An investigation of the effects of conservation incentive programs on management of invasive species by private landowners

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Abstract
Invasive species are a large and growing threat to biodiversity and ecosystem service provisioning globally as well as in southern Ontario, Canada’s most biodiverse region. As in many other world regions, most land in southern Ontario is privately owned and therefore conservation programs that aim at private lands are important. Conservation incentive programs that target private lands are increasingly popular, but little is known about their effectiveness in achieving conservation objectives. To address this knowledge gap, we used a large survey of 1,200 Ontario landowners to investigate how successful conservation incentive programs are at motivating landowners to engage in invasive species management. Utilizing a quasi-experimental approach, we surveyed landowners participating in the Conservation Lands Tax Incentive Program (CLTIP), the Managed Forest Tax Incentive Program (MFTIP), or in both programs, as well as landowners who were program eligible but did not participate. Our results demonstrate the differential effects of participation in the two programs on specific landowner conservation behaviors: While participation in the MFTIP increased the likelihood of removing invasive species by a factor 2.5 and the planting of native species by a factor 4.3, participants in the CLTIP were no more likely to engage in these behaviors than landowners who did not participate in either program. We suggest that this behavioral disparity is due to the differences in the program designs: The CLTIP does not require a management plan, favors a short planning horizon, and mainly encourages passive management; in doing so it essentially breaks the causal chain that reinforces landowners’ environmental awareness and a sense of responsibility for taking conservation actions. Our recommendations include requirements for impact evaluations of private land conservation incentive programs to ensure they achieve stated program outcomes, as well as conservation incentive program designs that oblige landowners to actively manage their land over longer time horizons.

Keywords
conservation program, education, impact evaluation, long-term, management plan, private land, social psychology

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INTRODUCTION

Invasive species are a large and growing threat to biodiversity, agriculture, forestry and fisheries globally (Pyšek & Richardson, 2010). Worldwide, it is estimated that to date 134 species have been gone extinct due to invasive species (Bellard, Cassey, & Blackburn, 2016) and global economic costs due to invasive insects alone are estimated at over $70 billion per year (Bradshaw et al., 2016). For Canada, the total estimated economic costs to society of the effects of invasives are in excess of $29 billion per year (ECCC, 2012). Of all species-at-risk in Canada, 22% are threatened by invasive species (Venter et al., 2006) while annual crop losses caused by invasive species between 2005–2010 were estimated to have costed $2.2 billion (ECCC, 2012).

Southern Ontario is the most biodiverse region of Canada owing to its favorable climate and generally high soil fertility, as well as the local effects of various physio-geographic features (e.g., Great Lakes) and its location at the confluence of various biomes. However, southern Ontario is also a major entry point for invasive species in Canada owing to its high population density, extensive international trade, and the multitude of transportation access points by ground, water and air (OMNR, 2012) and harbors more invasive plant and fresh water fish species than any other province (OMNR, 2012). There is no overall estimate available of costs and damages for all invasive species in Ontario, but the total impact of zebra mussel alone is estimated at up to $19 million annually (Marbek Resource Consultants Ltd., 2010). It is undeniable that in some cases invasive species can lead to extreme changes to host communities across trophic levels (e.g., Robichaud & Rooney, 2017), economic losses (e.g., ECCC, 2012) and decline of valued native species (Pyšek & Richardson, 2010). By and large, the effects of invasive species are considered undesirable. If society is to limit these most extreme effects of invasive species, then introduction pathways have to be limited, invasive species have to be managed across the landscape, and/or these species have to be eradicated (Pyšek & Richardson, 2010).

Over 90% of the land in southern Ontario is privately owned and the largest land use is as farm land including crop, pasture and managed forest lands (47%). The private land that is in less-intensive agricultural production, or not in production at all, is of great importance for conservation, because it can buffer protected areas (Davis & Hansen, 2011) and can provide critical species habitat and ecosystem services such as for water regulation, removal of pollution, carbon sequestration, and climate control (Brown, Bergstrom, & Loomis, 2007). Because of the importance of private land for conservation in southern Ontario, conservation legislation and programs that aim specifically at private land (agricultural and nonagricultural) are of major importance in this region. Unfortunately, in Canada much federal conservation legislation is difficult to enforce on private land as their reach is constitutionally limited to federally owned lands, migratory species, trans-boarder issues and some exceptional situations (Olive, 2015). Provincial conservation legislation does apply to private land, but in many cases provincial legislations is not enforced either due to financial resource constraints that limit government agencies’ enforcement efficacy or because of governmental concern for political backlash if conservation legislation would be enforced strictly (e.g., Melstrom, Lee, & Byl, 2018). Accordingly, instead of using penal legislation to punish conservation-detrimetal behaviors, increasingly conservation incentive programs are used to reward conservation-friendly behaviors, including conservation tax incentive programs (Kamal, Grodzinska-Jurczak, & Brown, 2015; Kilgore, Ellefson, Funk, & Frey, 2018).

Many governmental conservation tax incentive programs exist across North America, Europe, and Australia. An extensive discussion of the diversity of strategies and approaches to private land conservation is provided by Kamal et al. (2015). However, despite the increasing popularity of conservation incentive programs for encouraging private landowners to engage in conservation behaviors, overall little is known about their effectiveness in achieving actual conservation objectives. Part of the reasons for this limited understanding is that in practice most conservation program evaluations are focused on program outputs (e.g., how many landowners are enrolled in the program) and not on program outcomes (e.g., has the program caused a change in landowners’ conservation behaviors) (Kleiman et al., 2000). This makes it difficult to understand which characteristics of conservation incentive programs make them work particularly well and how programs could be modified to work even better.

