GREEN ANALYTICS

FORESTS ONTARIO

THE ECONOMIC VALUE OF TREE PLANTING IN SOUTHERN ONTARIO

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Executive Summary

Forests Ontario is dedicated to making Ontario's forests greener through tree planting, education and community engagement. The province of Ontario has committed to planting 50 million trees under the 50 Million Tree Program. Forests Ontario is helping to achieve this goal by engaging landowners and aiding tree planting activities. Between 2008 and 2018, Forests Ontario supported the planting of over 24 million trees covering almost 15 thousand hectares.

The people of Ontario benefit in numerous ways from the trees planted by Forests Ontario. People are employed to prepare planting sites, plant the seedlings and undertake follow-up visits to increase survival rates. There are also other employment impacts from seed forecasting and collection, tree nurseries and other ancillary support activities. Tree planting leads to economic gains as nurseries, landowners and Conservation Authorities engage in tree planting activities. Trees also provide ecosystem services, including recreation opportunities, carbon sequestration and storage and water and air filtration to surrounding residents and municipalities.

To demonstrate the value derived from tree planting in Southern Ontario, Forests Ontario commissioned Green Analytics to conduct an economic assessment of tree planting. This report presents the results of that assessment. There are two components to the assessment: the first focuses on the jobs and the gross domestic product (GDP) impact resulting from Forests Ontario's tree planting activities; and the second focuses on the ecosystem services that are provided to people living near the areas that have been planted.

The GDP impact on the Canadian economy of tree planting activities in Southern Ontario is estimated to be $12.7 million annually. This equates to a 3:1 return on investment for the government's annual investment in the 50 Million Tree Program. The number of full-time-equivalent jobs resulting from Forests Ontario's tree planting efforts in Southern Ontario is 103.8 annually. This is equivalent to 311.4 people employed in full-time jobs over the four spring/summer months when tree planting typically takes place.

The value of ecosystem services derived from the trees planted through Forest Ontario's efforts is conservatively estimated at $82.7 million annually with significant benefits derived from pollination and dispersal, recreation opportunities, aesthetic/amenity benefits and nutrient and waste regulation. For every $1.80 that Forests Ontario spends to support tree planting, no less than $19.85 in ES value is derived. The value estimates presented here do not account for all of the benefits derived from tree planting. In some cases, a defensible estimate of the value of services from tree planting is not readily available. As well, the ecosystem service value estimates capture only market values; for some services, non-market values can be significant. Further, while physical and mental health benefits resulting from time spent in nature are not typically included in ES valuation studies, they are increasingly recognized as significant in the literature. The value of the services derived from tree planting has increased over time and will continue to do so as the trees mature and the goal of planting 50 million trees in Ontario draws closer.

1 Introduction

Forests Ontario is dedicated to making Ontario's forests greener through tree planting, education and community engagement. The province of Ontario has committed to planting 50 million trees. Forests Ontario is helping to achieve this goal by engaging landowners and aiding tree planting activities. Between 2008 and 2018, Forests Ontario supported the planting of over 24 million trees covering almost 15 thousand hectares in Ontario (Table 1).

Table 1. Number of Trees and Area Planted in Southern Ontario, 2008 to 2018

Year	Trees (number)	Area (hectares)
2008	1,275,326	697.26
2009	2,005,777	1,121.49
2010	2,054,032	1,157.92
2011	2,531,260	1,410.70
2012	2,671,631	1,431.14
2013	2,355,057	1,274.25
2014	2,272,465	2,736.25
2015	2,464,069	1,314.00
2016	2,431,512	1,329.84
2017	2,123,710	1,140.88
2018	2,247,013	1,187.79
TOTAL	**24,431,852**	**14,801.52**

The people of Ontario benefit in numerous ways from the trees planted by Forests Ontario. People are employed to prepare planting sites, plant the seedlings and undertake follow-up visits to assess survival rates. Employment is also generated further up the supply chain in activities related to seed forecasting, seed collection and tree nurseries. In addition to this, various ancillary economic activities are supported, such as staff training, education programs, management activities and other professional services necessary to the tree planting industry. Tree planting leads to economic gains as nurseries, landowners, Conservation Authorities (CAs), stewardship councils, First Nations and private consultants engage in tree planting activities. As trees mature into forests, ecosystem services (ES), including recreation opportunities, water filtration and carbon sequestration and storage are provided to surrounding residents and municipalities. To demonstrate the value derived from tree planting in Southern Ontario, Forests Ontario commissioned Green Analytics to conduct an economic assessment of tree planting. This report presents the results of that assessment. There are two components to the assessment, each of which is discussed in the following sections. The first focuses on the jobs and gross domestic product (GDP) resulting from Forests Ontario's tree planting activities. The second focuses on the ES that are provided to people living near the areas that have been planted.

