Adoption influences in Ontario's 50 Million Tree Program

by Heather MacDonald[1*], Daniel W. McKenney[1], John H. Pedlar[1], Emily S. Hope[1], Kerry McLaven[2] and Suzanne Perry[2]

ABSTRACT

Ontario's 50 Million Tree Program (50 MTP) has been underway since 2007, with a mandate to encourage afforestation in the province. Under this program, Forests Ontario provides financial support to offset the costs of planting trees on properties at least one ha in size; in return, landowners agree to maintain their newly planted trees for a minimum of 15 years. The current study examines adoption influences in the 50 MTP, particularly the role of agricultural land rent values (which help to provide an indication of opportunity cost/trade-offs between agriculture versus forests), the per-tree support level offered by the 50 MTP, and personal motivations such as the desire to enhance wildlife habitat. Our results indicate that landowners in census sub-divisions with lower agricultural land rent values (and therefore lower "opportunity costs") were most likely to participate in the 50 MTP. Further, census sub-divisions with low agricultural rent values were more likely to show increased trends in forest cover. The effect of the per-tree support offered by the 50 MTP (between $1.25-1.35) on participation in the 50 MTP (and on afforestation in general) was explored, but the limited variation in support levels made it challenging to draw definitive conclusions. Finally, a follow-up survey of 50 MTP participants indicated that wildlife and enhancing native forest cover were the most common motivations for participating in the program.

Key words: afforestation; wildlife; 50 Million Tree program; Ontario; opportunity cost

RÉSUMÉ

Le programme 50 millions d'arbres de l'Ontario (*Million Tree Program-50 MTP*) qui se poursuit depuis 2007 a pour objet de promouvoir le boisement des terres dans la province. En marge de ce programme, Forests Ontario offre un soutien financier couvrant les frais de plantation d'arbres pour les propriétés d'un hectare ou plus; en échange, les propriétaires terriens s'engagent à entretenir leurs nouveaux plants pendant au moins 15 ans. Cette étude se penche sur les effets de cette « adoption » sur 50 MTP, notamment le rôle que jouent les valeurs de la rente agricole (donnent un indice du coût de capital/risques d'une utilisation agricole versus forestière), le niveau de l'aide offerte par le 50 MTP pour chaque arbre planté ainsi que les motivations personnelles comme le désir d'améliorer l'habitat pour la faune. Nos résultats montrent que les propriétaires dans les subdivisions du recensement qui avaient les plus faibles valeurs de rente agricole (et donc de plus faibles coûts de capital) avaient plus de chances de participer au 50 MTP. De plus, les subdivisions qui avaient de faibles rentes agricoles avaient plus tendance à pencher vers un couvert forestier. On a aussi cherché à savoir si le montant offert par 50 MTP pour chaque arbre planté (entre 1,25 $ et 1,35 $) avait un effet sur la décision, mais le peu de différence entre les montants offerts n'a pas permis d'en arriver à des conclusions fermes. Enfin, un suivi effectué auprès des participants au 50MTP a révélé que c'était d'abord le volet faunique et l'amélioration du couvert forestier indigène qui les motivaient à adhérer au programme.

Mots clés : boisement; faune; programme 50 millions d'arbres; Ontario; coût du capital

Introduction

Afforestation refers to the establishment of forests by deliberate planting or seeding on land not previously considered a forest (FAO 2015). In Ontario, the 50 Million Tree Program (50 MTP) has been underway since 2007 to encourage afforestation. As incentive to participate in this program, Forests Ontario covers up to 90% of tree planting costs for afforestation projects greater than 1 ha in size. In return, owners sign a 15-year management agreement for the trees. The purpose of the 50 MTP is to plant 50 million trees across the province, thereby sequestering approximately 6.6 million tonnes of carbon dioxide over time (Parker *et al* 2009). Initially, the focus of 50 MTP was southern Ontario; however the reach of the program was extended to northern Ontario in 2014. The purpose of this study is to explore some of the factors influencing the adoption of this afforestation program by Ontario landowners.

Motivations for planting trees

There are many direct and indirect benefits to private land owners from converting part or all of a property to forest. Owners gain direct benefits from forests such as tim-

[1]Great Lakes Forestry Centre, Canadian Forest Service, Natural Resources Canada, Sault Ste. Marie, Ontario, Canada, P6A 2E5 * Email: Heather.MacDonald4@Canada.ca
[2]Forests Ontario, 144 Front Street West, Suite 700, Toronto, Ontario, M5J 2L7

ber and shade. Ecologically, forests store carbon in biomass and soil, prevent erosion and flooding, improve water quality, provide wildlife habitat, and filter the air, among other benefits. Even for absentee owners, forests can generate indirect (and/or difficult to quantify) benefits such as the maintenance of ecosystem processes, and psychological values such as naturalness, or a sense of legacy for future generations (see for instance McKenney *et al*. 1999).

