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Updated Expenditure Estimates on Invasive Species in Ontario: 2018 Survey Results

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Table of Contents

Executive Summary.....	iv
1.0 Introduction	1
2.0 Survey Data	2
2.1 Survey Results: Municipalities	2
2.1.1 Survey Results by Region	3
2.2 Survey Results: Conservation Authorities.....	3
2.2.1 Survey Results by Region	4
2.3 Summary of Results	5
2.4 Data Issues and Limitations	5
2.5 Comparison of Survey Results between 2017 and 2018	6
2.6 Sample Representativeness	7
2.6.1 Sample Representativeness: Municipalities	7
2.6.2 Sample Representativeness: Conservation Authorities.....	8
3.0 Methods for Estimating Total Expenditure.....	10
3.1 Extrapolation Methods	10
3.2 Regression Model Approach.....	11
3.3 Combined Data from 2017 and 2018 Surveys	12
4.0 Results	14
4.1 Extrapolation Results	14
4.2 Regression Model Results	15
4.3 Extrapolation Results for Combined Data.....	16
4.4 Limitations and Other Considerations	16
5.0 Costs and Benefits of Invasive Species Control.....	18
6.0 Conclusions	19
Tables and Figures	21
Table 1: Expenditure, geographic, and demographic data for sample municipalities	21
Table 2: Species-specific expenditures reported by sample municipalities and conservation authorities	24
Table 3: Expenditure and demographic statistics by region for sample municipalities	25
Table 4: Expenditure and geographic data for sample conservation authorities.....	26
Table 5: Summary of results for estimated total expenditure, by estimation approach	27

Table 6: Results of the regression model for expenditure by municipalities 28

Figure 1: Priority invasive species reported by sample municipalities and conservation authorities.... 29

Figure 2: Regional divisions for Ontario municipalities 30

Figure 3: Map of conservation authorities in Ontario 31

Executive Summary

The purpose of this report is to estimate expenditures on invasive species by municipalities and conservation authorities in Ontario. Surveys were conducted in early 2018 of municipalities and conservation authorities to derive information on expenditures for invasive species prevention, detection, control, and management activities. Responses were received from 68 municipalities and 13 conservation authorities. The information collected through these surveys is used to estimate total expenditures on invasive species incurred by all municipalities and all conservation authorities across Ontario.

This report updates and extends a similar study conducted in 2017 for the Invasive Species Centre. The 2017 survey received usable responses from only 35 municipalities, with the sample being heavily weighted toward higher populated municipalities. By comparison, the 2018 survey received almost double the number of responses from municipalities, with a much more balanced sample, and also received responses from over 30% of conservation authorities in the province.

The survey results indicate that expenditures on invasive species were reported by 34 of 68 municipalities, with an average expenditure of \$62,328, and by 8 of 13 conservation authorities (CAs), with an average expenditure of \$51,438. Total expenditures were \$4,238,277 for responding municipalities and \$668,700 for responding CAs. For both groups, the majority of reported expenditures were incurred for control of emerald ash borer (84.4% for municipalities; 71.3% for CAs).

These survey results are used to estimate the total annual expenditure on invasive species across all municipalities and all conservation authorities in Ontario. The primary approach used to estimate total expenditure for both municipalities and CAs is an extrapolation approach. Extrapolations are conducted based on average expenditures by sample municipalities and sample CAs, and based on per capita expenditures for sample municipalities and expenditures per square kilometre for sample CAs. Each of these extrapolation processes is conducted in two ways: first, extrapolations are conducted directly to the provincial level; and second, extrapolations are conducted to the regional level prior to aggregating up to the provincial level. The results of these extrapolations indicate a range for the estimated total expenditure on invasive species by municipalities and conservation authorities in Ontario of \$16.8 million to \$29.6 million per year.

Extrapolations are also conducted on a combined sample comprised of both the 2017 and 2018 survey respondents. This approach addresses potential representativeness issues associated with both samples. The results of the extrapolations on the combined sample generate an estimated total expenditure by municipalities and conservation authorities of \$38.8 million per year. This estimate may be more accurate than the estimates based on the individual 2017 and 2018 samples.

While this report provides an estimate of total expenditure on invasive species across the province, it is important to note that many of the municipalities and CAs indicated that current funding was not sufficient to effectively combat invasive species. There were 17 municipalities and 7 CAs that provided an approximation of additional funding requirements; on average, for municipalities these amounts were almost twice the amounts actually spent and for CAs these amounts were 1.2 times the amounts spent. This implies that considerably more expenditures could be incurred across the province to effectively prevent, detect, manage, and control invasive species.

1.0 Introduction

Ontario's Invasive Species Act, 2015, defines invasive species as species that are not native to Ontario, or to a part of Ontario, and are harming, or are likely to harm, the natural environment of Ontario. To prevent significant losses to the natural environment, as well as subsequent economic, social, cultural, and health and safety impacts, expenses are incurred by various levels of government to prevent, detect, manage, and control invasive species. A 2017 report, entitled "An Assessment of the Costs and Economic Impacts of Invasive Species in Ontario", was conducted for the Invasive Species Centre to estimate the expenditures incurred by Ontario municipalities on invasive species. These expenditures were estimated based on a survey conducted of individual municipalities. The results of extrapolation and regression approaches generated a range of estimated annual expenditures from \$40.9 million to \$55.0 million.

However, this report identified concerns with the surveys that may affect the accuracy of these estimates. First, the sample size was quite small, comprised of only 35 out of 444 municipalities in the province. Second, the sample was not very representative of all municipalities, as it was heavily weighted toward municipalities with high populations. This could bias the estimate upward, since population was found to influence the level of expenditure on invasive species activities. Finally, in addition to municipalities, there are also other government bodies or agencies within the province that may incur expenditures on invasive species, which would not be accounted for in the estimated provincial expenditure.

To address these concerns, another survey was conducted early in 2018. Rather than contacting individual municipalities by phone, a link to an online survey was sent to all municipalities, as well as to all conservation authorities in the province. This resulted in a much greater response rate than the 2017 survey, which could improve the accuracy of the estimated expenditure.

The purpose of this report is to update and extend the 2017 estimate of invasive species expenditures in Ontario. The larger, more representative sample of municipalities may permit a more accurate estimate of the total expenditure across all municipalities in the province. In addition, this report builds on the 2017 report by also using survey responses from conservation authorities to estimate total expenditure across all conservation authorities in the province.

This report consists of six sections. In the following section, the survey data results are summarized for the sample municipalities and sample conservation authorities, and the representativeness of each sample is discussed. The methods for estimating total expenditure are described in the third section, while the results of the extrapolation and regression model estimation approaches are provided in the fourth section. In the fifth section, the estimated total expenditure is compared to the potential benefits of invasive species control, which were estimated in the 2017 report. Conclusions of this report are discussed in the final section.

2.0 Survey Data

The surveys were conducted through SurveyMonkey, an online survey tool. Links to the surveys were sent to municipalities and to conservation authorities across the province. These surveys requested information on expenditures incurred in 2016/17 on invasive species, including type of expense (e.g., wages, equipment), type of activity (prevention, detection, or control and management), and a breakdown of expenses by invasive species. Surveys were completed by 68 municipalities and by 13 conservation authorities. The results of these surveys for each of the two groups of respondents are described in this section.

2.1 Survey Results: Municipalities

Survey responses were received from both upper-tier municipalities (e.g., counties, regional municipalities) and lower-tier municipalities (e.g., cities, towns, townships). Of the 444 municipalities in Ontario, responses were received from 68, or 15.3%.¹ A summary of the reported expenditure amounts and allocations is provided in Table 1. This table also provides geographic and demographic data for each municipality, including region, land area, population, and median household income.

Forty-seven respondents, or 69.1%, indicated that invasive species are currently impacting their municipality, while 29 respondents (42.6%) indicated that it is a high priority to manage invasive species. Expenditures on invasive species have been incurred by 47 municipalities (69.1%), but only 34 (50.0%) indicated that funding was allocated for invasive species management, either from a dedicated funding budget or from other funded projects.

Specific expenditures were reported by 34 municipalities (50.0%).² These municipalities spent a total of \$4,238,277 on invasive species activities in 2016/17. Expenditures ranged from \$400 to \$1,186,500, with an average of \$124,655 across the 34 municipalities that reported expenditures (or an average of \$62,328 across all responding municipalities). Categories of expenditures from which respondents could select include staff wages, tools and equipment, travel and conferences/workshops/training, educational/outreach materials and activities, payment to contractor, and other. Payment to contractor was the largest expense category across responding municipalities, comprising 60.2% of all reported expenditures. Respondents were also asked to break down expenditure by type of activity: prevention, detection, and control and management. Control and management activities accounted for the majority of expenditures (84.2%), while prevention activities and detection activities accounted for 6.7% and 9.1%, respectively.