To address this knowledge gap in conservation incentive program effectiveness, we investigated invasive species management as an example of conservation behaviors by private landowners. The objectives of the current study were to assess (a) how successful conservation incentive programs are at motivating landowners to engage in invasive species management and (b) how landowners’ engagement with invasive species management is varying with characteristics of conservation incentive programs, landowners, and landholdings.
conservation programs and the conservation behaviors of private landowners in Ontario. As examples for conservation incentive programs, we used two Ontario conservation tax incentive programs that are administered by the provincial Ministry of Natural Resources and Forestry (MNRF), the Conservation Lands Tax Incentive Program (CLTIP) and the Managed Forest Tax Incentive Program (MFTIP) (Table 1).

Using a natural experiment design, we compared landowners who participated in one, or both, of the two conservation incentive programs, as well as landowners who did not participate in either program (but were eligible for one of the programs) as counterfactuals (sensu Ferraro, 2009). According to this design, landowners who participate in one of the conservation incentive programs have received the treatment (with two different treatment levels), and landowners who do not participate in either of the two programs are the control group. For a similar design see the recent study by Josefsson, Lokhorst, Pärt, Berg, and Eggers (2017) who investigated conservation behaviors of farmers in the Swedish Volunteer and Farmers Alliance, utilizing two treatment groups and a control.

### 2.1 Conservation incentive programs

The CLTIP supports the stewardship of provincially important conservation lands by providing property tax relief to private landowners who protect the natural heritage features of their properties (Ontario, 2019a). Eligible lands must be at least 0.2 ha in size but can be part of larger parcels of land of which the remainder may consist of ineligible lands. Program-enrolled lands enjoy 100% property tax exemption in exchange for their conservation, with the tax exemption meant as a stewardship incentive, not as a revenue tool to produce net income gains for the landowner. Conservation of enrolled lands is achieved by regulating land use activities on these lands; however, a management plan for the enrolled land is not required. Land use activities are classified as: (a) consistent with program objectives, (b) permitted but subject to other legislative requirements, (c) maybe permitted after notification and approval by MNRF, and (d) inconsistent with program objectives (Table 1). The activities that are permitted but subject to other legislative requirements include invasive species management. After successful program application, eligible lands are enrolled for a 1-year period, which has to be renewed on an annual basis (Appendix A).

The MFTIP encourages the stewardship of privately owned forests in Ontario, by providing tax relief to private forest owners who manage their program-eligible forests according to an approved forest management plan (Ontario, 2019b). Program-eligible forests are defined by the program as forests that are privately owned and at least 4 ha in size, with a certain minimum tree density. Program-enrolled lands enjoy a reduction of municipal property tax by 75%. Stewardship of the enrolled forests is achieved by requiring that forest owners prepare a managed forest plan for the forest to be enrolled. This plan has to have a long planning horizon (i.e., 20 years or more) and needs to describe the activities that will be carried out over the next 10 years. The plan must be approved by a ministry-designated Managed Forest Plan Approver to confirm that the forest is program-eligible and to ensure that the plan and proposed activities meet program standards. Under the program, forest management activities are classified as: (a) encouraged and (b) not permitted (Table 1). Among the not-permitted activities is continued inactivity. After successful program application, eligible forests are enrolled for a 10-year period, which can be renewed in the 10th year (Appendix A).

### 2.2 Sampling

The total study sample consisted of 1,200 landowners, including farmers and nonfarmers, as well as resident and absentee landowners. Of these landowners, 400 were enrolled in the CLTIP, 400 were enrolled in the MFTIP, and 400 were eligible for the CLTIP but not enrolled in either program (the counterfactual or control group). To protect the privacy of all program-eligible and participating landowners (CLTIP and MFTIP), MNRF required us to use a sampling procedure that anonymized all landowners. Therefore, all regular landowner contacts occurred via a third-party mail service working with MNRF, and the identity of landowners in the study sample (responders and nonresponders) is not known to us, unless they self-identified.