Landowners may also plant trees as a financial asset, potentially for them or future owners to later harvest the timber for income. The following assumptions are typically made when formalizing landowners decision-making process in an economic (cost/benefit) framework: a) afforestation will occur if the parcel of land is cropland and the delayed net forest revenue is greater than the present value of typical expected agricultural revenues, and b) deforestation will occur if net agricultural revenue exceeds the present value of expected net forest revenue plus the cost of conversion (Stavins 1999). Site quality directly affects agricultural yields, which simultaneously impacts opportunity costs of taking land out of agricultural production, and financial returns from forestry due to variations in tree growth rates. A number of U.S. studies have concluded that marginal cropland represents the most feasible option for afforestation, as the opportunity costs for quality agricultural land are prohibitively expensive (Stavins 1999, Winsten *et al.* 2011). Empirically, as Miao *et al.* (2016) observe, maps illustrating Conservation Reserve Program (CRP) enrolment in the U.S. show high concentration in marginal cropland regions. In Canada, studies on afforestation have also focused on lower-cost agricultural land as candidates for afforestation (McKenney *et al.* 2004, Bird and Boysen 2007), although it is noted that non-farmland may also be available for afforestation.

One of the challenges in estimating costs to landowners of afforestation is the preponderance of private land and multiple landowners, hence detailed knowledge of costs is difficult to ascertain. Establishment costs to a landowner include not just direct expenditures such as seedlings and site preparation but also indirect costs associated with planning, learning and opportunities lost when changing land use. In Ontario, Bird and Boysen (2007) factored in planting costs of \$1000/ha to \$2700/ha in planning for the 50 MTP. Yemshanov *et al.* (2012) simulated a broad range of management regimes and costs and benefits for three long-rotation species, (assuming thinnings at different ages with final harvest ages of 55–70 years), red pine – *Pinus resinosa* Ait, Norway spruce – *Picea abies* L., and black walnut – *Juglans nigra* L.), inclusive and exclusive of possible carbon returns across southern Ontario. Present values of establishment costs range from ~\$1100–\$2200/ha depending on the species and site class. Rates of return varied spatially according to site class and carbon price assumptions. To achieve a 6% real rate of return, break-even carbon prices were \$10.7/t CO_2e for red pine, \$12.6/t CO_2e for Norway spruce and \$17.2/t CO_2e for black walnut for the "best" 10 000 ha. Based on these assumptions, Yemshanov *et al.* (2012) concluded that few attractive afforestation options in Ontario exist when they applied a rate of return of 8%.

The per tree support of 50 MTP was designed to provide a large percentage (70–90%) of the direct establishment costs of afforestation but was not intended to cover other opportunity costs perceived by landowners. Because of this, other co-benefits may be required to justify afforestation in Canada as suggested by Yemshanov *et al.* (2005). Several surveys in Canada and the United States indicate that landowners in North America do not typically view their property as an economic undertaking in a financial sense. National surveys of U.S. woodlot owners have found that un-priced values such as beauty, wildlife habitat, nature protection, and family legacy are important reasons for owning woodlots (Butler *et al.* 2004, 2016). In a survey of Mississauga, Ontario residents regarding motivations for planting trees, beauty was most important, followed by a desire for landscaping, privacy, and shade (Conway 2016). In Quebec, Coté *et al.* (2012) and Bissonnette *et al.* (2017) noted that a high percentage of small private forest owners were 55 years or older, suggesting that legacy may be an important motivation for forest owners.

Another issue identified as important in the ecological literature, but of uncertain importance to landowners, is the selection of tree species. The importance of using native species is clear in land restoration literature (e.g., Thomas *et al*. 2014); however, a recent survey of southern Ontario communities found that knowledge levels concerning native species was relatively low (Almas and Conway 2017). Knowledge of native tree species was higher among those with experience planting trees compared to those with no such experience. As a result, it is possible restoring native tree species may be a common motivation for people participating in the 50 Million Tree program.

The preceding discussion underscores the influence of opportunity costs in the uptake of afforestation projects. In regions with high opportunity costs, we predict that uptake of the 50 MTP will be lower, consistent with a conclusion from behavioural economics that "the supply of altruism often depends on its opportunity cost" (Altman 2008, p. 46). In southern Ontario, with relatively high opportunity costs (agricultural values), we predict that afforestation activity will be motivated more by non-market values rather than financial returns.

Methods

We considered a number of variables for their effect on participation in the 50 MTP, including:

1) agricultural land rent values (\$/ha);
2) support level from the 50 MTP (\$1.25 to \$1.35 per seedling);
3) the amount of agricultural land rented or leased in each census division, reflecting sites potentially available for afforestation; and,
4) project proponent motivations, measured from a short survey completed by ~10% of the landowners participating in the 50 MTP.

In order to assess the effect that the amount and value of available agricultural land, support rates, and personal motivations had on participation in 50 MTP, we analysed program data, socioeconomic data from Statistics Canada, and tree cover maps. Program data provided by Forests Ontario contained 2119 50 MTP project records from 2007 to 2016. As of the date that the administrative data were generated, there were 7494 ha planted as part of the program. The "snapshot" provided by this report reflects participation as of early 2017, however participation in the program has continued to evolve since then. The *State of Ontario's Biodiversity* update (Ontario

Biodiversity Council 2017) reports that closer to 9100 ha of new forest have been established as part of the program, resulting in the planting of some 16.8 million trees.