2 Economic Impact of Tree Planting

Economic impact assessments calculate the economy-wide impacts created when successive rounds of spending result from a direct spending stimulus undertaken in the economy. In this assessment, the economic impact of Forests Ontario's annual tree planting activities are calculated. Statistics Canada Industry Accounts Division's input-output (I-O) multipliers were used as the basis for analysis (see Appendix A for more information on economic impact assessments).

The economic impact assessment employed is expenditure driven. To calculate the total economic impact of tree planting activities in Ontario, an estimate of total expenditures made for tree planting activities in a given year was first required. Total expenditures were derived through a survey of planting delivery agents (PDA). The survey collected primary information on the total average cost incurred to plant a tree in 2018, on a per-tree basis, including all administrative overhead, material costs, labour costs, equipment, site preparation costs and any costs incurred for maintenance and survival assessments. Data was also collected on funding sources for the tree planting activities of the PDA, with a funding breakdown on a per-tree basis by quantity and source of funding. All cost figures are in 2018 Canadian Dollars.

A total of 10 PDAs participated in the survey. The survey data was used to estimate the direct expenditure stimulus from tree planting activities in Ontario catalyzed by Forests Ontario funding support under the 50 Million Tree Program. The average cost per tree was estimated at $2.81 in 2018 (Table 2).

Table 2. Survey Data on Average Cost Per Tree

Survey Respondent	Average Cost Per Tree ($)
1	2.94
2	2.15
3	1.39
4	1.77
5	3.00
6	2.10
7	2.51
8	6.75
9	3.42
10	2.05
Average of all Surveyed	**2.81**

Each PDA operates under a cost structure unique to its activities and business model. Based on the survey of 10 PDAs, with an average cost per tree of $2.81 in 2018, it was identified that $1.50 of the cost per tree was funded by the Government of Ontario's 50 Million Trees Program administered by Forests Ontario, and the remaining $1.31 was provided by other sources (Table 3). In effect, each $1.00 of Forests Ontario contribution leveraged an additional $0.87 through a variety of private and public sources. These other funding sources varied for each surveyed PDA, but include CAs, landowners, provincial grants, federal grants, funding from regional municipalities and funding from corporate sponsors.

Table 3. Survey Data on Average Funding Per Tree

Funding Source	Average Funding Per Tree ($)
Forests Ontario	1.50
Other Sources	1.31
Total	**2.81**

Forests Ontario also spends an additional $0.30 per tree on communications and marketing to help facilitate the 50 Million Tree Program. While these dollars do not flow directly to PDAs, they are an expenditure for ancillary activities necessary to facilitate the delivery of the program and so are included in the analysis.

Between 2008 and 2018, 24.4 million trees were planted. The year 2008 was the pilot year of the program and thus a low-planting outlier year with only 1.275 million trees planted due to the program requiring development and ramping up to reach the scale achieved from 2009 to 2018. The average annual number of trees planted between 2009 and 2018 was 2.316 million trees. Due to the variance in tree planting activity from year to year, the annual average from 2009 to 2018 is used as a basis for the number of trees planted each year in the economic impact assessment, with 2008 excluded from the average as it was the outlier pilot year.

Using the annual average number of trees panted under the 50 Million Tree Program of 2.316 million, the estimated total annual expenditures made in Ontario for these tree planting activities are $7,195,682 (Table 4).