### 2.3 Survey

In the summer of 2014, we conducted an anonymous mail survey targeting landowners eligible for the CLTIP (enrolled and not enrolled) or enrolled in the MFTIP. We followed the total design method devised by Dillman, Smyth, and Christian (2009), and added enhancements such as the option of an online version of the questionnaire and provision of a $5 cash incentive. All landowners in the study sample first received an advance letter explaining the study and assuring confidentiality. This contact was followed up by a questionnaire package that included a cover letter, the questionnaire, and a postage-paid return envelope. The questionnaire package was followed up by mailing a reminder postcard and then two more complete follow-up questionnaire packages. These additional landowner contacts occurred at 3-week intervals and were limited to nonrespondents. When a returned questionnaire was received, the respondent was sent a thank you letter and no further contacts made.
| Program characteristics | CLTIP | MFTIP |
|-------------------------|-------|-------|
| Eligibility criteria    |       |       |
| Land cover type         | - areas of natural and scientific interest | Forests with minimum stem density: |
|                        | - provincially significant wetlands       | - 1,000 trees (any size) per hectare, or |
|                        | - habitats of endangered species          | - 750 trees (>5 cm dbh) per hectare, or |
|                        | - Niagara escarpment plan areas           | - 500 trees (>12 cm dbh) per hectare, or |
|                        |       | - 250 trees (>20 cm dbh) per hectare     |
| Minimum size           | 0.2 ha | 4 ha (may include up to 10% of nonforest area) |
| Classified activities  | Consistent with program objectives       | Encouraged |
|                        | Low-impact recreational activities (e.g., hiking, hunting, fishing) | - planting native tree species, tending, thinning, pruning and harvesting |
|                        |       | - low-impact recreational activities (e.g., hiking, hunting, fishing) |
|                        |       | - wildlife management                     |
|                        |       | - protecting environmentally sensitive areas by limiting disturbance |
|                        |       | - learning about the forest               |
|                        | Maybe permitted (subject to other legislation) | Not permitted |
|                        | - invasive species management             | - high-grading or diameter limit cutting |
|                        | - infill planting of native species        | - pasturing livestock |
|                        | - planned prescribed burns                 | - removing soil |
|                        | - planned trail maintenance                | - continued inactivity |
|                        | - tree felling/removal for health or safety (wood not for sale) | |
|                        | Maybe permitted after notification and approval by MNRF | |
|                        | - culling nonnative tree species to enhance natural heritage values | |
|                        | - tree felling/removal for health or safety (wood for sale) | |
|                        | - fuelwood removal for sustainable personal use | |
|                        | - trail development/upgrading without negative impacts on natural heritage values | |
| Property tax reduction  | 100%  | 75%   |
| Enrolment period       | 1 year | 10 years |
| Unenrollment process   | - automatic after 1 year                  | - automatic after 10 years |
|                        | - observed deviation from program objectives | - failed submission of 5-year report |
|                        |       | - upon written notice and submission of progress report at any time |
|                        |       | - observed deviation from program objectives |
| Penalty for non-compliance | Recovery of property tax for period of non-compliance (up to maximum of 4 years) | Recovery of property tax for period of non-compliance (no maximum number of years) |
| Number of enrolled propertiesa | 21,372 | 14,708 |
| Average size of enrolled landsa | 23 ha | 107 ha |

CLTIP, Conservation Lands Tax Incentive Program; MFTIP, Managed Forest Tax Incentive Program.

*aAs of time of data collection in 2014.
2.4 | Questionnaire

The questionnaire consisted of approximately 250 question items inquiring into: (a) past and present conservation program participation and characteristics that qualify the land for the programs, (b) landowners’ environmental stewardship activities, their stewardship history, and the condition of the natural heritage features on their land, (c) landowner’s opinions regarding the need for and performance of governmental conservation programs, (d) landowners’ general opinions regarding environmental issues, (e) landowners’ personal characteristics, and (f) landowners’ consumer behavior and environmental activism. The majority of question items involved Likert-type scales plus some closed- and open-ended questions. Some of the questions were previously developed such as the new environmental paradigm scale, which is a widely utilized measure of pro-environmental inclinations (Dunlap & Van Liere, 1978, 1984; Dunlap, Van Liere, Mertig, & Jones, 2000); most other questions were developed specifically for this study. Of all questions only a small fraction was used for the current study (see Appendix B for short forms of questions relevant to this study). Previous analysis of other questions inquired into social-psychological determinants of conservation program participation and was previously published elsewhere (Drescher, Warriner, Farmer, & Larson, 2017).

Before survey rollout, the questionnaire was tested with eight private landowners. Of these landowners, at least two were eligible for the CLTIP and at least three were participating in the MFTIP. The landowners were asked for their feedback regarding understanding and relevance of the questions and their comments were used to improve the questionnaire.

2.5 | Analyses

We conducted initial Chi-square tests to assess differences between landowner groups (enrolled in CLTIP, enrolled in MFTIP, not enrolled in either program). Dependent variables were whether the landowner feels that invasive species are a problem in Ontario, whether the landowner removes invasive species from their land, whether the landowner plants native species (re—planting native species can limit or reduce the spread of invasive species [Levine, Adler, & Yelenik, 2004]); both of the latter variables record whether a private landowner has removed invasive species and planted native species on their land, respectively (Table 2). Two dependent variables are used for these analyses and record whether a private landowner has removed invasive species and planted native species on their land, respectively (Table 2). Because we are interested in assessing the potential impact of conservation incentive programs on this behavior, enrolments in the CLTIP and the MFTIP were used as main independent variables. We included attributes of landowners and their landholdings as control variables to account for the influence of social, economic, and ecological factors (Table 2).

Following the continuum of resistance model (e.g., Lin & Schaeffer, 1995), nonresponse bias was investigated through assessment of the difference between early and late responders. To do so, we divided participants into approximate equal halves by postal delivery date of the returned questionnaire (early vs. late) and compared these groups by age, property size, household income, and membership in an environmental group.

2.6 | Ethics

The University of Waterloo Office of Research Ethics has reviewed the study proposal. Full ethics clearance has been granted (ORE# 19326).

3 | RESULTS

3.1 | Response rate and participant profile

Based on receipt of 598 completed questionnaires and exclusion of 110 unreachable landowners that had moved or were deceased, the survey resulted in an overall (eligible/enrolled in CLTIP, enrolled in MFTIP) response rate of 54.9%. Of the participating landowners, 245 participated in the CLTIP, 252 in the MFTIP, 29 in both the CLTIP and the MFTIP, and 72 were eligible for the CLTIP but did not participate in either program (the numbers of landowners do not sum to 598 because some landowners participated in both conservation incentive programs). For the participating landowners (Table 2), average property size was 19.2 ha. The average household income class was 5.6, suggesting an average household income close to $100,000. The average age of participants was 61.5 years and 27% of them were members in an environmental group.

Early and late responders did not differ significantly by property size (t = −0.652, df = 428.75, p = 0.515), income (W = 22,682.5, p = 0.505), or membership in an environmental group (X² = 1.704, df = 1, p = 0.192). However, early responders were significantly older than late.
responders (average age early responders: 64.6 years; average age late responders: 60.8 years; \( t = 3.317, df = 422.19, p = 0.001 \)).