Data from 50 MTP was combined with socioeconomic data from Statistics Canada (CANSIM). Agricultural land opportunity costs were calculated at the level of Census Consolidate Subdivision units from the rental and lease expenses listed in the Canadian Census of Agriculture (Statistics Canada 2017a). In addition, the CANSIM product 004-0202 (Statistics Canada 2017b) was used to calculate the agricultural land base. Spatial data on forest cover (250 m resolution) in communities eligible for the 50 MTP were also examined for 2001 and 2011 (Beaudoin *et al.* 2014). Spatial estimates of forest cover change from 2001 to 2011 were calculated using forest attribute maps (250 x 250 metre) of Beaudoin *et al.* (2014). These maps rely on Moderate Resolution Imaging Spectroradiometer (MODIS) imagery as predictors using Canadian National Forest Inventory (NFI) photo plot data (Gillis *et al.* 2005) for calibration and validation. Our focus was on historical trends from 2001 to 2011 within census subdivisions.

For the purpose of this study, we defined two afforestation outcomes or response variables. The number of hectares enrolled in 50 MTP was of primary interest. As well, the change in spatially mapped forest cover from 2001 (before the commencement of 50 MTP) to 2011 was also analysed as a broader afforestation outcome. Linear regression models were conducted in SAS software, Version 9.4 of the SAS System for Windows using agricultural land rents ($/ha), amount of agricultural land for rent (ha), as well as average 50 MTP support by census sub-division. The general model may be defined as:

$$\hat{y}_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \varepsilon_i$$

where $\hat{y}_i$ = the estimated afforestation outcome (number of ha planted with 50 MTP and tree cover change) for the i^{th} census subdivision; β_0 = the intercept; β_1 = average agricultural land rental values; β_2 = average support level provided by the 50 MTP; β_3 = amount of agricultural land available for rent or lease in the county; and ε_i is the error term reflecting all other factors affecting afforestation outcomes.

An analysis of variance (ANOVA) was also undertaken in SAS on the number of hectares afforested by level of support for communities with different agricultural land rents. ANOVA partitions the variance of an output variable over the different input variables to provide "quantitative insights of both the independent influence of each individual design parameters and the interacting effect among these individual design parameters" (Lam *et al.* 2016, p. 299). Proc GLM (General Linear Model) was used in SAS Version 9.4 of the SAS System for Windows for this analysis. The purpose of this model was to examine the effect of increasing the 50 MTP support rate in communities with more expensive agricultural land rents.

Results and Discussion

The typical 50 MTP afforestation project was less than 5 ha in size, as indicated in Table 1; 23.6% of projects funded by the 50 MTP were less than 2 ha in size, with an additional 57.7% being 2 ha to 5 ha. Only 4.2% of 50 MTP projects were 10 ha or more. Nearly 80% of participants had a property less than 50 hectares (78.4%), compared to 14% of participating properties with 50–99 hectares, 4.9% with 100–199 hectares, and 2.6% with 200 hectares or more. Most property owners participated one time in the program (1417 properties or 82.2%). In comparison, 223 property owners participated twice (12.9% of properties), 44 participated three times (2.6%), and 39 four times or more (2.3%).

Table 1. Number of afforestation projects under the 50 Million Tree Program by number of hectares planted (2007–2014)

Afforestation Project Size	Number of Projects	Percent of Projects
Less than 2 ha	500	23.6%
2 ha to 4.99 ha	1222	57.7%
5 ha to 9.99 ha	307	14.5%
10 to 40 ha	90	4.2%
Total	**2119**	**100.0%**

In terms of the range of tree species planted, 73 species are listed in the administrative data, with the most common species planted being: eastern white pine (28.1%); white spruce (19.3%), red pine (11.4%), and Norway spruce (11.2%). Figure 1 presents the number of trees planted for species accounting for greater than 1% of seedlings planted.

The role of agricultural land area and value

Table 2 presents data used in the regression analysis at the census sub-division level. Grey County had the highest participation rate in the 50 MTP with over 1500 ha afforested and over 350 afforestation projects. In terms of the independent variables, Grey was the only county to have over 100 000 ha of agricultural land available for rent with an average rental value of less than $100/ha. Leeds & Grenville (average agricultural land rents of $76/ha) had the second highest participation rate in terms of ha with 425 ha planted and 132 afforestation projects. In terms of tree cover change, Lanark County, with low agricultural land rental/lease values of $45/ha, showed the greatest change in tree cover from 2001 to 2011 (+9.3%). In all, 25 of the 37 census subdivisions considered in the analysis had positive changes in tree cover from 2001 to 2011.