Table 4. Total Annual Expenditure Stimulus

Calculating Annual Expenditure Stimulus	
Number of Trees Planted in an Average Year	2,315,653
Average Cost to Plant a Tree by PDA	$2.81
Forests Ontario Communications and Marketing Ancillary Expenditure per Tree	$0.30
Total Annual Expenditure Stimulus	**$7,195,682**

It should be noted that this total expenditure only includes tree planting activities directly catalyzed by the Government of Ontario's 50 Million Tree Program. It does not include any private tree planting activities undertaken outside of this program. Furthermore, while the period 2009 to 2018 was used as the basis for establishing the average number of trees planted per year, the trend going forward is expected to be higher. For these reasons, the stimulus can be interpreted as a conservative estimate of the total industry expenditure stimulus. Including tree planting activities performed by other private or public organizations external to the 50 Million Tree Program would increase this number. A separate economic impact assessment was conducted, using the same approach and cost parameters described here, on an additional 2 million trees that were planted through other programs.

2.1 Methodology

The economic impact assessment was conducted using Statistics Canada's 2014 I-O multipliers for Ontario. These multipliers are tabulated by Statistics Canada through the creation of I-O models. I-O models are essentially mathematical matrix depictions of the industrial structure of the economy. They represent the complex interrelationships between industry sectors and between industry sectors and end-consumers.

When one industry sector is "stimulated" in an I-O model, it accounts for how all other industries are affected and how the total economy is impacted. For example, if an agricultural producer purchased new machinery at a cost of $1 million, there would be a direct stimulus to the agriculture machinery manufacturing industry of $1 million. This demand stimulus would elicit a chain of indirect expenditures throughout the economy: the agriculture machinery industry would have to purchase raw inputs such as steel, plastic and vinyl from other intermediate industries to produce the machinery; steel, plastic and vinyl manufacturing industries would need to further purchase their own requisite input mix to produce their product—for example, plastic and vinyl manufacturers would need to purchase petrochemicals; even further down the chain, petroleum refiners would need to purchase heavy machinery and distillation equipment to yield the petrochemicals required by the plastic and vinyl manufacturers. This succession of expenditures would continue indefinitely.

The above example illustrates how a $1 million stimulus to the economy generates a total economic impact that is greater than $1 million. The $1 million expenditure from the agricultural producer represents the direct impact. The subsequent expenditures made by intermediate industries, for example the purchase of raw steel by the agriculture machinery manufacturer, constitute the indirect impact. Taking it one step further, the income earned in the form of wages by those employed throughout this chain of inter-industry spending becomes household income, which is then spent on various consumer goods and services. The impacts of the household sector expenditures constitute the induced impact resulting from the expenditure stimulus. The total economic impact is the sum of direct, indirect and induced impacts.

The economic impact assessment estimates the GDP and employment effects of the direct spending stimulus. The I-O tables generated by Statistics Canada are lagged by 28 months from the reference year, hence, 2014 is the most recent available data.[1] The input-output industry structure of the economy tends not to significantly change from year to year. Thus, the lagged inter-industry sales and purchase data from 2014 that underlies the model will not significantly distort the results of the 2018 impact analysis.

2.2 Economic Impact Assessment Results

As is noted above, the average annual direct economic impact resulting from tree planting activities directly catalyzed by the Government of Ontario's 50 Million Tree Program is $7,195,682 (Table 4). This stimulus is the sum of Forests Ontario funding to PDAs, ancillary activities funded by Forests Ontario, and funding from other public and private third party sources. In effect, this is the amount of money flowing directly into Ontario's tree planting industry subsector each year.

The GDP and employment impacts resulting from Forests Ontario's tree planting programs are shown in

Table 5. In an average year, tree planting activities in Ontario generate $12,664,460 in Canadian GDP. GDP refers to the value of all final goods and services produced in a given period. GDP is the most common

[1] Lal, Kishori. 2001. *Evolution of the Canadian Input-Output Tables: 1961 to date*. System of National Accounts Branch. Statistics Canada. Catalogue no. 13F0031MIE2001009.

indicator used to measure the size of an economy, or the size of impact an industry sector has on the broader economy. It is thus universally used as a comparator, both within countries, across countries, and across time periods. When one industry sector's contribution to GDP is estimated, it enables the total output comparisons with other industry sectors, or with the same industry sector in previous years to observe how the sector has grown or shrunk.