### 3.2 Differences between landowner groups by conservation incentive program participation

The initial Chi-square tests indicated differences between landowner groups (eligible/enrolled CLTIP, enrolled MFTIP) in awareness of the problem of invasive species, invasive species management activities, and effects of conservation incentive programs on land management practices (Table 3). Awareness of the invasive species problem in Ontario was associated with participation in the two conservation incentive programs (\( \chi^2 (6, 575) = 21.725, p = 0.001 \)). More MFTIP participants than expected thought invasive species were a problem. At the same time, of the landowners who did not participate in either program (but were eligible for the CLTIP), less than expected believed invasive species were a problem. The number of CLTIP participants who thought that invasive species were a problem did not deviate from what was expected by chance.

| Variable | Description | Mean | SD | Min | Max |
|----------|-------------|------|----|-----|-----|
| Awareness of invasive species problem | Dependent, nominal, ordinal; extent to which respondent feels invasive species are a problem (1 = definitely not a problem, 4 = serious problem, 5 = do not know). | 1.40 | 0.61 | 1 | 4 |
| Removal of invasive species | Dependent, nominal, binary; landowner has or is currently removing invasive species from their property (yes = 1, no = 0). | 0.25 | 0.43 | 0 | 1 |
| Planting of native species | Dependent, nominal, binary; landowner has or is currently planting native species on their property (yes = 1, no = 0). | 0.37 | 0.48 | 0 | 1 |
| Effect of conservation incentive program | Dependent, nominal; extent to which respondent states that program affects their land management (1 = definitely agree, 4 = definitely disagree, 5 = do not know). | 3.06 | 1.02 | 1 | 4 |
| CLTIP | Independent, binary; landowner is enrolled in the CLTIP. | 0.46 | 0.50 | 0 | 1 |
| MFTIP | Independent, binary; landowner is enrolled in the MFTIP. | 0.47 | 0.50 | 0 | 1 |
| Age | Independent, age of respondent. | 61.5 | 12.4 | 30 | 99 |
| Property size | Independent, natural logarithm of property size in hectares. | 2.95 | 1.39 | −0.90 | 6.94 |
| Income | Independent, ordinal; respondent's household income (1 ≤ 19,999, 10 ≥ 180,000). | 5.56 | 2.64 | 1 | 10 |
| Environmental group | Independent, binary; respondent is member of an environmental group (yes = 1, no = 0). | 0.27 | 0.44 | 0 | 1 |
| Plantation/agriculture | Independent, binary; property includes plantations/agriculture (yes = 1, no = 0). | 0.39 | 0.49 | 0 | 1 |
| Grassland/meadow | Independent, binary; property includes grasslands/meadows (yes = 1, no = 0). | 0.66 | 0.48 | 0 | 1 |
| Pastures | Independent, binary; property includes pastures (yes = 1, no = 0). | 0.31 | 0.46 | 0 | 1 |
| Woodland | Independent, binary; property includes woodlands (yes = 1, no = 0). | 0.96 | 0.21 | 0 | 1 |
| Wetland | Independent, binary; property includes wetlands (yes = 1, no = 0). | 0.82 | 0.38 | 0 | 1 |

CLTIP, Conservation Lands Tax Incentive Program; MFTIP, Managed Forest Tax Incentive Program. Shown are the mean, standard deviation (SD), minimum (min) and maximum (max) for each variable.

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**TABLE 2** Summary statistics describing the variables used in the analysis of landowner awareness of the invasive species problem, invasive species management activities, and effects of conservation incentive programs on land management practices.
Planning or taking action for invasive species removal also was associated with participation in the two conservation incentive programs ($X^2 (9, 488) = 41.088, p < 0.001$). Less CLTIP participants than expected had undertaken action to remove invasive species, while more MFTIP participants than expected had done so. At the same time, more CLTIP participants than expected did not plan to remove invasive species, while less MFTIP participants than expected did not (Table 3).

Planning or taking action for planting native species was associated with participation in the two conservation incentive programs as well ($X^2 (9, 498) = 35.674, p < 0.001$). Less CLTIP participants than expected had taken action to plant native species, while more MFTIP participants than expected had done so. At the same time, more CLTIP participants than expected did not plan to plant native species, while less MFTIP participants than expected did not (Table 3).

Finally, landowners also differed in the extent to which they indicated their land management activities were affected by the two conservation incentive programs ($X^2 (2, 439) = 27.950, p < 0.001$). More CLTIP participants than expected stated that their land management practices were not affected by their program participation, while more MFTIP participants than expected stated that their land management was affected by this. At the same time, less CLTIP participants than expected stated that their land management was affected by their program participation, while less MFTIP participants than expected stated that their land management was not affected by this (Table 3).