Single-variable relationships between both response and explanatory variables were analyzed in a correlation matrix (Table 3). Change in tree cover from 2001 to 2011 was not significantly related to the total ha planted under 50 MTP ($r = 0.136$, $p = 0.422$), or to 50 MTP plantings in ha prior to 2012 ($r=0.141$, $p=0.407$). Thus, tree cover change is only weakly related to participation in 50 MTP in southern Ontario census sub-divisions. However, 2011 was soon after the initiation of 50 MTP to observe substantial changes in tree cover from 50 MTP afforestation projects undertaken in 2007–2011. Further, the changes in percentage tree cover from 2001 to 2011 reflects the impacts of all afforestation efforts at a given location—including 50 MTP, other initiatives, and individual actions—as well as natural succession in some areas.

Of the various explanatory variables, the amount of agricultural land for rent or lease was most strongly correlated

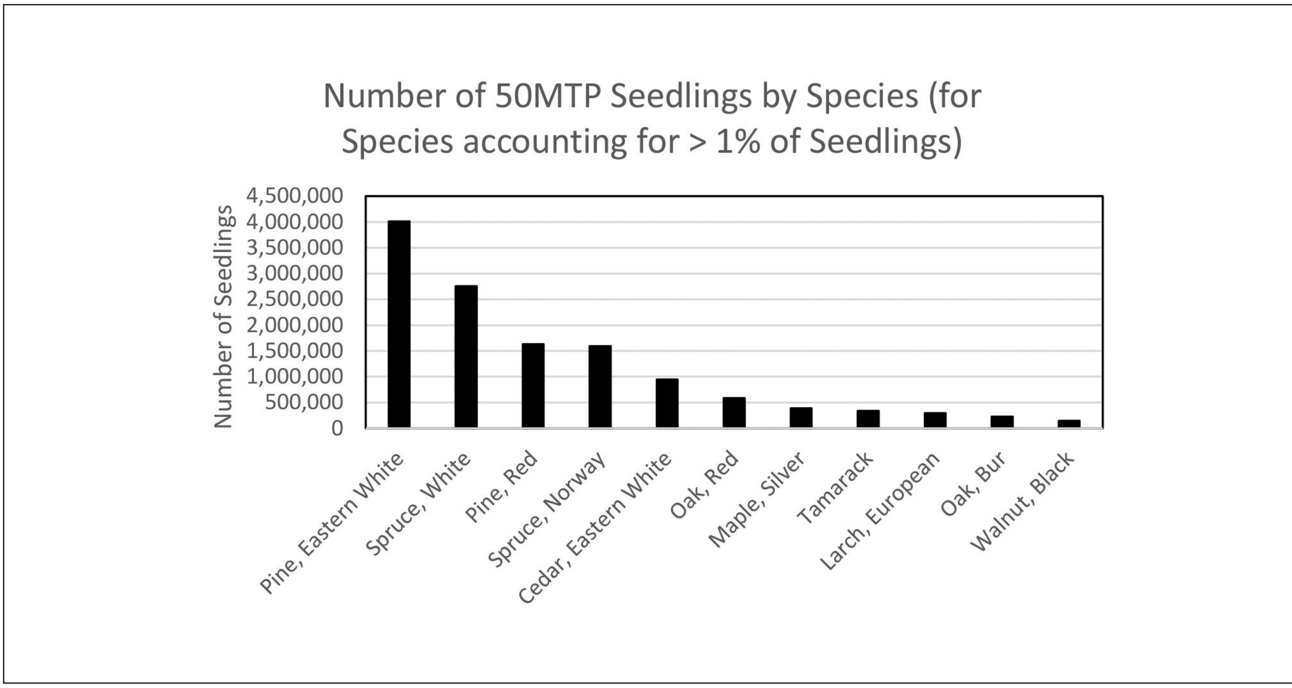

Fig. 1. Number of seedlings planted as part of the 50 MTP (for species representing more than 1% of seedlings)

with the number of ha planted as part of the 50 MTP ($r = 0.279$, $p = 0.09$). The univariate correlation between average agriculture land rent values and area planted as part of 50 MTP was not significant ($r = -0.206$, $p = 0.220$). The change in forest cover from 2001 to 2011 was highly and negatively correlated to agriculture land rent values ($r = -0.777$, $p < 0.0001$).

There was some evidence of collinearity among the explanatory variables, with the amount of agricultural land rented being positively related to rental values ($r = 0.53$, $p = 0.001$), indicating that more agricultural land was available for rent or lease in areas with higher land rent values.

Linear regression models were developed for the total ha afforested as part of the 50 MTP as well as for the percentage tree cover change from 2001 to 2011 at the census subdivision level. The results of the regression model for the number of ha planted as part of the program indicate that both the amount of agricultural land available in the community and agricultural land rental values were statistically significant predictors (Table 4). Model 1 residual analysis suggested that Grey County was an outlier in model 1, with a studentized residual of 5.2. In order to assess the extent to which the model results were impacted by Grey County, a second regression model was conducted with this county removed. The results for the number of ha planted as part of the 50 MTP show the same pattern of coefficients (i.e., same direction and significance of relationship). As well, both agricultural land rent values and total agricultural land rents were statistically significant, similar to the model with Grey County included.