Forests Ontario's tree planting programs also generate 103.8 full-time-equivalent jobs throughout the Canadian economy. Full-time-equivalent jobs do not imply that all jobs are full time. They can be full-time, part-time or seasonal. Full-time-equivalent jobs is defined as the total hours worked, divided by the average annual hours worked in a full-time job. One full-time-equivalent job is essentially a reference point for one employed individual working a full time job for an entire year; two people working half the hours of one full-time worker for a full year is equivalent to one annual full-time job; twelve full-time workers on a job for one month is equivalent to one annual full-time job. Given that many of the direct and ancillary employment activities associated with tree planting are seasonal, the 103.8 full-time-equivalent jobs would likely take place in the spring/summer months. For example, if the majority of employment activities occur over four spring/summer months, the 103.8 full-time equivalent jobs could result in as many 311.4 people employed in full-time jobs during peak season. If all who are employed worked half the hours of a full time job, the number of individuals employed during the peak months would double to 622.8 workers.

Table 5 : Annual Income and Employment Impacts

Indicator	Impact
Gross Domestic Product (GDP)	**$12,664,460**
Number of Full-Time Equivalent Jobs	**103.8**

Recall that the figures above account only for planting activities directly catalyzed by the Government of Ontario's 50 Million Tree Program. Additional trees were planted over the same time period that were leveraged by the 50 Million Tree Program but were supported by other programs. The average annual trees planted through other programs is 181,815. These additional activities generate an expenditure stimulus of $564,974 per year. The GDP impact from this stimulus is $994,359, and is associated with 8.1 full-time-equivalent jobs per year.

3 Ecosystem Services from Tree Planting

In addition to jobs and income, tree planting results in numerous ES for the people living near the planted areas. Ecosystem services provided by forests are numerous and include recreation, regulating atmospheric gases, habitat and aesthetic and cultural benefits.

To demonstrate the value of tree planting in Southern Ontario, the benefits derived from a range of services were estimated. The ES values employed in this analysis come from the Spatial Informatics Group (SIG).[2] They were extracted from SIG's Natural Assets database, which contains a large number of valuation studies categorized by value, ecosystem service, land/aquatic type and location. The Natural Assets database was chosen as the source for the ES values as they are applicable to the Ontario context, they are comparable across services, and they have been vetted with experts and are thus defensible. The services included in the database are recreation, aesthetic/amenity, other/general cultural services, pollination and seed dispersal, habitat refugium and biodiversity, atmospheric regulation, soil retention and erosion control, water quality maintenance and nutrient/waste regulation, water supply and regulation, and disturbance avoidance. The values in the database reflect market values (i.e. actual expenditures) and were chosen to avoid double counting. The studies (which are largely peer reviewed studies) from which the values were extracted, focus on temperate areas of North America, Europe and New Zealand, as these represent roughly comparable environmental and socio-economic contexts to Ontario. The ecosystem service values in the database are categorized by landcover types and differentiate between landcovers located in proximity to beneficiaries. The land cover types in the Natural Assets database of relevance to the current study are:

- Forest: non-urban
- Forest: suburban[3]
- Forest: urban[4]

The rationale for the distinction between these forested land covers is that while some services are global (e.g. carbon storage and sequestration), others are only realized when consumers access the ecosystem (e.g. recreation). Using the information in the database, SIG developed a matrix of mean ecosystem service values per hectare per year by service type and land cover category. The mean values for the forested land cover categories were employed in the current assessment. More specifically, the mean ecosystem service values for the forested land cover categories were converted from 2011 Canadian dollars to 2018 Canadian dollars and applied to the area of land for each forest land cover category that has been tree planted as part of Forests Ontario's tree planting efforts. The mean per hectare per year

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[2] Spatial Informatics Group Ltd. 2013. *Estimation of Ecosystem Service Values for Southern Ontario*, report prepared for the Ontario Ministry of Natural Resources.

[3] Designated as areas in or within 5km of a Census dissemination area with a population density greater than 100 people/sq km located within a municipality of 50,000+ people or in a municipality that shares a border with a 50,000+ municipality.