### 3.3 Effects of conservation incentive program participation on invasive species management

The logistic regression analyses suggest that the conservation incentive programs differ in their effects on landowners' invasive species management (Tables 4 and 5). Model fit was assessed using several scalar model statistics, including a Chi-square test, count $R^2$ and by visually analyzing residuals. Both models are highly statistically significant. Count $R^2$ results, which report the fraction of observations correctly

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**Table 3** Chi-square test of independence results for private landowner awareness of invasive species problem, invasive species management activities (i.e., removal of invasives and planting of natives), and effect of conservation incentive programs on land management practices

| Abbreviated question | CLTIP Observed | Expected | MFTIP Observed | Expected | CLTIP and MFTIP Observed | Expected | None Observed | Expected | $X^2$ | $p$ |
|----------------------|----------------|----------|----------------|----------|------------------------|----------|--------------|----------|-------|-----|
| Is the spread of invasive species a serious problem in Ontario? | | | | | | | | | | |
| Problem | 191 | 190.6 | 210 | 201.4 | 50 | 47.7 | 66 | 77.3 | 21.725 | 0.001 |
| Not a problem | 10 | 11.4 | 8 | 12.1 | 2 | 2.9 | 11 | 4.6 | 4.088 | 0.038 |
| Do not know | 11 | 10.0 | 6 | 10.5 | 1 | 2.5 | 9 | 4.0 | 4.088 | 0.038 |
| Have you undertaken or planned removal/control of invasive species? | | | | | | | | | | |
| Undertaken | 29 | 45.1 | 62 | 47.6 | 19 | 11.4 | 11 | 16.9 | 41.088 | <0.001 |
| Planned | 13 | 16.4 | 17 | 17.3 | 9 | 4.1 | 5 | 6.1 | 4.088 | 0.038 |
| Not planned | 79 | 62.7 | 48 | 66.1 | 10 | 15.8 | 31 | 23.4 | 4.088 | 0.038 |
| Not applicable | 61 | 57.8 | 65 | 61.0 | 8 | 14.6 | 21 | 21.6 | 4.088 | 0.038 |
| Have you undertaken or planned planting of native species? | | | | | | | | | | |
| Undertaken | 51 | 68.7 | 87 | 73.6 | 29 | 16.4 | 19 | 27.3 | 35.674 | <0.001 |
| Planned | 23 | 19.6 | 22 | 21.0 | 3 | 4.7 | 5 | 7.8 | 4.088 | 0.038 |
| Not planned | 80 | 68.7 | 59 | 73.6 | 10 | 16.4 | 37 | 27.3 | 4.088 | 0.038 |
| Not applicable | 30 | 27.0 | 29 | 28.9 | 2 | 6.4 | 12 | 10.7 | 4.088 | 0.038 |
| The conservation incentive program does not affect how we manage this property. | | | | | | | | | | |
| Agree | 85 | 61.7 | 41 | 64.3 | 27.950 | < 0.001 |
| Disagree | 118 | 144.0 | 176 | 150.0 | 27.950 | < 0.001 |
| Do not know | 12 | 9.3 | 7 | 9.7 | 27.950 | < 0.001 |

CLTIP, Conservation Lands Tax Incentive Program; MFTIP, Managed Forest Tax Incentive Program. Shown are observed and expected numbers of landowners by conservation incentive program participation and response type, as well as Chi-square value ($X^2$) and $p$ value.

*For full question text, see Appendix A.*
assigned by the models, indicate that both models correctly assign over three quarters of the observations, though count \( R^2 \) is slightly higher for the removal of invasive species (count \( R^2 = 0.80 \)) than for the planting of native species (count \( R^2 = 0.76 \)).

The results indicate that participation in the MFTIP has a positive effect on the likelihood of removing invasive species (Table 4), and on the likelihood to planting native species (Table 5); while CLTIP has no impact on either activity. In addition to the effects of conservation incentive program participation, the regression analyses suggest that landowners with plantations or agriculture on their property are more likely to remove invasive species and plant native species; while those with pastures and natural grasslands or meadows are more likely to remove invasive species, but not more likely to plant native species. The presence of woodlands or wetlands did not affect the likelihood to remove invasive species or to plant native species. While landowners that express awareness of the problem of invasive species are not more likely to remove invasive species, they are more likely to plant native species. Against expectation, landowners that are members of an environmental group are less likely to remove invasive species from their land, though there is no effect on planting of native species.

Predicted probabilities of having removed invasive species and having planted native species, as depending on conservation incentive program participation, were calculated holding all other parameters at their respective sample means (Figures 1 and 2). Point estimates for both conservation incentive programs and invasive species management actions are below 50%. Nonetheless, the predicted probability that a landowner will have removed invasive species from their property is highest for participants in the MFTIP program. MFTIP participants are approximately 2.8 times more likely to have removed invasive species than CLTIP participants, and 2.5 times more likely to have done so than landowners who are not enrolled in either program. Similarly, MFTIP participants are approximately 2.8 times more likely to have planted native species than CLTIP participants, and 4.3 times more likely to have done so than landowners who are not enrolled in either program (Figures 1 and 2). In contrast, the CLTIP participants are not any more likely to have removed invasive species or planted native species than landowners who do not participate in either conservation incentive program.

4 | DISCUSSION

Advances have been made in recent years in the evidence-based evaluation of conservation program impacts. This is
especially true for evaluations of the impact of protected areas (Coad et al., 2015) and of payment-for-ecosystem services schemes (Hejnowicz, Raffaelli, Rudd, & White, 2014). However, conservation program evaluation is not yet as widespread as it should be (Baylis et al., 2016). Reasons for this lack of uptake include technical difficulties, organizational barriers that do not facilitate a culture of evaluation, and political obstacles (Keene & Pullen, 2011). Especially, impact evaluations of governmental conservation incentive programs for private landowners are lacking (but see York, Janssen, & Carlson, 2006 for an institutional assessment of several incentive programs in Indiana). Most studies still rely on the assessment of program outputs (e.g., how many landowners are enrolled in the program, or, how many landowner workshops were held) instead of program outcomes (e.g., has the program caused a change in landowners' conservation behaviors, or, has the program led to a recovery of ecological function) (Kilgore et al., 2018). The current study is a rare exception from this pattern and stands out for its analysis of the reported behavior of participants in two conservation programs as well as for its quasi-experimental design utilizing two treatment levels (CLTIP and MFTIP) and a control group (not participating in either program) (but see Josefsson et al., 2017). As a result, the findings from the current study can make important contributions to our understanding of institutional design effects in conservation programs.