The second dependent variable was the percentage of tree cover change from 2001 to 2011. In this model, average agricultural land rental values were significant ($p = 0.001$) and explained much of the variability in tree cover change ($r^2 = 0.6198$).

In sum, the value of agricultural land predicted afforestation outcomes to some degree. However, there were some census subdivisions with high agricultural land values that showed comparable rates of participation in the 50 MTP compared to other communities. In Haldimand-Norfolk County, for instance, with high agricultural rents of $369/ha, there were 77 projects resulting in 302 ha afforested. In York County, with moderately high agricultural rental values of ~$237/ha and an increasing population, there is a move to recognize urban canopy cover from trees associated with current and future residential land use (York Region Natural Heritage and Forestry 2010). Also, the new Rouge National Urban Park, located in the greater Toronto area, involved an expansion of the area in the original Rouge Park to agricultural lands to the north (Parzei 2013).

Support levels

Support rates have evolved over the life of the program, with a support rate of $1.25 per tree between 2008 and 2011, and $1.35 between 2012 and 2018. The administrative data indicate that on average, 1800 seedlings were planted per ha. At $1.25 per seedling, this amounts to $2250/ha of support, and at $1.35, the total support is $2430/ha as detailed in Table 5. In comparison, Bird and Boysen (2007) estimated establishment costs of up to $2700/ha and Yemshanov *et al.* (2012) factored in costs of $1100–$2200/ha.

The correlation between the support level and number of hectares planted under 50 MTP was not statistically significant ($r = -0.259$, $p = 0.122$). Further, the support level was not a statistically significant predictor in the course of regression modelling. It should be noted again, however, that the support level did not vary widely, and therefore does not provide a good test of the relationship between financial support and afforestation outcomes.

Table 2. Summary of the data set used for regression modeling for census subdivisions participating in the 50 MTP from 2007–2010. This excludes census sub-divisions eligible for the 50 MTP starting in 2014)

County	Total ha Planted 50MTP	Ag Land Rental Value/ha[1]	Average Support ($/seedling)	Area of Land Rented/Leased (ha)[a]	% of Ag Land Area Planted 50MTP	% Tree Cover, 2001	% Tree Cover, 2011	Change% Tree Cover, 2001–2011
Lanark	117.7	$44.53	$1.30	39 185	0.30%	55.5	64.8	9.3
Leeds & Grenville	425.3	$76.22	$1.27	71 076	0.60%	39.8	48.2	8.4
Frontenac	233.2	$34.11	$1.31	26 731	0.90%	54.4	62.7	8.3
Lennox & Addington	136.2	$31.65	$1.30	33 448	0.40%	54.6	62.1	7.5
Prince Edward	91.9	$76.17	$1.27	35 622	0.30%	19	26	7
Northumberland	189.6	$72.04	$1.29	66 202	0.30%	30.2	36.9	6.7
Hastings	178.75	$36.76	$1.30	56 598	0.40%	66.4	72.6	6.2
Ottawa[1]	155.99	$158.14	$1.29	31 710	0.50%	29.2	34.8	5.6
Kawartha Lakes (Victoria)	84.42	$68.20	$1.27	89 180	0.10%	35.9	41.5	5.6
Peterborough	115.7	$45.40	$1.27	52 348	0.20%	53.4	58.7	5.3
Dundas & Glengarry	268.87	$193.47	$1.29	72 718	0.40%	26.7	31.7	5
Renfrew	263.86	$42.59	$1.29	63 447	0.40%	69.5	73.9	4.4
Durham	91.52	$148.80	$1.32	103 006	0.10%	22.1	25.6	3.5
Grey	1506.17	$77.23	$1.28	126 573	1.20%	31.8	35.2	3.4
Prescott & Russell	115.84	$136.32	$1.28	24 694	0.50%	26	28.9	2.9
Simcoe	324.03	$149.47	$1.31	176 767	0.20%	32.1	34.5	2.4
York	235.65	$236.86	$1.28	78 437	0.30%	17.5	19.7	2.2
Dufferin	273,31	$144.66	$1.29	51 327	0.60%	20.9	22.9	2
Bruce	331.23	$148.37	$1.28	119 997	0.30%	29.5	31.1	1.6
Peel	162.63	$86.98	$1.28	38 154	0.50%	16.7	18.1	1.4
Chatham-Kent	87.4	$458.79	$1.31	102 022	0.10%	4.1	5.5	1.4
Halton	189.34	$176.99	$1.30	35 860	0.60%	23	23.5	0.5
Huron	57.39	$343.15	$1.31	189 016	0.00%	9.8	10.2	0.4
Wellington	400.767	$212.41	$1.28	125 404	0.30%	14.4	14.8	0.4
Essex	121.7	$329.90	$1.33	79 163	0.20%	3.8	4.1	0.3
Brant	85.7	$337.74	$1.30	56 712	0.20%	15.4	15.2	-0.2
Waterloo	59.58	$298.19	$1.28	56 308	0.10%	10.1	9.8	-0.3
Niagara[2]	123.29	$355.51	$1.33	70 551	0.20%	13.2	12.9	-0.3
Perth	36.8	$468.89	$1.28	119 170	0.00%	5	4.1	-0.9
Hamilton (part of Northumberland)	41.6	$176.81	$1.33	55 333	0.10%	16.2	15.3	-0.9
Oxford	84.35	$449.41	$1.28	96 028	0.10%	8.1	6.9	-1.2
Lambton	104.99	$357.46	$1.31	99 391	0.10%	9.8	8.5	-1.3
Haldimand-Norfolk[3]	301	$369	$1.30	140 062	0.20%	13.7	12.2	-1.5
Middlesex	165.9	$349.88	$1.31	152 613	0.10%	9.2	7.6	-1.6
Elgin	38.6	$306.05	$1.29	90 436	0.00%	13.8	10.6	-3.2

