	\$8,249,637	\$34,464,929	\$21,357,283
Dutch Elm Disease	\$7,385,850	\$30,856,244	\$19,121,047
Japanese Knotweed	\$5,909,517	\$24,688,489	\$15,299,003
Noxious Weeds	\$5,488,696	\$22,930,403	\$14,209,549
Canada Thistle	\$4,604,760	\$19,237,542	\$11,921,151
Phragmites	\$4,467,543	\$18,664,282	\$11,565,912
Himalayan Blackberry	\$4,001,044	\$16,715,367	\$10,358,206
Leafy Spurge	\$2,917,298	\$12,187,743	\$7,552,520
Parrot's Feather	\$2,177,555	\$9,097,284	\$5,637,419
Yellow Toadflax	\$1,978,483	\$8,265,610	\$5,122,047
Spotted Knapweed	\$1,691,284	\$7,065,764	\$4,378,524
Buckthorn (all spp.)	\$1,532,963	\$6,404,336	\$3,968,649
Zebra/Quagga Mussels	\$1,404,723	\$5,868,583	\$3,636,653
Giant Hogweed	\$1,317,287	\$5,503,297	\$3,410,292
Scentless Chamomile	\$1,152,237	\$4,813,758	\$2,982,997
Spongy Moth	\$769,681	\$3,215,536	\$1,992,608
Norway Rat	\$727,290	\$3,038,438	\$1,882,864
Wild Parsnip	\$671,344	\$2,804,708	\$1,738,026
Absinth	\$654,176	\$2,732,984	\$1,693,580
Clubroot	\$638,220	\$2,666,326	\$1,652,273
Common Tansy	\$594,215	\$2,482,483	\$1,538,349
Chafer Beetle	\$542,487	\$2,266,377	\$1,404,432
Nodding Thistle	\$542,487	\$2,266,377	\$1,404,432
Tall Buttercup	\$414,843	\$1,733,112	\$1,073,978
Garlic Mustard	\$414,501	\$1,731,681	\$1,073,091
English Ivy	\$382,932	\$1,599,796	\$991,364
White Cockle	\$382,932	\$1,599,796	\$991,364
European Elm Scale	\$297,411	\$1,242,508	\$769,959
Dog Strangling Vine	\$257,203	\$1,074,529	\$665,866
Invasive Pests (insects)	\$255,288	\$1,066,530	\$660,909
Sow Thistle	\$248,906	\$1,039,867	\$644,387
Lamium	\$191,466	\$799,898	\$495,682
Blueweed	\$175,511	\$733,240	\$454,375
Himalayan Balsam	\$170,207	\$711,082	\$440,645
Common Burdock	\$161,080	\$672,954	\$417,017
Puncturevine	\$160,646	\$671,141	\$415,894
Scotch Broom	\$153,173	\$639,918	\$396,546
Baby's Breath	\$130,835	\$546,597	\$338,716
Ox-Eye Daisy	\$127,644	\$533,265	\$330,455
Purple Loosestrife	\$127,644	\$533,265	\$330,455
Smooth Brome	\$127,644	\$533,265	\$330,455
Thistle	\$127,644	\$533,265	\$330,455
Other	\$1,072,758	\$4,481,716	\$2,777,237
Total	\$95,750,920	\$400,023,497	\$247,887,208

^a These three estimates are \$95.8 million (Low), \$400.0 million (High), and \$247.9 million (Average).

References

Vyn, R. J. (2019). *Estimated expenditures on invasive species in Ontario: 2019 survey results*. Report written for the Invasive Species Centre, July 2019. Available at <https://www.invasivespeciescentre.ca/>.