[4] Designated as areas in or within 2km of a Census dissemination area with a population density greater than 386 people/sq km (1000 people/sq. mile) located within a municipality of 50,000+ people. This is based on the US Census definition of an urban area, which includes areas with population density greater than 1000 people/sq mile (386/sq km) located within jurisdictions of 50,000+ (StatsCan uses 400/ sq km).

values for each of the services relevant to the study area by land cover types are presented in Table 6.[5] As can be seen in the table, the SIG Natural Asset database does not contain value estimates for all land cover – ES combinations (see the cells labelled “unknown” below). It must be noted, however, that the lack of a value estimate does not imply the lack of ES value. Rather, the missing values reflect the state of knowledge in this area of study. More specifically, for some land cover – ES combinations, a reliable estimate of the value of services in the Ontario context, that is comparable with other values, is not readily available.

Table 6. Ecosystem Service Values per Hectare (CA$2018) per Year by Forest Type and Service

Service	Non-urban ($/ha)	Suburban ($/ha)	Urban ($/ha)
Aesthetic/amenity	unknown	4,149	4,149
Gas regulation	180	180	180
Habitat refugium/biodiversity	182	unknown	unknown
Nutrient and waste regulation	587	587	587
Other cultural	268	279	279
Pollination and dispersal	1,297[6]	1,297[7]	8,617
Recreation	216	2,026	18,761
Water supply regulation	unknown	1,884	1,884
TOTAL	**1,433**	**9,105**	**34,457**

The per hectare per year values presented in Table 6 were applied to the area of land that has been tree planted according to the forested land cover categories employed by SIG. To do this, the area of land planted was categorized by forested land cover using spatial land cover data from Forests Ontario. Spatial data was available for 2007 to 2017 so the first step was to extend the dataset to encompass tree planting activities undertaken in 2018. While tree planting data (i.e. number of trees and area of land planted) is available for 2018, it was not part of the spatial land cover dataset. To include the area planted in 2018 in the ES assessment, the total area of land planted in 2018 (1,188 hectares) was apportioned across the land cover types (i.e. forest: non-urban, forest: suburban and forest: urban) according to the breakdown in area planted by land cover type from 2007 to 2017 (e.g. between 2007 and 2017, 82% of tree planting occurred in forest: non-urban locations; this same percent was applied to the area of land planted in 2018

[5] Spatial Informatics Group Ltd. 2013. *Estimation of Ecosystem Service Values for Southern Ontario*, report prepared for the Ontario Ministry of Natural Resources.

[6] SIG does not provide a per hectare value for pollination services for non-urban landscape. However, based on a previous study completed by Green Analytics for the Ontario Ministry of Natural Resources (titled Total Economic Value of Wild Pollinators, 2016), we know that the value of pollination services in non-urban settings in Southern Ontario is significant. Thus, a per hectare value for pollination for forested land covers was obtained from the literature (David Suzuki Foundation, 2008, Ontario’s Wealth, Canada’s Future: Appreciating the Value of the Greenbelt’s Ecosystems), inflated to $2018 dollars, and assigned to this land type for the purposes of the current study.

[7] SIG does not provide a per hectare value for pollination services for suburban landscape. However, based on a previous study completed by Green Analytics for the Ontario Ministry of Natural Resources (titled Total Economic Value of Wild Pollinators, 2016), we know that the value of pollination services in non-urban settings in Southern Ontario is significant. Thus, a per hectare value for pollination for forested land covers was obtained from the literature (David Suzuki Foundation, 2008, Ontario’s Wealth, Canada’s Future: Appreciating the Value of the Greenbelt’s Ecosystems), inflated to $2018 dollars, and assigned to this land type for the purposes of the current study.

to derive a total value for tree planting in forest: non-urban areas from 2007 to 2018). Table 7 presents the area of land tree planted by forest category for 2007 to 2018.

Table 7. Area (ha) of Land Planted by Forest Category (2007 to 2018)

Category	Area (hectare)
Forest: Non-urban	12,288
Forest: Suburban	1,697
Forest: Urban	914
TOTAL	**14,899**

For each ES for which value estimates are provided, the area figures shown in Table 7 were multiplied by the appropriate per hectare per year ES value (Table 6) to derive an estimate of the annual value of services provided by Forests Ontario's tree planting activities. Each of the services and their estimated values are described and presented below. Note that given the age of the trees that have been planted (at most 11 years old), some of the services described below may not yet be fully realized. This would be the case for services that increase as trees mature (e.g. carbon storage) but not for trees that provide benefits immediately upon planting (e.g. aesthetic appreciation).