[a] Source: Statistics Canada 2017a, 2017b

[1]Metro area of Ottawa

[2]Includes 24.5 ha planted as part of 50 Million Tree Program in West Lincoln

[3]50 Million Tree Program lists Haldimand-Norfolk as a single entity. However, agricultural rental values separate these two areas. Because Haldimand has a land area of 1251.6 km^2 and Norfolk has a land area of 1607.6 km^2, the agricultural land rental value was calculated from a weighted average based on land area.

Since northern Ontario was not eligible for the 50 MTP until 2014, it offers a comparison to test the effect of 50 MTP support. However, there are several caveats and challenges associated with this. First, northern Ontario has a much higher rate of forest cover compared to southern Ontario. Also, northern Ontario has a much different economic base, with a greater dependence on natural resources compared to southern Ontario. As a result, the afforestation potential is very different in southern Ontario compared to central/northern Ontario. Such large differences in pre-existing characteristics obfuscates the interpretations of a pre-post comparison, even controlling for agricultural land availability.

In terms of community response to a $1.35 support level per seedling versus $1.25, there is some evidence that the higher support rate of $1.35 increased uptake in communities with more expensive agricultural lands.

In areas with more expensive agricultural land rents, there was a small increase in ha planted after the introduction of the $1.35 support rate (+15.8%). However, the higher support rate did not increase uptake in communities with less expensive agricultural land. An analysis of variance was undertaken of the effect of the level of support to determine whether there was a different pattern of uptake that was evident in communities with more expensive agricultural land compared to communities with less costly agricultural land. The overall model was significant ($F = 26.82$, $p < 0.0001$). The effect of agricultural land rent values was statistically significant ($F = 7.85$, $p = 0.005$); number of hectares planted was four times

Table 3. Correlation matrix of the dependent and explanatory variables used in the current study. Each cell of the table presents the correlation coefficient (r) as well as the probability that the correlation coefficient is zero (p).

	y1: Total ha planted 5 0MTP	y2: Change in % Tree Cover 2001–2011	X1: Avg Ag Land Rental Values	X2: Avg Support level 50MTP	X3: Amount of Ag Land Rented
y1: Total ha planted 50MTP	—				
y2: Change in% Tree Cover 2001–2011	0.136 0.422	—			
X1: Avg Ag Land Rental Values	-0.206 0.220	-0.777 <.0001	—		
X2: Avg Support Rate 50MTP	-0.259 0.122	-0.229 0.173	0.147 0.384	—	
X3: Amount of Ag Land Rented	0.279 0.093	-0.443 0.006	0.530 0.001	-0.062 0.718	—

Table 4. Regression results for each of two response variables. For each variable in the models, estimated coefficients, t-values, and p-values are reported. The last three rows include model r-square, adjusted r-square, and the root mean squared error.

	y1: Total ha planted 50MTP			y2: Change in% Tree Cover 2001–2011		
	Coefficient Estimate	t-value	p	Coefficient Estimate	t-value	P
Intercept	3375.31	1.38	0.177	32.89183	1.37	0.1801
X1: Avg Ag Land Rental Values	-0.798	-2.59	0.0142	-0.01721	-5.69	0.0001
X2: Avg Support Level 50MTP	-2506.99	-1.33	0.194	-23.3758	-1.23	0.2273
X3: Amount of Ag Land Rented	0.00288	3.01	0.0049	-0.00000413	0.44	0.6632
Model R-Square		0.2909			0.6198	
Adjusted R-Square		0.2264			0.5853	
Root Mean Squared Error (RMSE)		216.158			2.123	

Table 5. Support rates used in the 50 Million Tree Program per seedling as well as average support per hectare, total seedlings planted, total area planted and percent of total planted area

Support Rate	Average Support by 50MTP/ha*	Total Seedlings under 50 MTP	Total Planted Area 50 MTP (ha)	Percent of Total Planted Area
$1.25	$2250	7 885 195	4382	56.0%
$1.35	$2430	5 783 631	3107	39.7%
Total	–	**13 668 826**	**7489**	**100.0%**