Our results demonstrate the differential effects of two governmental conservation tax incentive programs on specific landowner conservation behaviors. Both investigated programs, the CLTIP and the MFTIP, are meant to encourage the stewardship of valued environmental features in Ontario. Both programs incentivize private landowners through reductions in property taxes in exchange for stewardship behaviors that are consistent with stated program goals. However, for the examined conservation behaviors, only the MFTIP shows effects that are consistent with program objectives. MFTIP participants are significantly more likely to engage in the removal of invasive species and in the planting of native species, compared to landowners who do not participate in any of the two conservation incentive programs. In contrast, CLTIP participants are no more likely to engage in these behaviors than landowners who do not participate in these programs.

It might be tempting to explain the observed differences in landowner conservation behaviors between the CLTIP and the MFTIP with different land cover types that may differ in their susceptibility to colonization by invasive species,

| Variable                | B     | Odds ratio | SE    | P     | Confidence interval |
|-------------------------|-------|------------|-------|-------|--------------------|
| CLTIP                   | 0.515 | 1.674      | 0.447 | 0.294 | −0.360, 1.391      |
| MFTIP                   | 1.537 | 4.650      | 0.482 | 0.001 | 0.592, 2.482       |
| Age                     | 0.023 | 1.023      | 0.015 | 0.120 | −0.006, 0.052      |
| Awareness               | 0.824 | 2.279      | 0.327 | 0.182 | 0.182, 1.465       |
| Property size           | −0.015| 0.986      | 0.143 | 0.919 | −0.296, 0.267      |
| Income                  | −0.092| 0.913      | 0.069 | 0.188 | −0.228, 0.045      |
| Environmental group     | 0.405 | 1.499      | 0.397 | 0.307 | −0.372, 1.182      |
| Plantation/agriculture  | 1.227 | 3.410      | 0.368 | 0.001 | 0.507, 1.947       |
| Grassland/meadow        | 0.121 | 1.129      | 0.358 | 0.735 | −0.580, 0.822      |
| Pasture land            | 0.606 | 1.834      | 0.433 | 0.161 | −0.242, 1.454      |
| Woodland                | −0.643| 0.526      | 0.813 | 0.429 | −2.236, 0.950      |
| Wetland                 | −0.173| 0.841      | 0.410 | 0.673 | −0.977, 0.631      |
| Constant                | −5.653| 1.901      | 0.003 | < 0.001| −9.379, −1.927     |

N = 218

Log-likelihood: −108.96

Chi-squared: 54.24

Mean VIF: 1.26

Max VIF: 1.91

Count \( R^2 \): 0.76

CLTIP, Conservation Lands Tax Incentive Program; MFTIP, Managed Forest Tax Incentive Program. Shown are coefficient estimates (B), odds ratios, standard error (SE), p-value and 95% confidence intervals.
as shown in the study by Decker et al. (2012) for Nebraska. Indeed, the presence of plantations or agriculture, grasslands or meadows, and pastures, had positive effects on invasive species management activities. These effects might be explained with high utilitarian value of these land cover types, which may lead landowners to make stronger efforts for invasive species management. However, the defining difference between the CLTIP and the MFTIP is the presence of larger forest tracts (Ontario, 2019a, 2019b), which did not have an effect on invasive species management activities. This result contrasts with the study by Mosher, Silander Jr., and Latimer (2009) in Connecticut, who found that intact forest blocks discourage colonization by invasive species, which should have led to a negative effect on invasive species management in our study. At the same time, the presence of wetlands, which is one of the main reasons for lands to be eligible for the CLTIP, had no effect on invasive species management in the current study. The lack of an effect of wetlands on landowners’ invasive species management activities may be surprising because of the widespread presence of aquatic invasive plants and animals in southern Ontario: Just for European common reed (Phragmites australis [Cav.] Trin. ex Steud.), the Early Detection & Distribution Mapping System (Anonymous, 2018) shows approximately 5,000 recorded observations. The widespread presence of these, and other, invasive species in southern Ontario wetlands suggests a need for similarly widespread invasive species management activities (Wilcox, Buckler, & Czayka, 2018).

Despite the effects of land cover, MFTIP participation had a strong independent effect on invasive species management, different from CLTIP participation. We speculate that this disparity in effects is due to differences in the design of these two programs. Crucially, the MFTIP is requiring landowners to write and follow an approved forest management plan. The forest management plan is examined by a designated Forest Management Plan Approver who can modify the plan if it is found not to meet program standards (Ontario, 2019b). These procedures create strong opportunities for landowners to become educated about environmental processes and natural resource management, to consider longer-term effects of their management actions during the 20-year forest management plan horizon, and to adhere to best management practices. These effects correspond to findings by Rasamoelina, Johnson, and Hull (2010), who describe the beneficial effects of technical assistance and forest management plans on practices by private woodlot owners that affect forest health and productivity in Virginia.