The invasive species that are of primary concern to responding municipalities include emerald ash borer (EAB), giant hogweed, and phragmites. Emerald ash borer was identified as high priority by 17 municipalities, or 38.6% of the 44 municipalities that provided responses regarding priority levels, and as medium priority by 7 (15.9%), giant hogweed was high priority for 7 (15.9%) and medium priority for 16 (36.4%), and phragmites was high priority for 9 (20.5%) and medium priority for 10 (22.7%). Figure 1 provides a list of invasive species that were reported to be high or medium priority and indicates the

¹ By comparison, the 2017 survey had 35 respondents.

² Two other municipalities had indicated that funding was allocated, but did not report any expenditures.

combined number of municipalities and conservation authorities for which each species was reported to be high priority and medium priority.

The frequency that specific invasive species were reported to be high or medium priority coincides to some degree with expenditure. Table 2 provides expenditures by invasive species for both municipalities and conservation authorities. The amount spent by responding municipalities on emerald ash borer (\$1,943,590) accounted for the majority of reported species-specific expenditures (84.4%). Aside from EAB, the next two invasive species that accounted for the most spending are phragmites and wild parsnip. The responding municipalities spent \$179,304, or 7.8% of reported species-specific expenditures, on phragmites and \$78,500, or 3.4%, on wild parsnip.

It is evident from the survey responses that considerably more could be spent on invasive species activities. Thirty municipalities (44.1% of responding municipalities) indicated that funding in 2016/17 was not sufficient to combat invasive species, while only 14 (20.6%) indicated that funding was sufficient. Of the 30 that indicated insufficient funding, 17 (25.0%) provided estimated amounts of additional funding that would be required. The average of these additional amounts required was \$129,412, which is almost two times the average amount spent in these 17 municipalities.

2.1.1 Survey Results by Region

The survey results are broken down by region to examine for trends or differences in the results across regions. Municipalities in the province are divided into four regions – North, East, Central, and West – based on the map provided in Figure 2. A summary of expenditure statistics for the sample municipalities in the four regions is provided in Table 3, along with demographic statistics for each region.

There are similar numbers of sample municipalities within each of the four regions, ranging from 16 to 19. However, there are vast differences across regions in the reported expenditures. Only one of the 17 sample municipalities in the North region reported expenditures on invasive species, while at least half of the sample municipalities in each of the other three regions reported expenditures. The Central region had the highest proportion of sample municipalities with expenditures on invasive species, at 75%. The Central region also had, by far, the highest total expenditure reported by sample municipalities as well as the highest average expenditure. Despite having just one sample municipality with expenditures on invasive species, the North region did not have the lowest total or average expenditures among the four regions, as the one municipality (City of Thunder Bay) incurred a relatively large expenditure on invasive species. In fact, the expenditure per person was highest in the North region, where the population is much lower than in each of the other three regions.

2.2 Survey Results: Conservation Authorities

There are 36 conservation authorities (CAs) in Ontario (see Figure 3), which are responsible for the conservation and management of local watershed areas. The CAs tend to be much larger than municipalities, often encompassing several municipalities, with the boundaries defined based on watershed areas. The vast majority of the areas within the West, Central, and East regions are covered by conservation authorities, while CAs only comprise a very small percentage of the area in the North region. Survey responses were received from 13 of the 36 conservation authorities in Ontario, which is a 36% response rate. A summary of these responses is provided in Table 4.

It is evident from the survey responses that invasive species are a concern in many conservation authorities and that expenditures have been incurred for invasive species activities. Twelve of the CAs indicated that invasive species were having an impact within their jurisdiction, and 8 CAs indicated that managing invasive species was a high priority. While all 13 responding CAs indicated that expenditures were incurred as a result of invasive species, only 8 (61.5%) indicated that funding was available for invasive species management. The 2016/17 expenditures on invasive species reported by these 8 CAs ranged from \$3,000 to \$477,000, with an average of \$83,588. In addition, one CA reported in kind contributions of staff time, resources and land, but did not provide an estimated value of these contributions. In total, \$668,700 was spent by the 13 responding municipalities, or an average of \$51,438. It should be noted that a large proportion of this total expenditure was incurred in just one CA, as the Grand River Conservation Authority reported expenditures of \$477,000, or just over 70% of the total. For the total expenditures across all responding CAs, the top two expense categories were staff wages (48.2% of total expenditures) and payment to contractor (45.1%). The breakdown across the three categories of expenditures was an average of 11.9% for prevention, 21.7% for detection, and 66.4% for control and management.

Spending on control of emerald ash borer by the responding conservation authorities accounted for \$469,050, or 71.3% of reported species-specific expenditures (see Table 2). The next two invasive species for which the most spending occurred are phragmites (\$77,200, or 11.7%) and European buckthorn (\$58,950, or 9.0%). These three invasive species are also most frequently identified to be high or medium priority for responding CAs. Emerald ash borer is high priority for 9 CAs (69.2%) and medium priority for 2 CAs (15.4%), phragmites is high priority for 8 CAs (61.5%) and medium priority for 2 CAs (15.4%), and European buckthorn is high priority for 6 CAs (46.2%) and medium priority for 4 CAs (30.8%). Figure 1 provides the combined numbers of municipalities and CAs that indicated high or medium priority for specific invasive species.

As with the municipalities, most of the CAs (12 out of 13) indicated that funding was not sufficient to adequately combat invasive species. Estimates of additional funding requirements were provided by 7 CAs, which averaged \$76,429. On average, the additional funding requirement was 121% of the reported expenditure, which implies that many CAs believe that considerably more funding is needed to effectively control invasive species.

2.2.1 Survey Results by Region

Responses were received from conservation authorities in each of the four regions of the province. This allows for extrapolating the results for each region prior to estimating a total amount spent across all conservation authorities, which may result in a more accurate estimate. There are relatively proportional response rates across the four regions, with responses from two out of five CAs in the North (40.0%), three out of eight CAs in each of the East and Central regions (37.5%), and five out of 15 CAs in the West (33.3%).³

Differences across regions in expenditures on invasive species incurred by conservation authorities is evident from the survey responses (see Table 4). All five CAs in the West region reported expenditures, while neither of the two CAs in the North region reported expenditures. One of three CAs in the Central

³ These regional divisions are similar to those in Figure 2, but there are some differences in area due in part to the fact that CA boundaries do not follow municipality boundaries.

region and two of three CAs in the East region reported expenditures, all of which were relatively low (i.e., below the average expenditure).

2.3 Summary of Results

Average expenditures for municipalities (\$62,328) are greater than for conservation authorities (\$51,438), despite the fact that CAs tend to be much larger in size. This could be due to overlap in invasive species management activities. For example, if a municipality within a specific watershed is involved in controlling invasive species, there may be less need for the local CA to incur expenditures for these activities. Expenditures on invasive species are reported by a slightly higher percentage of sample CAs (61.5%) than sample municipalities (50.0%).

Similar trends are observed between municipalities and conservation authorities with respect to invasive species expenditures. Both focus their expenditures primarily on control and management activities. Management efforts for both municipalities and conservation authorities have focused primarily on terrestrial invasive plants (33 municipalities; 9 CAs) and on forest invasive pests and pathogens (30 municipalities; 7 CAs), while aquatic invasive plants, pests, and pathogens have received relatively little attention (4 municipalities; 2 CAs). Expenditures were least frequently reported for the North region by both sample municipalities (1 out of 17) and sample CAs (0 out of 2). Expenditures were far greater on emerald ash borer than on any other invasive species for both sample municipalities (84.4%) and sample CAs (71.3%).

2.4 Data Issues and Limitations

Not all respondents that reported expenditures on invasive species provided amounts for individual species. As a result, the data provided in Table 2 is based on the 19 municipalities that provided these amounts (out of 34 that reported expenditures). In addition, there are two conservation authorities that did not fully allocate their expenditures across invasive species. The expenditures on individual species reported by municipalities amounted to \$2,302,040, which is 54.3% of the total reported expenditures by sample municipalities of \$4,238,277, while the expenditures on individual species reported by conservation authorities amounted to \$658,250, or 98.4% of total reported expenditures. It is unclear from the survey results how the remaining expenditures were distributed across species.

In a number of cases, municipalities or CAs indicated that expenditures were incurred, but no amounts were reported. This may be due in part to how they responded to question 4 regarding funding. If the municipality or CA did not have funding allocated for invasive species activities, they were instructed to jump ahead in the survey past the question that asked for the amount spent on invasive species. However, it could be the case that expenditures on invasive species were incurred despite the lack of specific funding being allocated to invasive species; for example, funds may have been drawn from other departments or accounts to cover these expenditures. If this is the case, total expenditures on invasive species may be under-reported for the sample, which could cause the resulting estimate of provincial expenditure to be somewhat low.