3.1 Aesthetic/Amenity Value

Aesthetic value refers to the benefit people obtain from the aesthetic appreciation of natural and cultivated landscapes. Numerous studies show that properties adjacent to, or near natural areas command higher selling or rental prices.[8] The value of aesthetic appreciation is location-specific and depends not only on the aesthetic quality of an area, but also on the local real estate market. A study by DSS Management Consultants found that natural features in Mississauga increased individual property values by 2.4% to 3.6% of the average property value.[9] Tree planting results in aesthetic/amenity value because people have an appreciation for natural landscape. An estimate of the aesthetic/amenity value realized from tree planting in Southern Ontario can be derived by applying the per hectare values for aesthetic/amenity services from SIG to the respective areas of forested land (i.e. 1,697 ha of forest: suburban and 914 ha of forest: urban) that have been tree planted. Doing so yields a total value for aesthetic appreciation of $10,833,756 per year.

3.2 Gas Regulation

The forested areas created by tree planting in Southern Ontario play a role in regulating atmospheric gases and providing clear air. Specifically, trees regulate gases and improve air quality by collecting particulate matter on the surface area of leaves and absorbing gaseous pollutants into leaves. Trees remove many pollutants from the atmosphere, including nitrogen dioxide, sulfur dioxide, ozone, carbon monoxide and

[8] Luke M. Brander and Mark J. Koetse, "The Value of Urban Open Space: Meta-Analyses of Contingent Valuation and Hedonic Pricing Results," *Journal of Environmental Management* 92, no. 10 (October 2011): 2763–73, https://doi.org/10.1016/j.jenvman.2011.06.019.

[9] DSS Management Consultants Inc., "The Credit Watershed: Social, Economic and Environmental Services Provided to the Watershed Community. The Impact of Natural Features on Property Values," 2009.

particulate matter of ten microns or less. Improved air quality results in significant benefits to the surrounding population as fewer visits to the hospital for respiratory and other illnesses are realized.[10]

Forests also play an important role in mitigating climate change through the sequestration and storage of carbon dioxide and other greenhouse gases. Tree age affects the ability to store and sequester carbon. Older trees store more total carbon in their wood and younger trees sequester more carbon annually. To estimate the benefit of carbon sequestration from forests in Ontario, SIG employed an average sequestration rate per hectare of North American forests of 1.4 tons per year.[11] This, combined with a social cost of carbon, can be used to estimate the value of carbon sequestration from tree planting in Southern Ontario. Applying the per hectare values for gas regulation from SIG to the respective areas of forested land (i.e. 12,288 ha of forest: non-urban, 1,697 ha of forest: suburban and 914 ha of forest: urban) that have been tree planted yields a value of $2,681,782 per year.

3.3 Habitat refugium/biodiversity

Trees can increase habitat opportunities for birds and mammals. Improvements in the availability of nest sites or food resources means larger populations of species throughout the food chain. At a landscape scale, increasing treed areas has the potential to improve connectivity between habitat patches allowing for the movement of species across the land. An estimate of the habitat refugium value realized from tree planting in Southern Ontario can be derived by applying the per hectare values for habitat refugium services from SIG to the respective areas of forested land (i.e. 12,288 ha of forest: non-urban) that have been tree planted. Doing so yields a value of $2,236,346 per year.

3.4 Nutrient and Waste Regulation

Forests provide filtering services by absorbing nutrients such as nitrogen and phosphorus that run off farmlands due to the use of fertilizers and manure, and from livestock. They also absorb pollutants from roads and other surfaces in urban and suburban areas. Applying the per hectare values for nutrient and waste regulation from SIG to the respective areas of forested land (i.e. 12,288 ha of forest: non-urban, 1,697 ha of forest: suburban and 914 ha of forest: urban) that have been tree planted yields a value of $8,745,589 per year.

3.5 Other Cultural

Natural areas can deliver cultural benefits by providing information and opportunities to conduct science, education and research. To value such services, researchers have used an estimate of the social value of research. One estimate measures this proxy value as $12,000 per article per year,[12] measured by achievement of knowledge that leads to additional economic growth.[13] An estimate of the value of other cultural services realized from tree planting in Southern Ontario can be derived by applying the per hectare values for other cultural services from SIG to the respective areas of forested land (i.e. 12,288 ha

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[10] David J. Nowak, Satoshi Hirabayashi, Allison Bodine, Eric Greenfield. 2015. "Tree and forest effects on air quality and human health in the United States," *Environmental Pollution* 193 (119-129).