While the MFTIP explicitly states that continued forest management inactivity is not allowed, the CLTIP does not have any similar stipulation. In fact, the CLTIP emphasizes that most land use activities, except for low-impact recreation, may not be permitted, require government approval, or are prohibited. This program design leads to the encouragement of passive management, that is, management through inaction, instead of active management. The differential encouragement of various land use activities by the MFTIP and CLTIP situates the discussion of these two programs within the larger scientific debate of the merits of active versus passive management. While passive management can lead to positive environmental outcomes under some circumstances (Gornish, Lennox, Lewis, Tate, & Jackson, 2017), this approach is more likely to be successful when environmental threats have ceased as shown in studies from the
allied field of restoration ecology (Barral, Rey Benayas, Meli, & Maceira, 2015; Meli et al., 2017; Morrison & Lindell, 2010). However, if negative land use legacies persist or new threats emerge, passive management, or benign neglect, is less likely to lead to the positive outcomes that comprehensive, active management can do (Carey, 2006) and even the Conservation Reserve Program includes an active component of planting species that “improve environmental health and quality” (USDA [United States Department of Agriculture], 2019). Of course, passive management is likely to be less costly than active management (though not cost free [Zahawi, Reid, & Holl, 2014]). This may also be one of the reasons why CLTIP participants, who are not permitted to generate income from the program-enrolled lands to offset conservation-related expenses, choose for passive over active management. The above is not to say that active management always will lead to the expected successes. Sometimes goals might have to be adjusted, an adaptive management approach followed, or functional goals pursued over biodiversity goals (Cordell, Ostertag, Michaud, & Warman, 2016). The ultimate decision about passive or active management should be taken after comprehensive consideration of various factors including site-specific goals, costs, benefits, and time scales (Brancalion et al., 2016). However, the blanket roll out of a program such as the CLTIP to all qualifying landowners does not facilitate such a case-specific approach.

Our results suggest that invasive species management practices of CLTIP participants are not affected by their program participation, while MFTIP participants are affected by it. Social psychological theories describe pro-environmental behaviors as the result of causal links between social psychological constructs (e.g., Ajzen, 1991). We suggest that these theories can provide an explanation for the observed difference in invasive species management between CLTIP and MFTIP participants. Norm-activation theory (Schwartz, 1970) states that altruistic behaviors, including pro-environmental behaviors (Van Liere & Dunlap, 1978), are the consequences of people's acceptance of the consequences of their actions and their responsibility for them. Building on these approaches, Value-Belief-Norm Theory (Stern, Dietz, Abel, Guagnano, & Kalof, 1999) causally starts with fairly stable basic value systems that lead to the generation of a person's pro-environmental worldview. However, before a person engages in pro-environmental behaviors, first the person has to become aware of the environmental consequences of their action (or inaction), and accept responsibility for changing environmental consequences, which then leads to the formation of a pro-environmental personal norm, that is, a sense of an obligation to act (Stern, Kalof, Dietz, & Guagnano, 1995). This pro-environmental personal norm is then related to the likelihood to engage in pro-environmental behaviors (Stern et al., 1999). Different than the MFTIP, the CLTIP provides little opportunity for learning about environmental issues and does not require landowners to write a management plan for their land. We suggest that these aspects reduce the likelihood that CLTIP participants are aware of the consequences of their inaction with regard to invasive species, and that they feel less responsibility to act to manage invasive species. Next to these learning elements, this might also lead to less opportunity for landowners to deepen collective or individual relationships with their land (Allen, Quinn, English, & Quinn, 2018; Chan et al., 2016; Drescher, 2014). While the MFTIP reinforces landowners' awareness of the environmental consequences of their actions (or inactions), increases a sense of responsibility for these consequences, and may deepen relations between landowners and their land, the CLTIP in fact breaks this causal chain by discouraging landowners from taking invasive species management actions on their land (Stern et al., 1999).

A surprising finding of this study was the negative effect of environmental group membership on invasive species management. Explanations for this finding have to remain speculative. It could be that landowners who are members of environmental groups are more aware of the potential negative environmental impacts of pesticides and of the prohibition of most pesticide use in Ontario (Ontario, 2009). This might discourage these landowners from invasive species management altogether. Or, landowners who are members of environmental groups could be more aware of the concept of novel ecosystems and could be more prepared to accept invasive species as new additions to native ecosystems (Walther et al., 2009; Williams, 1997).

Based on our findings we are making the following recommendations for private land conservation incentive programs:

1. Private land conservation incentive programs need to undergo impact evaluations to ensure that they achieve stated program outcomes. These evaluations have to focus on actual program outcomes over program outputs.

2. Impact evaluations of private land conservation incentive programs need to follow best practices to ensure that observed changes in target variables can really be attributed to program effects and are not spurious correlations.

3. Private land conservation incentive programs have to include educational components and should require landowners to draw up land management plans. These plans should be for longer time horizons and should comply with best land management practices.

4. Private land conservation incentive programs, especially in a context of active environmental threats, have to
encourage landowners to be active land managers instead of passive ones.

5 | CONCLUSION

Passive management of valued environmental features may be sufficient when environmental threats have ceased (Barral et al., 2015; Meli et al., 2017; Morrison & Lindell, 2010). Yet in southern Ontario the widespread pressure from invasive species (Anonymous, 2018) threatens valued environmental features (OMNR, 2012). If these environmental values are to be maintained, active management may be required, especially invasive species management. Both investigated programs, the CLTIP and the MFTIP, refer to the threat of invasive species. But only the MFTIP requires landowners to be active managers of their lands with long-term plans. In fact, the CLTIP discourages landowners from taking action and promotes passive management. Given the threat of colonization by invasive species and the current program structure of the CLTIP, it appears questionable whether this program will be sufficient to protect the environmental features it is meant to preserve for the long term.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interests.

AUTHORS' CONTRIBUTIONS

Study design: M.D, K.W.; data collection: M.D.; data analysis and writing the article: M.D., G.E.; critical review: G.E., K.W., R.R.