The proportion of municipalities that indicated no expenditure on invasive species is higher in the 2018 survey than in the 2017 survey. The potential issue highlighted above may have contributed to this

difference. However, this difference may also have occurred due to a greater response rate from less populated municipalities, as the level of population was found to influence the amount of funding in the 2017 report. So it is difficult to say whether, and to what extent, this issue may have affected the results of this report.

2.5 Comparison of Survey Results between 2017 and 2018

As mentioned above, there is a considerably higher proportion of municipalities in the 2018 survey that reported no expenditure on invasive species. In the 2017 survey, 10 out of 35 municipalities (28.6%) did not indicate any expenditures, while in the 2018 survey, 34 out of 68 municipalities (50.0%) did not report expenditures. This may have been due in part to differences in sample representativeness between the two surveys. The 2017 sample was heavily weighted toward higher populated municipalities, as the responding municipalities represented 7.9% of all municipalities in the province but accounted for 43.3% of Ontario's population. Municipalities with higher population are more likely to have resources (i.e., staff; funding) available for invasive species management activities. As a result, these municipalities would be less likely to have zero expenditures on invasive species. By comparison, the responding municipalities in the 2018 survey represented 15.3% of all municipalities and accounted for 29.0% of Ontario's population.

There is a large difference in the total expenditure reported by municipalities between the 2017 and 2018 surveys. Despite the fact that the 2017 survey had only just over half the number of respondents as the 2018 survey, the total of all expenditures reported by municipalities in the 2017 survey (\$18,264,984) is much greater than the total reported by municipalities in the 2018 survey (\$4,238,277). As with the difference in municipalities reporting no expenditure, this difference may have been due in part to the high proportion of heavily populated municipalities in the 2017 survey.⁴ In addition, the 2017 sample had a number of municipalities reporting very high expenditure amounts, which could be related to the disproportionate amount of highly populated municipalities in the sample. There were four municipalities that reported expenditures of greater than \$1 million, while only one municipality in the 2018 sample reported an expenditure of greater than \$1 million.

There is consistency in the survey results across both years for a number of factors. Expenditures tend to be higher for municipalities with higher population. Expenditures were incurred primarily for control and management of invasive species, with 77.3% allocated to these activities in 2017 and 84.2% in 2018. The majority of reported expenditures for invasive species were allocated to emerald ash borer, with 95.8% in 2017 and 84.4% in 2018.

Additional minor differences exist between the 2017 and 2018 reports with respect to the demographic data for municipalities. The 2017 report used data from the 2011 Census since not all data from the 2016 Census was available, while by 2018 the 2016 Census data was fully available. This resulted in a difference in the measure of household income, which was based on average household income (from the 2011 National Household Survey) for the 2017 report and based on median household income (from the 2016 Census) for the current report. The median income is generally lower than the average income.

⁴ It should be noted that both the extrapolation process and the regression analysis used to estimate the total expenditure based on the 2017 survey accounted for population in an attempt to reduce the potential bias from the disproportionate number of highly populated municipalities in the sample.

2.6 Sample Representativeness

When estimating a value for an entire population based on a sample of that population, the accuracy of the estimate depends in part on how well the sample is reflective of the characteristics of the population. As such, it is important to assess the representativeness of the sample. Since estimates of total expenditure are conducted separately for municipalities and for conservation authorities, it is necessary to assess the representativeness of both samples. The representativeness is assessed based on a number of factors, including land area, population, and household income. This assessment is conducted based on the full sample as well as on samples within each of the four regions in the province. The areas encompassed by these regions – North, East, Central, and West – are displayed in Figure 2.

2.6.1 Sample Representativeness: Municipalities

The municipality sample is comprised of 68 of the 444 municipalities in Ontario, or 15.3%. The population of these 68 municipalities accounts for 29.9% of Ontario's population of 13,448,494, while the land area of these municipalities accounts for 21.4% of the combined land area of all municipalities. The average of the median household income levels across the sample municipalities is \$73,197, which is 98.5% of the provincial median household income of \$74,287.⁵ From these statistics it is evident that the sample is relatively representative with respect to household income. However, based on population, the sample does not appear to be too closely representative of the entire set of municipalities, while there is a slight bias among the sample municipalities towards those with larger land areas. While the lack of representativeness based on population may be concerning at first glance, this level of representativeness is actually much better than the 2017 sample, where the sample of 7.9% of municipalities accounted for 43.3% of Ontario's population. As with the 2017 sample, the reduced level of representativeness based on population could contribute to bias in the estimated total expenditure by municipalities, particularly since population influences expenditures on invasive species (see results section). To address this potential bias, the influence of population is accounted for in the methods used to estimate total expenditure.

The sample representativeness is also assessed for each of the four regions. There is a relatively even distribution of sample municipalities across the four regions, with 17 in the North region, 16 in each of the East and Central regions, and 19 in the West region. Hence, in terms of number of observations by region, there does not appear to be any bias. There are, however, some differences in the proportions of municipalities within each region that are included in the sample.

The sample for the North region is comprised of 17 out of a total of 144 municipalities, or 11.8%. The sample municipalities account for 18.6% of the population of the North region and 11.6% of the land area in the region. The average of the median household income levels across the sample municipalities is 100.1% of the average across all municipalities in the region. Hence, the sample for the North region is very representative of the entire set of the region's municipalities in terms of land area and household income, but the sample is weighted slightly toward more populated municipalities.

The sample for the East region is comprised of 16 out of a total of 114 municipalities, or 14.0%. This sample accounts for 15.9% of the region's population and 18.5% of the region's land area, while the average of

⁵ Statistics on population, land area, and household income are derived from Statistics Canada's 2016 Census.

the median household income levels across the sample municipalities is 96.7% of the average across all municipalities in the region. It is evident that the sample is relatively representative based on population, but slightly less representative based on land area and on household income.

The sample for the Central region is comprised of 16 out of 55 total municipalities within the region, or 29.1%, which was the highest proportion of responding municipalities across the four regions. These municipalities accounted for 33.2% of the population in the Central region, which implies that the sample is fairly representative of the region's municipalities in term of population. The sample is also somewhat representative in terms of median household income, which was 102.3% of the average across all municipalities. However, the sample was not very representative in terms of land area, for which the sample municipalities accounted for 50.7% of total land area across all the region's municipalities.

Finally, the sample for the West region consists of 19 out of 131 municipalities within the region, or 14.5%. This sample is not very representative with respect to population, as the sample municipalities account for 30.8% of the region's population. With respect to median household income, the sample is more representative, as the average across the sample municipalities is 98.2% of the regional average. The sample is also somewhat representative in terms of land area, as the sample municipalities account for 19.3% of total land area across all municipalities in the region.

Overall, the sample of responding municipalities is somewhat representative of the entire population of municipalities in Ontario, and has a much higher degree of representativeness relative to the 2017 sample. For this survey, it is unlikely that a slight bias toward municipalities with higher populations can be avoided. Municipalities with low populations are less likely to have the capacity to respond to surveys, and may also be less likely to have resources to address issues with invasive species. Conversely, municipalities with higher populations, which would contribute to a larger tax base, are more likely to have resources to manage invasive species, which may also make them more responsive to a survey that may be viewed as applicable to their mandate. These municipalities may also be more likely to have staff available to complete the survey.

2.6.2 Sample Representativeness: Conservation Authorities

The conservation authority sample is comprised of 13 of the 36 CAs in Ontario, or 36.1%. With such a small number of conservation authorities, it is difficult to obtain a truly representative sample. Since Census data on population and household income is not aggregated at the conservation authority level, the sample representativeness cannot be assessed based on these factors. However, data on land area encompassed by each conservation authority is available on the individual CA websites. This allows for assessing the sample representativeness based on this factor. The sample conservation authorities account for 28.2% of the land area across all CAs. Hence, the sample is not fully representative of the population in terms of land area, as the average size of the responding CAs is slightly lower than the average size of all CAs in the province. This could bias the resulting estimate if expenditure is influenced by land area. For example, CAs that are larger in size may need to spend more to control invasive species within their watershed. To address this potential for bias, the land area is taken into account in the extrapolation process.

As described above, the sample proportions within each of the four regions were quite similar. The percentages of CAs within each region represented in the sample ranged from 33.3% in the West region to 40.0% in the North region. As such, the sample of CAs is fairly representative based on regional

distribution. This is important given the observed differences across the regions in expenditures incurred for invasive species.

3.0 Methods for Estimating Total Expenditure

Similar to the 2017 report, the methods used to estimate total expenditure include extrapolation and regression modeling approaches. However, unlike the 2017 report, extrapolation is the primary approach used to estimate expenditure based on the 2018 surveys, rather than regression modeling. Due to a lack of data for conservation authorities on factors that may influence expenditure, such as population and household income, a regression modeling approach is not feasible for estimating total expenditure across all CAs in Ontario. In addition, with a small sample size there are likely too few degrees of freedom to generate regression results that are of significance. As a result, for consistency an extrapolation approach is used for both municipalities and conservation authorities to estimate total combined expenditure in Ontario. However, the regression modeling approach is used for comparison purposes for the municipalities. The description of these approaches below is primarily derived from the 2017 report.