Note: There were a small number of projects in the administrative data that did not state the funding level, and these were excluded from the table
*Based on 1800 seedlings planted on average per hectare from the administrative data

higher in communities with agricultural land rents of less than $300/ha compared to more expensive communities. As well, the interaction between agricultural land costs and the support rate was statistically significant ($F = 5.02$, $p = 0.025$), indicating that while uptake in communities with higher land rents increased with the larger incentive, uptake in communities with less valuable agricultural land showed a different pattern. Specifically, uptake in areas with less costly agriculture land decreased after introduction of the higher support rate, perhaps because uptake was higher initially, and then trailed off. Despite the increase in the support rate, the communities in more expensive census sub-divisions continued to show a lower participation rate in the 50 MTP, likely due to the disproportionately higher opportunity costs in these communities.

Table 6. Property size distribution for surveyed participants versus all participants

Property Size	Survey Group: count (%)	All Participants: count (%)
<50 ha	217 (85.4%)	1751 (78.4%)
50–199 ha	31 (12.2%)	423 (18.9%)
200+ ha	6 (2.4%)	59 (2.6%)
Total	**254 (100.0%)**	**2233 (100.0%)**

Motivations of participants

Approximately 254 of 2289 applicants to 50 MTP completed a short survey concerning motivations for participating in the program. The surveyed participants planted nearly 700 ha with 50 MTP, or 8.8% of area planted in the administrative data. The survey respondents were compared to all participants to assess the representativeness of the survey group. Respondents were significantly more likely to own smaller properties (85.4%) compared to all participants in the program (78.4%, $z = 2.71$, $p < 0.05$). Properties 50–199 ha were under-represented in the surveyed participants (12.2%) versus all participants (18.9%, $z = 2.72$, $p < 0.05$). However, there was virtually no difference between the groups with respect to percentage of properties with 200 ha or more (2.4% versus 2.6%, $z = 0.2$, $p = 0.84$). Survey respondents planted an average of 2.7 ha compared to 3.5 ha for all participants, a statistically significant difference ($t = 5.80$, $p < 0.05$). In summary, survey participants owned smaller properties and planted fewer hectares compared to all participants in the program. Table 6 presents the property size for respondents to the survey as well as all participants in 50 MTP.

Of those responding to the survey, 165 volunteered a motivation (objective) for participating. The most common objective was to enhance wildlife habitat (57.5%), followed by adding native forest cover (54.5%), protecting the local environment (46.1%), providing shade (40.7%), and mitigating climate change (35.9%); generating income and providing a legacy to descendants were less common as objectives (12.5% and 28.1% respectively). Most respondents provided multiple objectives (93 people). Previous research has indicated that owners of large properties are more likely to view their woodlot as an economic undertaking (Côté *et al.* 2016); however, of the 21 respondents who gave income as a motivation, 19 owned properties 50 ha and less (90.5%), similar to all participants in the program (85.4%).

Of the participants that gave a reason for participating, 12 participated more than one year (7.2%). These 12 participants represented 30 afforestation projects. Of these repeat participants, none gave income as a reason for participating, compared to 12.6% of all survey responses. In contrast, 16 repeat afforestation projects were partly motivated by shade. Shade was more common among repeat afforestation events (53%) compared to all afforestation projects (40.7%). Figure 2 illustrates the motivations for participating among repeat participants compared to all survey responses. It should be noted that the analysis of motivations is based on a subset of all participants and represents smaller properties compared to participants overall.

The results from the current program suggest that motivations other than future income were more important to participants, such as restoring native forest cover and wildlife habitat enhancement. This is not particularly surprising, given the low financial returns associated with silvicultural investments in Canada (Yemshanov *et al.* 2005). Given the high agricultural land rental values in some Ontario regions,