[11] Spatial Informatics Group Ltd. 2013. *Estimation of Ecosystem Service Values for Southern Ontario*, report prepared for the Ontario Ministry of Natural Resources.

[12] Note this value is reported in USD currency for the year 2000.

[13] Loomis, J. & Richardson, R. 2000. *Economic Values of Protecting Roadless Areas in the United States*. Washington, DC: The Wilderness Society and Heritage Forests Campaign.

of forest: non-urban, 1,697 ha of forest: suburban and 914 ha of forest: urban) that have been tree planted. Doing so yields a value of $4,021,598 per year.

3.6 Pollination and dispersal

Pollination provided by wild pollinators and their supporting habitat is an essential service needed for plant cultivation. Without this service, many crops would simply not grow or otherwise be dependent on other forms of pollination, resulting in reduced agricultural outputs. An estimate of the pollination value realized from tree planting in Southern Ontario can be derived by applying the per hectare value for pollination services from forests from SIG for urban land types and from the literature for suburban and non-urban land types[14] to the respective areas of forested land (i.e. 12,288 ha of forest: non-urban, 1,697 ha of forest: suburban and 914 ha of forest: urban) that have been tree planted. Doing so yields a value of $26,018,191 per year.

3.7 Recreation

Forested areas provide recreation opportunities to local residents including hiking, walking, running, biking and birdwatching. In fact, nature recreation is one of the most tangible ways in which people directly derive benefit from green spaces. Applying the per hectare values for recreation from SIG to the respective areas of forested land (i.e. 12,288 ha of forest: non-urban, 1,697 ha of forest: suburban and 914 ha of forest: urban) that have been tree planted yields a value of $23,237,744 per year.

3.8 Water Supply Regulation

Trees work with soil to absorb and intercept water on leaves, branches and trunks. Some of the intercepted water evaporates back into the atmosphere and some soaks into the ground reducing the total amount of runoff resulting from a rain event. An estimate of the water supply regulation value realized from tree planting in Southern Ontario can be derived by applying the per hectare values for water supply regulation services from SIG to the respective areas of forested land (i.e. 1,697 ha of forest: suburban and 914 ha of forest: urban) that have been tree planted. Doing so yields a value of $4,919,450 per year.

3.9 Summary of Ecosystem Service Values

Table 8 summarizes the ES values presented above. Value estimates are presented by service type and by forest type. The benefits derived from tree planting in Southern Ontario are estimated to be worth more than $80 million annually. Significant value is derived from pollination and dispersal and recreation. Other services contributing high value include aesthetic/amenity benefits and nutrient and waste regulation.

[14] David Suzuki Foundation, 2008, Ontario's Wealth, Canada's Future: Appreciating the Value of the Greenbelt's Eco-system Services (https://davidsuzuki.org/wp-content/uploads/2018/02/ontario-wealth-canada-future-value-greenbelt-eco-services.pdf).

Table 8. Summary of Annual Ecosystem Service Values from Tree Planting in Southern Ontario

Service	Non-urban	Suburban	Urban	TOTAL
Aesthetic/amenity	unknown	$7,042,167	$3,791,589	**$10,833,756**
Gas regulation	$2,211,771	$305,517	$164,494	**$2,681,782**
Habitat refugium/biodiversity	$2,236,346	unknown	unknown	**$2,236,346**
Nutrient and waste regulation	$7,212,831	$996,325	$536,434	**$8,745,589**
Other cultural	$3,293,081	$473,551	$254,966	**$4,021,598**
Pollination and dispersal	$15,941,462	$2,202,031	$7,874,698	**$26,018,191**
Recreation	$2,654,125	$3,438,764	$17,144,855	**$23,237,744**
Water supply regulation	unknown	$3,197,745	$1,721,705	**$4,919,450**
TOTAL	**$33,549,616**	**$17,656,099**	**$31,488,741**	**$82,694,456**