The sample size for municipalities in the 2018 survey is much larger than in the 2017 survey, which results in a lower margin of error. The larger the margin of error, the less confidence that an extrapolation of the survey results will generate an accurate estimate for the entire population. Based on a population of 444 municipalities in Ontario, the sample size of 68 municipalities results in a margin of error of 10.95%.⁶ By comparison, the margin of error for the 2017 sample was 15.92%. The lower margin of error for the 2018 sample enhances confidence in the accuracy of the extrapolated survey results, and provides justification for the use of the extrapolation approach as the primary approach for estimating expenditure.

The sample of conservation authorities (CAs) consists of 13 out of 36 conservation authorities in the province, or 36.1%. However, despite the high response rate, the margin of error for this sample is relatively large, at 22.03%. This is primarily due to the small population size, rather than due to the sample being a relatively small percentage of the total population. For example, to obtain a margin of error similar to that of the municipality sample, a sample consisting of 25 of the 36 CAs (69.4%) would be required.

After estimating total expenditures for municipalities and for conservation authorities through separate extrapolation processes, the estimates for both groups are aggregated to generate an estimate of total expenditure across all municipalities and CAs in the province. In addition, for comparison purposes and to address considerable differences in the samples and the resulting estimates, survey responses from both 2017 and 2018 are combined and an extrapolation approach is used to generate an alternate estimate of total provincial expenditure.

3.1 Extrapolation Methods

Invasive species expenditures reported on the surveys are extrapolated to the provincial level for both municipalities and for conservation authorities. For each of these samples, two extrapolation approaches are used. The first approach, which is applied to both samples, involves a simple extrapolation based on the average expenditure for the sample municipalities (or CAs) and the total number of municipalities (or CAs) in the province, where the average expenditure is multiplied by the number of municipalities (444)

⁶ This margin of error is calculated based on a 95% confidence level, using the calculator available at: <https://www.checkmarket.com/sample-size-calculator/>.

or CAs (36) to estimate the total expenditures by municipalities and by conservation authorities across the province.

The second approach differs between the two samples. For municipalities, this approach involves an extrapolation based on per capita expenditure within the sample municipalities and the total population of the province, where the expenditure per person is multiplied by the total population. This approach is used for two reasons: first, the sample is somewhat weighted toward higher populated municipalities; and second, population has a significant impact on the level of expenditure, as evident from the results of the regression model (provided in the following section). Hence, accounting for the influence of population in the extrapolation process may reduce the potential bias inherent in the simple extrapolation approach and generate a more accurate estimate of total expenditure.

For conservation authorities, the second approach involves an extrapolation process that takes land area into account. For sample CAs, the expenditure per square kilometre is calculated, and the extrapolation is conducted by multiplying this figure by the total area of CAs to generate an estimate of total expenditure across all CAs.

These two approaches are also used to conduct extrapolations from the sample municipalities and sample CAs within each region to the regional level. These regional extrapolated amounts are then aggregated to estimate the total provincial expenditures for municipalities and for conservation authorities. This may generate more accurate estimates relative to the extrapolations to the provincial level. However, the small sample size for conservation authorities and the low numbers of CAs within the four regions may affect the accuracy of this approach. For example, while the sample for the North region is relatively high at 40% of the population of CAs in this region, it is important to note that there are only 5 CAs in this region. As a result, the estimated expenditure for CAs derived through this approach should be viewed with some caution.

3.2 Regression Model Approach

This estimation approach, conducted only for municipalities, involves regressing observed expenditure (as reported by responding municipalities) on a set of factors that are likely to influence the level of expenditure and that are observable for both sample and non-sample municipalities. The parameter estimates from the regression model are then applied to each municipality in Ontario to predict the level of expenditure for each municipality based on the observable factors included in the regression model. This involves multiplying the parameter estimate for each factor by the observed level of the factor for each municipality and summing these products across all factors (including a constant term) to derive a predicted expenditure for the municipality. These predicted expenditures are then aggregated for all municipalities to generate an estimate of total expenditure for municipalities across the province.

A log-linear functional form is used for the regression model estimated in this analysis. This involves log-transforming the dependent variable (expenditure), while the explanatory variables (i.e., factors that influence expenditure) remain in their level form. A number of factors that may influence expenditure can be observed from the survey responses. First, it appears from the survey results (see Table 1) that expenditure on invasive species is greater in municipalities with higher populations. A higher population would likely result in a larger tax base for the municipality, which could increase the ability to allocate funds to invasive species activities. To account for this influence, variables indicating whether a

municipality is a census division (e.g., county; regional municipality) or a city are included as explanatory variables. Both of these variables are highly correlated with population, and are found to be a better fit for the model than a measure of population.

There also appears to be regional differences across sample municipalities in the amount of funding allocated for invasive species management activities. As a result, variables are created to represent each of the four regions of the province, where each variable is set equal to 1 for municipalities located within the region, and 0 otherwise. Only three of the region variables are included in the regression model in order to avoid a multicollinearity issue. The variable for the North region is omitted from the model; as a result, parameter estimates for the other three region variables indicate the differences in expenditures relative to those of municipalities in the North region.

Finally, as indicated in the previous section, expenditures reported for emerald ash borer (EAB) were much higher than for other invasive species. As a result, a variable is included to account for municipalities in which EAB has been detected (equal to 1, 0 otherwise), as expenditure may be higher in these municipalities relative to those in which EAB has not been detected.⁷ Hence, the set of explanatory variables included in the regression model consists of variables indicating whether the municipality is a census division or a city, whether the municipality is located in the East, Central, or West regions of the province, and whether emerald ash borer has been detected in the municipality. In addition, a constant term is included in the regression model.

While there are likely other factors that influence expenditure by municipalities, they cannot be included as explanatory variables in the regression model if they are not observable or if data is not available for all municipalities. For example, the number of invasive species that are indicated by a municipality to be high priority may influence the amount of expenditure on invasive species, but this data is available only for the survey respondents and not for non-responding municipalities. This highlights a potential shortcoming of this approach, and may impact the ability of the regression modeling approach to generate an accurate estimate of total expenditure.

3.3 Combined Data from 2017 and 2018 Surveys

To increase sample size and to address representativeness issues with both samples, the responses from municipalities from the 2017 survey and the 2018 survey are combined, with extrapolations conducted on the combined survey data. There may be potential issues with combining the data, as it combines expenditures by municipalities across two different years, and different sets of questions were used in each year, which may influence the nature of the data collected. These issues could negatively affect the accuracy of the total expenditure estimated based on this data. However, conducting analysis on the combined data could be worthwhile as a means to assess and reconcile differences in the estimated total provincial expenditure between the two surveys.

It is evident from the 2017 survey that there are municipalities in Ontario that incur annual expenditures on invasive species of well over \$1 million, as four out of 35 municipalities reported expenditures of over \$1 million, two of which were over \$5 million. These high expenditure municipalities were most likely

⁷ This variable is specified based on municipalities for which detections have been reported by the Emerald Ash Borer Information Network (<http://www.emeraldashborer.info/>).

over-represented in the 2017 sample, which may have biased the estimated total expenditure upward. By comparison, only one out of 68 municipalities (and none of the 13 CAs) from the 2018 survey reported an expenditure of at least \$1 million. Hence, the high expenditure municipalities may be under-represented in the 2018 sample, which may be part of the reason for the lower estimate of total provincial expenditure based on the 2018 survey (see results section). As such, combining the survey responses across the two years may help to offset these representativeness concerns. Despite the potential issues inherent in combining the two data sets, as discussed above, this approach may provide a more accurate estimate of total expenditure in the province.

There were 35 responses from municipalities in 2017 and 68 in 2018. However, there were 9 municipalities that are included in both samples, which effectively creates duplicates. The 2017 responses for these 9 municipalities were omitted from the combined data, leaving a sample of 94 municipalities. With this larger sample size, the margin of error is further reduced to 8.98%. This may help to offset the potential bias arising from the issues associated with combining the data.

The extrapolation approach is similar to the description in Section 3.1, with a simple extrapolation based on the number of municipalities as well as an extrapolation that accounts for the influence of population. The resulting estimates of total expenditure are compared to those of the 2018 survey as well as to those of the 2017 survey.

4.0 Results

4.1 Extrapolation Results

Extrapolations are conducted for both municipalities and conservation authorities, as described in the previous section, which are then aggregated to generate estimates of total expenditure on invasive species by municipalities and CAs in Ontario. Some variation is evident in the results across the different methods of conducting these extrapolations. These results are summarized in Table 5.