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APPENDIX A. DESCRIPTION OF CONSERVATION INCENTIVE PROGRAMS ASSESSED IN THIS STUDY

Conservation Lands Tax Incentive Program

The Conservation Lands Tax Incentive program (CLTIP) recognizes, encourages, and supports the stewardship of provincially important conservation lands by providing property tax relief to private landowners who agree to protect the natural heritage features of their properties (Ontario, 2019a). Provincially important conservation lands are defined by the program as lands of areas of natural and scientific interest (significant geological and biological features), provincially significant wetlands, habitats of endangered species, as well as lands part of a number of conservation-oriented land use plan areas (e.g., Niagara Escarpment Plan). Program-eligible lands are identified by MNRF on a proactive basis and entered into a ministry-administered database. All owners of eligible lands are contacted each year and program application packages supplied.

Eligible lands must be at least 0.2 ha in size but can be part of larger parcels of land of which the remainder may consist of ineligible lands. Built structures and associate lands are subtracted from the eligible land area. Program-enrolled lands enjoy 100% property tax exemption in exchange for their conservation, with the tax exemption meant as a stewardship incentive not as a revenue tool to produce net income gains for the landowner. Conservation of enrolled lands is achieved by regulating land use activities on these lands. Land use activities are classified as: (a) consistent with program objectives, (b) permitted but subject to other legislative requirements, (c) maybe permitted after notification and approval by MNRF, and (d) inconsistent with program objectives (Table 1). The activities that are permitted but subject to other legislative requirements include invasive species management. After successful program application, eligible lands are enrolled for a 1-year period, which has to be renewed on an annual basis. Conducting inconsistent land use activities on enrolled land may lead to the unenrollment of the land. Such unenrollment may also lead to the recovery of previously exempted property tax for the period of past non-compliance, up to a maximum of 4 years. The MNRF may audit enrolled lands from time to time to ensure program compliance. At the time of data collection, MNRF’s database contained information on 53,734 program-eligible properties of which 21,372 (39.8%) were participating in the CLTIP.

The CLTIP allows for the enrolment of lands under control by Conservation Authorities, which are semi-governmental land conservation agencies; however, we excluded these lands from analysis because Conservation Authorities are not private landowners in the strict sense.

Managed Forest Tax Incentive Program

The Managed Forest Tax Incentive Program (MFTIP) recognizes and encourages the stewardship of privately owned forests in Ontario, by providing tax relief to private forest owners who manage their program-eligible forests according to an approved forest management plan (Ontario, 2019b). Program-eligible forests are defined by the program as forests that are privately owned and at least 4 ha in size with a certain minimum tree density (varying with tree size, e.g., 500 trees per hectare with diameter-at-breast-height of at least 12 cm), though certain open areas (e.g., beaver ponds) may contribute up to 10% of the eligible forest area. The presence of residential structures and landscaped areas leads to a deduction of 0.4 ha from the eligible forest area but buildings specifically used for forestry purposes are exempt from this. The MNRF does not proactively identify eligible forests but relies on private forest owners to identify their forest to MNRF as eligible at the time of program application. These forests are then entered into a ministry-administered database.

Program-enrolled lands enjoy a reduction of municipal property tax by 75% (to 25% of the residential property tax
Stewardship of the enrolled forests is achieved by requiring that forest owners prepare a managed forest plan for the forest to be enrolled. This plan has to have a long planning horizon (i.e., 20 years or more) and needs to describe the activities that will be carried out over the next 10 years. The plan must be approved by a ministry-designated Managed Forest Plan Approver who will visit the forest, confirm that the forest is program-eligible, and ensure that the plan and proposed activities meet program standards. The Approver may also prepare forest maps and an inventory, recommend forest management activities, and revise a forest management plan to meet program standards. The Approver is an independent contractor and requires fees for their services. Under the program, forest management activities are classified as: (a) encouraged and (b) not permitted (Table 1). Among the not permitted activities is continued inactivity. After successful program application, eligible forests are enrolled for a 10-year period, which can be renewed in the tenth year. After 5 years in the program a progress report has to be submitted to the ministry, and the forest management plan has to be updated and approved at least every 10 years. If the program participation is not renewed in its 10th year, or if the 5-year progress report is not submitted, the forest will be unenrolled from the program. However, the program can also be left at any point in time, requiring a written notice and submission of a progress report. A forest can also become unenrolled if the ministry finds that the forest has become ineligible. If found that an enrolled forest has become ineligible during the period of program participation (e.g., as a result of not permitted activities), this may lead to the recovery of previously exempted property taxes for the period of past noncompliance without a maximum number of years. The MNRF may conduct audits, including field visits, of enrolled forests at any time to ensure program requirements are met. At the time of data collection, MNRF’s database contained information on 14,709 forests enrolled in the MFTIP.

APPENDIX B. SHORT FORMS OF SURVEY QUESTIONS RELEVANT FOR THIS STUDY

**Question:** To what extent do you feel the following environmental issue is a serious or not serious problem in Ontario? … Spread of invasive species.

*Answer:* Serious problem, slight problem, probably not a problem, definitely not a problem, unsure/don’t know.

**Question:** In terms of environmental management practices for this property, please indicate which of the following has been undertaken or is planned. … Removal/control of invasive species … Planting of native species …

*Answer:* Completed/underway, planned, not planned, not applicable to this property

**Question:** The CLTIP or MFTIP really have no influence on how we manage the environmental features of this property.

*Answer:* Definitely agree, somewhat agree, somewhat disagree, definitely disagree, don’t know/cannot say.

**Question:** Are you currently a member of any group whose main aim is to preserve or protect the environment?

*Answer:* Yes, no.