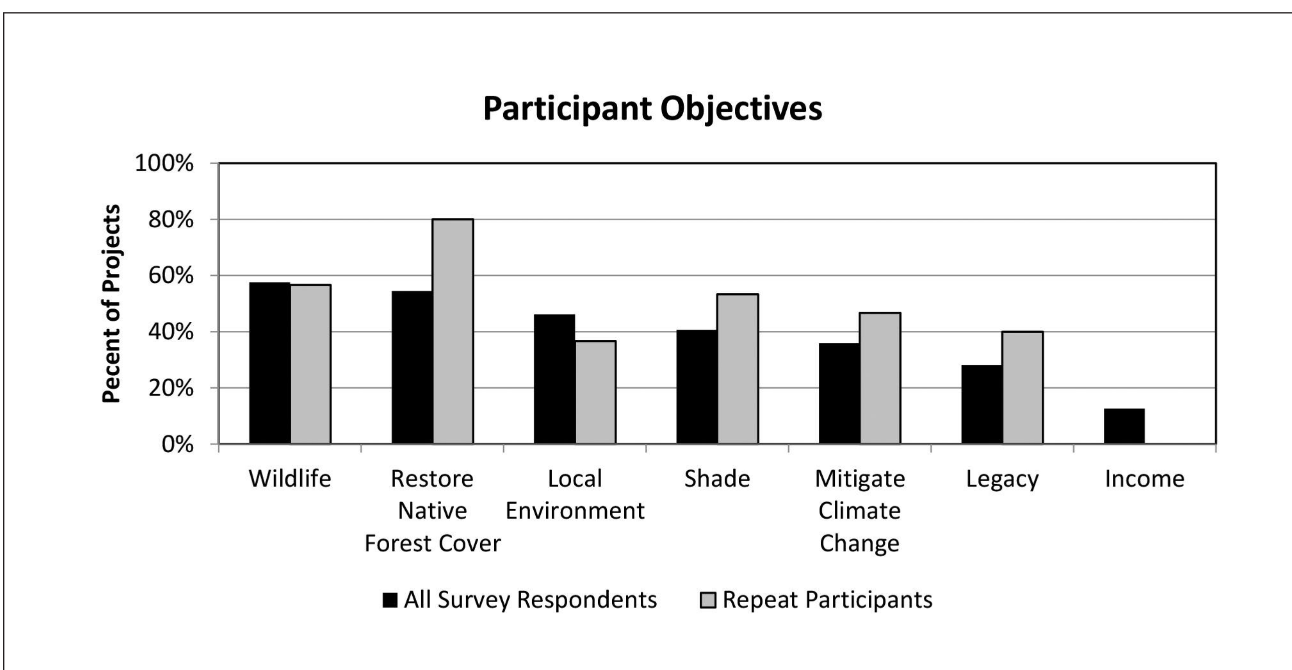

Fig. 2. Motivations of 50 Million Tree Program afforestation projects (of those completing the survey question about motivation). All respondents (n = 167) compared to repeat participants (n = 30)

(upwards of $500/ha/year), and the potential for carbon markets to emerge in the future in Ontario (Ministry of the Environment and Climate Change 2017), high carbon prices may be required to encourage landowners to plant trees. It remains to be seen if projected carbon prices of up to $10–50 (Hamrick and Gallant 2017) will be sufficient.

Conclusions

The value of agricultural land was strong to moderately correlated with afforestation outcomes. Census sub-divisions with lower agricultural rental values, reflecting lower opportunity costs, were more likely to participate in a program converting land to forest. Census sub-divisions with lower agricultural land rental values were more likely to show an upward trend with respect to overall tree cover. Because the support level offered by the 50 MTP did not vary widely across communities, it was difficult to determine whether varying support levels would have prompted landowners from communities with higher agricultural land rental values to afforest. The small increase in support from $1.25 to $1.35 in 2012 did not increase uptake of the program overall. This could be a consideration for future research and/or incentivizing landowners in afforestation programs. Very high agricultural land values suggest it may be difficult for some regions to find land for afforestation. Larger investments to support land acquisition, (possibly through conservation authorities as in the past), may be necessary in these regions. Nevertheless, based on the information in the York Regional Forest Management Plan for instance, an opportunity may exist for regions with high value agricultural land to increase tree cover densities in more residential areas. For example, tree planting opportunities may exist for municipalities interested in adding tree cover in urban locations. For the 50 MTP, realizing such an opportunity may require modifying program requirements for the urban setting (e.g., reducing minimum property size requirements).

The tree cover data presented in this paper provides an historical account of forest cover rates from 2001 to 2011. Rates of tree cover, of course, have continued to change since 2011. For instance, the South Nation Conservation Authority in Ontario have identified declines in forest cover from 2008 to 2014 (Mesman 2016). It is possible that the changes documented by this conservation authority may be related to changes in land values. Indeed, Farm Credit Canada (2018) reported that Ontario agricultural prices increased by 9.4% in 2017 alone. This trend in land value may drive future forest cover loss, perhaps partly due to a shortage of land for sale. As with previous periods, changes in forest cover in southern Ontario are likely to be heterogeneous. For instance, the creation of the new Rouge National Urban Park (see Parzei 2013) may result in an increase in forest cover in that part of the province, while other communities may experience forest cover losses linked to increased land values.

Our work provides support for a key finding in behavioural economics: that "the supply of altruism often depends on its opportunity cost" (Altman 2008, p. 46). While opportunity costs are ultimately individually determined, agricultural land rental costs provide a commonly used surrogate and do provide some predictive power about which communities would take up programs like this. Other non-economic factors also appear to motivate participants to afforest their land. Key among these was the importance of wildlife to participants in intentionally re-treeing properties. The finding that wildlife is of importance to private forests is consistent with that of a major survey of woodlot owners in the United States (Butler *et al.* 2016). Follow-up surveys may help to identify whether the objectives of participants were realized, (such as the opportunity to experience wildlife). Reflections about the non-economic benefits of afforestation could further motivate previous participants and other landowners to afforest their land. Finally, the potential of financial gain from private forests for carbon sequestration credits may begin to influence landowner thought processes, but significant practical details on protocols (rules) and carbon markets themselves are still emerging.

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