Extrapolations are first conducted through a simple approach based on average expenditure for the sample municipalities and conservation authorities. Extrapolating the average expenditure for the sample municipalities across all 444 municipalities in the province generates an estimated expenditure of \$27.7 million across all municipalities, while extrapolating the average expenditure for the sample CAs across all 36 CAs in the province generates an estimated expenditure of \$1.9 million. Aggregating these two estimates produces a combined estimate of total expenditure in Ontario of \$29.6 million.

Next, the extrapolation approach accounts for the influence of population for municipalities and the influence of land area for conservation authorities. Conducting the extrapolation based on expenditure per capita generates an estimated expenditure of \$14.6 million across all municipalities, while conducting the extrapolation based on expenditure per square kilometre generates an estimated expenditure of \$2.4 million across all CAs. Hence, the aggregated estimate of total expenditure in Ontario is \$17.0 million.

These two extrapolation approaches are then conducted at the regional level prior to aggregating up to the provincial level. This accounts for observed differences across regions in the level of expenditure on invasive species. The extrapolations based on average expenditure generates estimates of \$20.5 million across all municipalities and \$2.0 million across all conservation authorities, for an aggregated estimate of total expenditure on invasive species of \$22.5 million in Ontario. The extrapolations based on expenditure per capita for municipalities and expenditure per square kilometre for CAs generates estimates of \$14.9 million across all municipalities and \$1.9 million across all CAs, for an aggregated estimate of total expenditure by municipalities and CAs of \$16.8 million.

It should be noted that the low numbers of sample CAs within each region may affect the accuracy of these estimates for CAs, relative to the estimates based on the extrapolation of the survey results to the provincial level. However, there is little variation in the estimates between these approaches (i.e., the range across the four estimates is \$1.9 to \$2.4 million), so this is unlikely to be an issue of concern.

Overall, there is relatively low variation in the estimates of total expenditure for municipalities and CAs in Ontario across the extrapolation methods used for this analysis. These results indicate a range in the estimated total expenditure of \$16.8 million to \$29.6 million.

Based on the survey results for reported allocation and distribution of expenditures, the estimated total expenditure can be broken down to provide additional estimates of expenditures for specific categories of activities, types of expenses, and invasive species. These estimates are calculated using the estimated total expenditure from the extrapolation of average expenditure to the regional level prior to aggregating up to the provincial level (\$22.5 million), which is close to the midpoint of the range indicated above. Based on the average percentages of expenditures allocated to each of the three categories of activities by the sample municipalities (see Table 1) and sample CAs (see Table 4), the distribution of this total

expenditure includes \$1.6 million for prevention activities, \$2.3 million for detection activities, and \$18.6 million for control and management activities. Based on the average percentages for specific types of expenses, approximately \$13.2 million is spent on payments to contractors and \$3.3 million on staff wages. Based on the percentages of reported species-specific expenditures (see Table 2), approximately \$18.3 million of the provincial estimate is spent on emerald ash borer, while \$2.0 million is spent on phragmites, and \$600,000 each is spent on wild parsnip and European buckthorn.

The differences in estimated expenditure between extrapolations based on average expenditure for sample municipalities and based on expenditure per capita are much lower than in the 2017 report. This is due to the much greater degree of representativeness of the 2018 sample, particularly with respect to population. The estimated total expenditure based on extrapolations of the 2018 sample is much lower than that of extrapolations of the 2017 sample based on average expenditure (\$231.7 to \$319.6 million) and based on per capita expenditure (\$40.9 to \$42.2 million).⁸ In fact, the low end of the range of estimates based on the 2018 sample (\$16.8 to \$17.0 million) is less than the sum of expenditures reported by municipalities in the 2017 sample (\$18.3 million). This implies that these lower estimates for 2018 are unlikely to be accurate, and that the extrapolations based on average expenditure may more closely approximate total provincial expenditure.

4.2 Regression Model Results

A regression modeling approach is used for municipalities to generate an estimate of expenditure across all municipalities, which is used primarily for comparison purposes with the results of the extrapolation approach. The parameter estimates for the regression model are provided in Table 6. The *F*-statistic for this model (8.66; $p < .001$) indicates that the parameter estimates are jointly different from zero. These estimates indicate that municipalities that are census divisions or cities have higher expenditures than other municipalities, which accounts for the influence of population on expenditure. The results of the region variables indicate that expenditure is significantly higher for municipalities in the Central and West regions, relative to municipalities in the North region. While the estimate for the East region indicates that expenditure is higher relative to the North region, this difference is not statistically significant. Similarly, the parameter estimate for emerald ash borer indicates that expenditure is higher in municipalities in which emerald ash borer has been detected, but this difference is not statistically significant.

The regression model results indicate an adjusted *R*-squared value of 0.4069, which implies that the variables included in the model explain approximately 41% of the variation in expenditure. This proportion is relatively low; by comparison, the adjusted *R*-squared value from the regression model in the 2017 report was 0.6158. The low *R*-squared value implies that other factors that account for a relatively large share of the variation are not included in the model, which reduces confidence in the accuracy of the resulting estimated total expenditure across all municipalities.

The parameter estimates are then used to predict expenditure on invasive species for each of the 444 municipalities in Ontario. Aggregating the predicted expenditures across all municipalities generates a

⁸ The 2017 estimates based on per capita expenditure are likely much more accurate than those based on average expenditure due to the heavy weighting of the relatively small sample toward highly populated municipalities, for which relatively high expenditures were reported.

total estimated expenditure by Ontario municipalities on invasive species of \$32.8 million per year. Combining this estimate with the estimate for CAs based on expenditure per square kilometre (\$2.4 million) produces a total estimated expenditure for Ontario of \$35.2 million. This estimate is slightly higher than the range of estimates from the extrapolation approaches. But this estimate should be viewed with caution due to the issue described above.

4.3 Extrapolation Results for Combined Data

Extrapolations are also conducted for the combined 2017 and 2018 survey results based on average expenditure and based on per capita expenditure. The latter extrapolation method is important in this case given the reduced representativeness of the combined sample with respect to population due to the inclusion of the 2017 sample. The combined sample of 94 municipalities, which is 21.2% of all municipalities, accounts for 55.2% of Ontario's population.

The extrapolation of expenditure from the combined 2017 and 2018 sample based on average reported expenditure from sample municipalities generates an estimate of total expenditure across all municipalities of \$94.9 million, while the extrapolation based on per capita expenditure generates an estimate of \$36.4 million. The estimate based on per capita expenditure is likely the more accurate estimate of total expenditure across all municipalities as it accounts for the bias in the sample toward higher populated municipalities. Aggregating this estimate with the estimate of total expenditure for conservation authorities based on expenditure per square kilometre (\$2.4 million) produces an estimate of total expenditure on invasive species across all municipalities and CAs in Ontario of \$38.8 million. This estimate is higher than the range of estimates based on the 2018 survey but lower than that of the 2017 survey. Given the potential offsetting nature of the issues associated with each sample, as described in the previous section, this estimate may in fact be more accurate than either of the estimates based on single-year samples.

4.4 Limitations and Other Considerations

While the primary limitation of this 2017 survey was the relatively small sample size, this issue is mitigated to some extent for the 2018 survey. The larger sample size for municipalities also helped to avoid issues with responses from individual municipalities having considerable influence on the results of the study. For example, there were two municipalities in the 2017 sample that accounted for 62.1% of the total expenditure across all sample municipalities, which may have negatively impacted the accuracy of the estimated total provincial expenditure. However, this issue did arise with the conservation authority sample, where one respondent accounted for 71.3% of the total expenditure across the sample CAs. This may have biased the estimated expenditure across all CAs. As such, this estimate should be viewed with caution. However, this estimate accounts for a relatively small proportion of the aggregated estimate across all municipalities and CAs; thus, it would likely result in only minimal bias of the aggregated estimate.

There are other potential sources of bias for the estimated expenditure. The sample in this study is not a randomized sample, as municipalities and conservation authorities could choose whether or not to respond to the survey. Bias is more likely to be an issue with voluntary response samples. There could be factors influencing the decision to respond that also impact the level of expenditure. For example,

municipalities and CAs with funding for invasive species activities may be more likely to respond, while municipalities and CAs that do not incur expenditures for invasive species may be less likely to respond. This would cause the resulting estimate of total expenditure to be biased upward. However, it should be noted that 34 municipalities (50.0% of responding municipalities) and 5 CAs (38.5% of responding CAs) that responded to the survey reported no expenditures on invasive species, which suggests that this issue is unlikely to be a significant source of bias.

It should also be noted that the estimated total expenditure is for spending at the municipality and conservation authority levels. As such, this estimate does not include or account for provincial or federal level funding for invasive species control and management. The 2017 report provided a number of examples of funding for and expenditures on invasive species by other levels of government, which suggests that expenditure on invasive species control in Ontario likely exceeds the total expenditure estimated in this report.

5.0 Costs and Benefits of Invasive Species Control

The 2017 report included a section on estimating the economic impacts of invasive species, which served as an estimate of the potential benefits associated with controlling or eliminating invasive species. Previous studies on the economic impacts of invasive species were used to estimate impacts on Ontario's agriculture, fisheries, forestry, health care, and tourism and recreation industries. These impacts include yield losses and increased herbicide costs for the agriculture industry due to invasive weed species, the impact of aquatic invasive species on the fisheries industry, the impact of forest invasive species such as Asian long-horned beetle and emerald ash borer on the forestry industry, health costs associated with skin burns from giant hogweed, and impacts on tourism and recreation due to invasive aquatic weeds. The potential economic impacts on these industries was estimated to be approximately \$3.6 billion per year, the majority of which was attributable to impacts on the forestry industry.

These estimated impacts provide an estimate of the potential benefits associated with controlling invasive species and minimizing or eliminating their impacts. These estimated benefits, along with the estimated total expenditure by municipalities in the province, were used in the 2017 report to conduct a cost-benefit analysis for invasive species prevention, detection, control, and management activities. A similar comparison can be done with the results of this report. As with the 2017 report, the potential benefits of controlling invasive species (\$3.6 billion per year) far exceed the estimated total expenditure on invasive species activities, which has been estimated in this report to be between \$16.8 million and \$29.6 million per year based on the 2018 survey and approximately \$38.8 million per year based on the combined 2017 and 2018 surveys.

However, there are a couple of caveats to consider with respect to the use of estimated expenditure as a measure of the costs of invasive species, to which the potential benefits are compared. First, this estimated expenditure does not include federal and provincial government funding or expenditure for invasive species activities in Ontario, so it does not capture total expenditure across all levels of government. Second, many of the responding municipalities and conservation authorities indicated that current funding for these activities is insufficient. This implies that considerably more than the estimated total expenditure would need to be spent in order to adequately prevent, detect, manage, and control invasive species and achieve the benefits associated with minimizing or eliminating the impacts on the natural environment and the resulting economic, social, cultural, and health and safety impacts. However, as noted in the 2017 report, even if ten times the estimated expenditure had to be spent to adequately prevent, detect, manage, and control invasive species, the potential benefits would outweigh these costs. The resulting implication – that a considerable increase in expenditure to control invasive species could generate a net benefit to the province – still holds based on the results of the 2018 survey and based on the combined results of the 2017 and 2018 surveys.

6.0 Conclusions

The main purpose of this report is to provide an updated estimate of the total expenditure on invasive species in Ontario, based on surveys of municipalities and conservation authorities conducted in early 2018. Total expenditure on invasive species across all municipalities in Ontario was previously estimated based on a survey conducted in 2017. However, the relatively small sample size and the lack of representativeness of this sample with respect to population (i.e., too many highly populated municipalities) may have affected the accuracy of the resulting estimated total expenditure. The 2018 survey had a much larger sample of municipalities and was also expanded to include conservation authorities, which may help to generate a more accurate estimate of total expenditure.

The primary approach used to estimate this expenditure is an extrapolation approach, which is conducted based on the expenditures reported by responding municipalities and conservation authorities in the 2018 survey. The results of the extrapolations indicate estimates of the total expenditure by municipalities and CAs in Ontario ranging from \$16.8 million to \$29.6 million. It is evident that the majority of the expenditures appear to be incurred at the municipality level rather than at the conservation authority level. The upper end of this range is likely more accurate than the lower end, as the sum of expenditures reported by the 35 municipalities in the 2017 sample (\$18.3 million) exceeds the lower estimates of \$16.8 to \$17.0 million, which implies that total expenditure by municipalities and CAs in Ontario must be greater than these estimated amounts.

For comparison purposes, a regression modeling approach is also used to estimate the total expenditure, which generated an estimate of \$35.2 million. However, it should be stressed that the results of this approach must be viewed with caution, as the relatively low *R*-squared value implies that the model does not include factors that account for a relatively large proportion of variation in expenditure, which may reduce the accuracy of the resulting estimate of total expenditure.

As an alternate approach to estimating total expenditure, the 2017 and 2018 samples are combined and extrapolations are conducted based on the combined sample. This increases the sample size and addresses representativeness concerns about each of the two samples, as high-expenditure municipalities appear to be over-represented in the 2017 sample and under-represented in the 2018 sample. The extrapolation based on per capita expenditures reported by municipalities generates an estimate of total expenditure across municipalities in Ontario of \$36.4 million. Combining this estimate with the estimated total expenditure for conservation authorities results in a total expenditure estimate for municipalities and CAs of \$38.8 million. Due to the potentially off-setting representativeness issues addressed through combining the two samples, this estimate may in fact be more accurate than the estimates for either of the 2017 or 2018 samples.

It should be noted that the accuracy of the estimated total expenditure for municipalities and conservation authorities in Ontario depends heavily on the accuracy of the responses to the survey questions. Possible survey data issues that may affect this accuracy have been identified in this report, such as responses from municipalities that indicated that expenditures had been incurred as a result of invasive species but did not provide expenditure amounts for 2016/17.

It is evident from the results of this report that the estimated total expenditure for municipalities and conservation authorities in Ontario is well below the potential benefits associated with minimizing or

eliminating the impacts of invasive species, as estimated in the 2017 report. As discussed in the previous section, even if ten times the total expenditure estimated in this report is required to effectively control invasive species in the province, there would still be a net benefit to the province.

Tables and Figures

Table 1: Expenditure, geographic, and demographic data for sample municipalities

Municipality	Region	Expenditure on Invasive Species	Expenditure Breakdown			Population ^a	Land Area (sq km)	Household Income	Per Capita Expenditure (\$/person)
			Prevention	Detection	Control & Management				
City of Barrie	Central	\$328,000	5%	5%	90%	141,434	99.04	\$77,904	\$2.32
City of Brockville	East	\$40,000	0%	0%	100%	21,346	20.85	\$51,168	\$1.87
City of Kenora	North	\$0				15,096	211.59	\$73,331	
City of Pembroke	East	\$0				13,882	14.56	\$51,051	
City of Thorold	West	\$150,000	25%	25%	50%	18,801	82.99	\$64,650	\$7.98
City of Thunder Bay	North	\$452,500	6%	8%	86%	107,909	328.36	\$66,163	\$4.19
County of Brant	West	\$50,000	0%	0%	100%	134,808	1,093.22	\$68,741	\$0.37
County of Haliburton	East	\$61,340	75%	10%	15%	18,062	4,076.08	\$58,125	\$3.40
County of Lambton	West	\$90,000	10%	10%	80%	126,638	3,002.25	\$70,022	\$0.71
County of Peterborough	East	\$23,500	0%	0%	100%	138,236	3,848.20	\$64,437	\$0.17
County of Simcoe	Central	\$46,000	10%	10%	80%	479,650	4,859.64	\$76,489	\$0.10
District Municipality of Muskoka	Central	\$72,300	0%	69%	31%	60,599	3,940.48	\$67,880	\$1.19
Dufferin County	West	\$1,500	0%	0%	100%	61,735	1,486.44	\$89,608	\$0.02
Haldimand County	West	\$88,540	0%	7%	93%	45,608	1,251.54	\$76,117	\$1.94
Halton Region	Central	\$17,000	0%	10%	90%	548,435	964.05	\$103,009	\$0.03
Middlesex County	West	\$20,000	0%	20%	80%	455,526	3,317.27	\$64,797	\$0.04
Municipality of Clarington	Central	\$150,000	0%	0%	100%	92,013	611.40	\$95,753	\$1.63
Municipality of Leamington	West	\$52,400	1%	23%	76%	27,595	262.01	\$62,313	\$1.90
Municipality of Magnetawan	North	\$0				1,390	531.53	\$54,336	
Municipality of Temagami	North	\$0				802	1,905.92	\$52,045	
Municipality of Trent Lakes	East	\$0				5,397	861.32	\$68,498	
Norfolk County	West	\$0				64,044	1,607.55	\$67,338	

Table 1: Expenditure, geographic, and demographic data for sample municipalities (cont'd)

Municipality	Region	Expenditure on Invasive Species	Expenditure Breakdown			Population ^a	Land Area (sq km)	Household Income	Per Capita Expenditure (\$/person)
			Prevention	Detection	Control & Management				
Regional Municipality of York	Central	\$1,186,500	48%	2%	50%	1,109,909	1,762.13	\$95,776	\$1.07
Town of Amherstburg	West	\$0				21,936	185.61	\$83,712	
Town of Arnprior	East	\$55,000	5%	0%	95%	8,795	13.07	\$61,810	\$6.25
Town of Bracebridge	Central	\$4,000	0%	25%	75%	16,010	628.22	\$69,461	\$0.25
Town of East Gwillimbury	Central	\$180,000	2%	0%	98%	23,991	245.04	\$104,716	\$7.50
Town of Fort Erie	West	\$0				30,710	166.27	\$60,800	
Town of Grimsby	West	\$0				27,314	68.93	\$93,145	
Town of Hanover	West	\$0				7,688	9.80	\$54,869	
Town of Iroquois Falls	North	\$0				4,537	600.01	\$64,400	
Town of Kearney	North	\$0				882	532.00	\$56,661	
Town of Midland	Central	\$7,000	20%	50%	30%	16,864	35.34	\$54,878	\$0.42
Town of Minto	West	\$5,897	0%	0%	100%	8,671	300.69	\$67,696	\$0.68
Town of Newmarket	Central	\$514,300	0%	0%	100%	84,224	38.45	\$95,589	\$6.11
Town of Parry Sound	North	\$0				6,408	13.40	\$51,153	
Town of Pelham	West	\$85,000	10%	0%	90%	17,110	126.43	\$95,052	\$4.97
Town of Tillsonburg	West	\$30,000	0%	0%	100%	15,872	22.33	\$58,418	\$1.89
Town of Whitchurch-Stouffville	Central	\$0				45,837	206.22	\$102,997	
Township of Adjala-Tosorontio	Central	\$0				10,975	372.34	\$100,523	
Township of Armstrong	North	\$0				1,166	90.20	\$65,579	
Township of Assiginack	North	\$0				1,013	226.72	\$63,189	
Township of Conmee	North	\$0				819	169.13	\$89,856	
Township of Douro Dummer	East	\$0				6,709	458.95	\$80,352	
Township of Georgian Bay	Central	\$15,000	0%	0%	100%	2,499	547.61	\$67,904	\$6.00
Township of Huron-Kinloss	West	\$125,000	5%	5%	90%	7,069	440.76	\$75,456	\$17.68
Township of King	Central	\$227,100	0%	0%	100%	24,512	333.25	\$118,309	\$9.26
Township of Lake of Bays	Central	\$0				3,167	677.91	\$69,888	

Table 1: Expenditure, geographic, and demographic data for sample municipalities (cont'd)

Municipality	Region	Expenditure on Invasive Species	Expenditure Breakdown			Population ^a	Land Area (sq km)	Household Income	Per Capita Expenditure (\$/person)
			Prevention	Detection	Control & Management				
Township of Limerick	East	\$0				346	205.37	\$42,880	
Township of Machar	North	\$0				882	184.35	\$62,464	
Township of North Frontenac	East	\$20,000	5%	0%	95%	1,898	1,164.77	\$51,942	\$10.54
Township of Opasatika	North	\$0				226	330.44	\$52,096	
Township of Otonabee-South	East	\$0				6,670	347.13	\$79,760	
Township of Pickle Lake	North	\$0				388	252.18	\$80,896	
Township of Red Rock	North	\$0				895	62.21	\$69,376	
Township of Russell	East	\$0				16,520	199.11	\$105,488	
Township of South Frontenac	East	\$16,000	0%	30%	70%	18,646	971.56	\$89,457	\$0.86
Township of South Stormont	East	\$0				13,110	447.58	\$76,092	
Township of Strong	North	\$0				1,439	159.93	\$60,672	
Township of Tarbutt	North	\$0				534	52.82	\$88,320	
Township of The North Shore	North	\$0				497	239.08	\$61,440	
Township of Tudor and Cashel	East	\$400	0%	0%	100%	586	445.66	\$45,952	\$0.68
Township of Uxbridge	Central	\$0				21,176	420.95	\$98,991	
Township of Wainfleet	West	\$0				6,372	217.31	\$80,205	
Township of West Lincoln	West	\$50,000	0%	0%	100%	14,500	387.81	\$91,325	\$3.45
Township of Woolwich	West	\$24,000	0%	0%	100%	25,006	326.15	\$97,113	\$0.96
United Counties of Leeds and Grenville	East	\$50,000	0%	0%	100%	100,546	3,382.89	\$68,305	\$0.50
Wollaston Township	East	\$0				670	219.14	\$48,640	
Total		\$4,238,277				3,904,965	52,664		
Average		\$62,328	6.7%	9.1%	84.2%			\$73,197	\$3.15

^a Since the sample includes both census divisions (CDs) and census subdivisions (CSDs), there are a few CSDs in the sample that are located within CDs in the sample. For example, the Town of Newmarket (a CSD) is located within the Regional Municipality of York (a CD), both of which are included in the sample. To avoid double-counting the population within these CSDs, they are omitted from the calculation of total population for the sample. As a result, the total population is not equal to the sum of all municipality populations in this table.

Table 2: Species-specific expenditures reported by sample municipalities and conservation authorities

Invasive Species	<u>Municipalities</u>		<u>Conservation Authorities</u>		<u>Combined</u>		
	Reported Expenditure	Percentage of Species-Specific Expenditures	Reported Expenditure	Percentage of Species-Specific Expenditures	Reported Expenditure	Percentage of Species-Specific Expenditures	Percentage of Non-EAB Species-Specific Expenditure
Emerald Ash Borer	\$1,943,590	84.4%	\$469,050	71.3%	\$2,412,640	81.5%	--
Phragmites	\$179,304	7.8%	\$77,200	11.7%	\$256,504	8.7%	46.8%
Wild Parsnip	\$78,500	3.4%	\$1,350	0.2%	\$79,850	2.7%	14.6%
European Buckthorn	\$20,280	0.9%	\$58,950	9.0%	\$79,230	2.7%	14.5%
Japanese Knotweed	\$11,784	0.5%	\$15,645	2.4%	\$27,429	0.9%	5.0%
Giant Hogweed	\$18,072	0.8%	\$7,770	1.2%	\$25,842	0.9%	4.7%
Beech Bark Disease	\$19,075	0.8%	\$5,120	0.8%	\$24,195	0.8%	4.4%
Dog Strangling Vine	\$9,600	0.4%	\$13,220	2.0%	\$22,820	0.8%	4.2%
Garlic Mustard	\$7,580	0.3%	\$1,750	0.3%	\$9,330	0.3%	1.7%
Scots Pine	\$6,000	0.3%	\$0	0.0%	\$6,000	0.2%	1.1%
Hemlock Woolly Adelgid	\$650	0.0%	\$5,120	0.8%	\$5,770	0.2%	1.1%
Asian Longhorned Beetle	\$3,355	0.1%	\$0	0.0%	\$3,355	0.1%	0.6%
Manitoba Maple	\$2,000	0.1%	\$0	0.0%	\$2,000	0.1%	0.4%
Eurasian Water Milfoil	\$1,000	0.0%	\$575	0.1%	\$1,575	0.1%	0.3%
European Black Alder	\$0	0.0%	\$1,500	0.2%	\$1,500	0.1%	0.3%
Wild Chervil	\$0	0.0%	\$1,000	0.2%	\$1,000	0.0%	0.2%
Oak Wilt	\$650	0.0%	\$0	0.0%	\$650	0.0%	0.1%
Zebra Mussels	\$600	0.0%	\$0	0.0%	\$600	0.0%	0.1%
Total	\$2,302,040	100.0%	\$658,250	100.0%	\$2,960,290	100.0%	100.0%

Table 3: Expenditure and demographic statistics by region for sample municipalities

	Region			
	North	East	Central	West
Sample municipalities	17	16	16	19
# reporting expenditures	1	8	11	12
# with no expenditures	16	8	5	7
Total expenditures	\$452,500	\$266,240	\$2,743,200	\$770,837
Average expenditure	\$26,618	\$16,640	\$171,450	\$40,570
Expenditure per person	\$3.12	\$0.80	\$1.19	\$0.69
Total municipalities	144	114	55	131
Total population	780,140	2,080,505	6,957,765	3,630,084
Median household income	\$65,346	\$67,464	\$85,517	\$76,216

Table 4: Expenditure and geographic data for sample conservation authorities

Conservation Authority	Region	Expenditure on Invasive Species	Expenditure Breakdown			Land Area (sq km)
			Prevention	Detection	Control & Management	
Cataraqui Region	East	\$7,500	70%	15%	15%	3,500
Catfish Creek	West	\$3,000	0%	20%	80%	490
Central Lake Ontario	Central	\$0				627
Ganaraska Region	Central	\$0				935
Grand River	West	\$477,000	10%	10%	80%	6,800
Grey Sauble	West	\$65,250	0%	54%	46%	3,169
Kawartha	Central	\$11,500	5%	40%	55%	2,563
Kettle Creek	West	\$15,000	0%	20%	80%	520
North Bay-Mattawa	North	\$0				2,800
Raisin Region	East	\$0				1,700
Sault Ste. Marie Region	North	\$0				552
South Nation	East	\$36,550	5%	10%	85%	4,384
Upper Thames River	West	\$52,900	5%	5%	90%	3,482
Total		\$668,700				31,522
Average		\$51,438	11.9%	21.7%	66.4%	

Table 5: Summary of results for estimated total expenditure, by estimation approach

Method	Extrapolation Level	Extrapolation Approach	Municipalities	Conservation Authorities	Total
			(\$ millions)	(\$ millions)	(\$ millions)
Extrapolations					
	Provincial	Average Expenditure	\$27.7	\$1.9	\$29.6
		Expenditure per capita and per km ²	\$14.6	\$2.4	\$17.0
	Regional	Average Expenditure	\$20.5	\$2.0	\$22.5
		Expenditure per capita and per km ²	\$14.9	\$1.9	\$16.8
	Provincial (2017 & 2018)	Expenditure per capita and per km ²	\$36.4	\$2.4	\$38.8
Regression					
			\$32.8	\$2.4	\$35.2

Table 6: Results of the regression model for expenditure by municipalities

Variable	Parameter Estimate	Standard Error
Census Division	5.262 **	1.462
City	4.665 *	1.777
East	2.185	1.798
Central	5.332 **	1.814
West	4.271 *	2.025
EAB	1.528	1.573
Constant	0.037	1.056

Note: Asterisks (*, **) indicate statistical significance at the 5% and 1% levels, respectively.

Figure 1: Priority invasive species reported by sample municipalities and conservation authorities

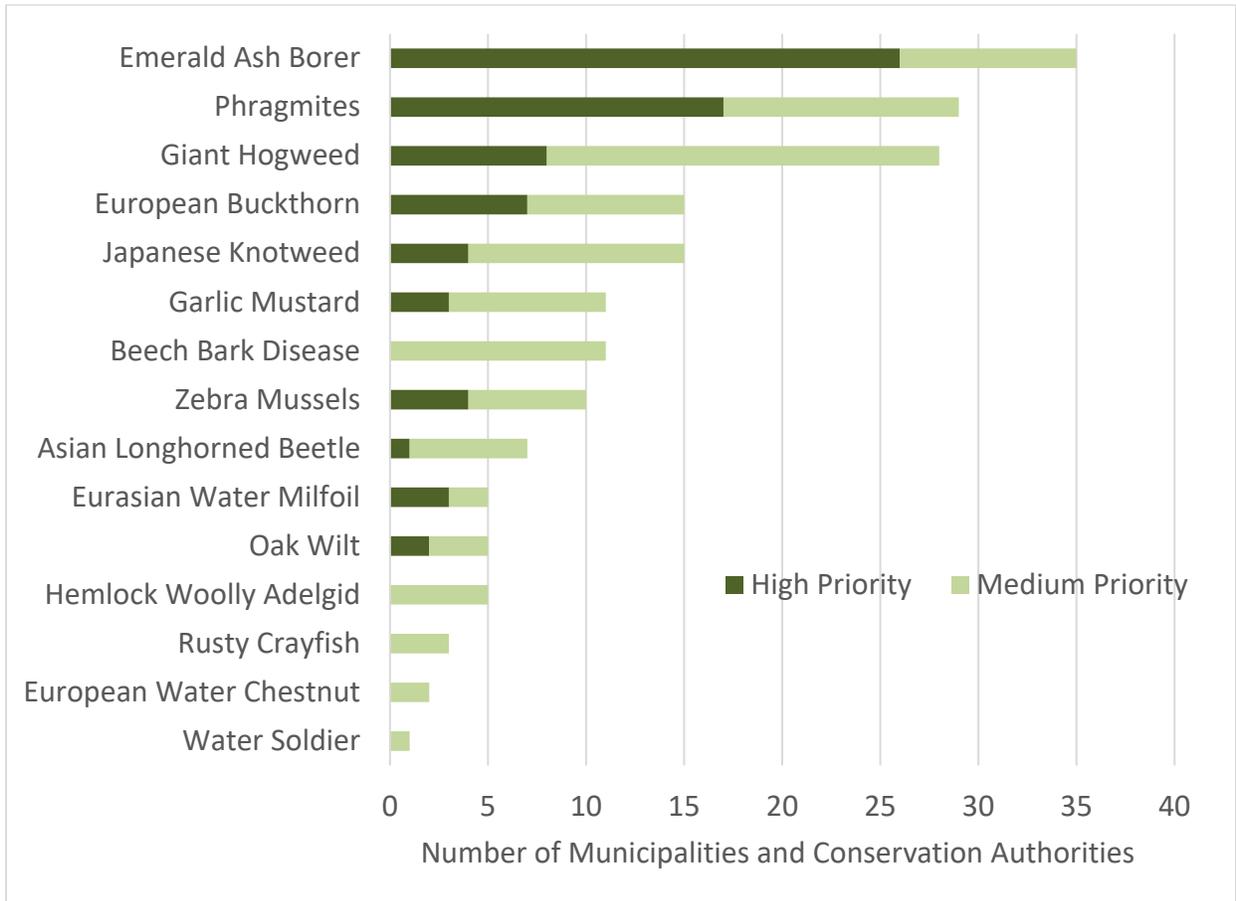
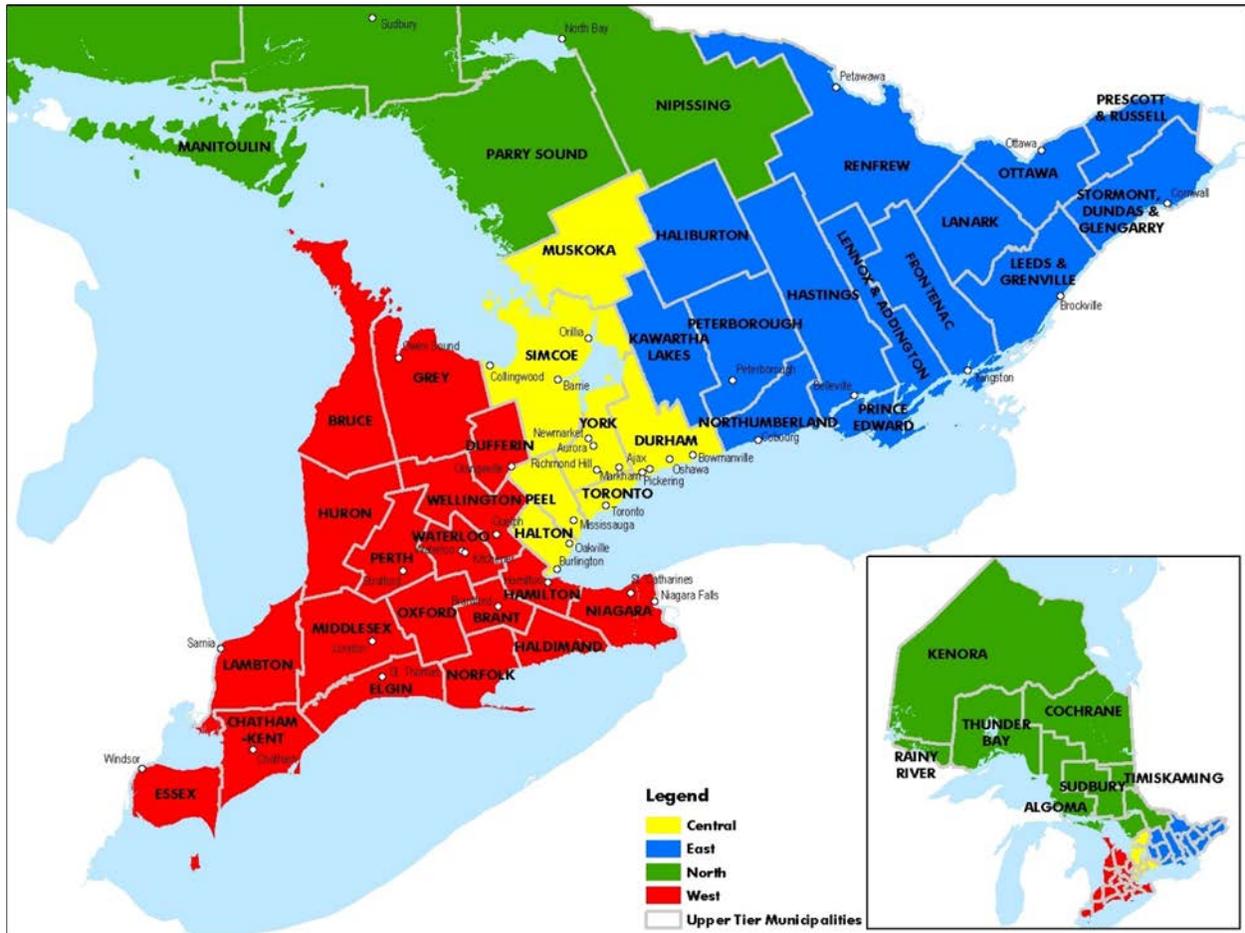


Figure 2: Regional divisions for Ontario municipalities



Source: <http://www.pavequity.gov.on.ca/en/AboutUs/Pages/Assesing-Proxy-Use-Map-of-Ontario-Regions.aspx>

Figure 3: Map of conservation authorities in Ontario



Source: <http://watershedcheckup.ca/conservation-authority-map>