The figures above demonstrate the significant value of ES derived from tree planting across the land types. Recreation opportunities are significant in urban settings where people have access to and can easily benefit from the areas where tree planting has occurred. In suburban settings, aesthetic/amenity values are significant and contribute substantially to the value derived from trees planted in such locations. In non-urban (rural) locations, the majority of the value is derived from pollination and dispersal. The service value derived from urban locations is a product of proximity to people. The closer people are to where tree planting takes place, the more they are able to derive value from it (especially in the form of recreational opportunities). This does not imply that tree planting in one location is more valuable than in another, just that the services derived from one location differ from those derived from another. Furthermore, it is important to note that in the case of some services, such as water supply regulation, the entire watershed contributes to the provision of the service, which is then realized (or consumed) in locations where people live. In this way, trees planted in non-urban settings are contributing to a service that is derived in urban settings. The value of ES realized from the different land types (i.e. urban versus suburban versus non-urban) should thus not be used as justification to pursue tree planting activities on one land type over another. To use these results in such a way would require taking into consideration the value of the land on which the planting will take place. This study is focused only on the value of the ES derived from different land types without consideration for the opportunity cost (i.e. the value of the land in its next best use) of those lands. The opportunity cost of planting in an urban location is going to be much higher than the opportunity cost of planting in a suburban or non-urban location. A benefit cost ratio of the value of the services to the opportunity cost of the land would demonstrate significant net gains from planting in non-urban locations. Such a metric would be required to help inform decisions related to where tree planting should take place.

The per hectare values employed in this analysis are conservative estimates derived by SIG. Due to the fact that the trees planted through the 50 Million Tree Program are at most 11 years old (i.e. the program started in 2007), the areas planted do not yet represent mature forests. The use of conservative estimates thus seems appropriate. That said, it should be noted that some of the value from the trees will not be realized until the trees have matured while other services will be realized at or soon after the time of planting. Carbon storage, for example, increases with tree age. At the same time, it is worth noting that the value derived from the planted trees has increased over time, as more trees have been planted, and it will continue to do so as the trees mature and the goal of 50 million trees is achieved. The amount of land that has been planted has increased by 70% since 2007. The Ontario government is almost half way to reaching its goal of 50 million trees planted. As more trees are planted and the planted trees mature, the value of the services derived from the forests will continue to grow at an increasing rate.

The value estimates presented here do not account for all of the benefits derived from tree planting. The lack of an estimate for some land cover – ES combinations, does not mean that no value is derived from that service, but rather that a defensible estimate of the value is not readily available for this study. The value of ES derived from non-urban tree planting activities, in particular, are underestimated in this study due to lack of estimates for the contribution of tree planting in non-urban settings to aesthetic appreciation and water supply regulation. Furthermore, the estimates above capture only market values; non-market values are not included. For some services, non-market values can be significant (e.g. the value derived from knowing that biodiversity exists even if it is never utilized or experienced (commonly referred to as existence value)). As well, while physical and mental health benefits resulting from time spent in nature are not typically included in ES valuation studies, they are increasingly recognized as significant in the literature. Research shows that green/blue space contact is associated with higher health perception, lower blood pressure and reduced rates of cardiovascular disease, asthma and respiratory illness.[15,16,17] Studies also document the physical benefits of stress reduction attributed to nature contact, such as reduced headaches and increased energy levels.[18] Numerous studies have also shown that accessing nature increases physical activity in a population.[19,20, 21]

With respect to mental health benefits, Maller, a leading authority on the health benefits of nature, contends that increasing access and exposure to green/blue space and natural areas may be the most effective population wide strategy for promoting mental health.[22] Maller's recommendation reflects over 30 years of research demonstrating that contact with nature reduces stress and increases sense of personal wellbeing.[23] Empirical studies have shown that being in nature reduces cortisol levels and blood pressure.[24,25] While explanatory pathways are not well understood, studies consistently find that people

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feel better in nature. Indeed, contact with nature is positively associated with increased self-esteem, higher life satisfaction, cognitive function and better job performance.[26,27,28,29]

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4 Conclusion

This report presents the results of an assessment of the value of Forests Ontario's tree planting activities through the 50 Million Tree Program in Southern Ontario. Tree planting benefits the people of Ontario in numerous ways. People are employed to prepare planting sites, plant the seedlings and undertake follow-up visits to increase survival rates. People are also employed further up the supply chain in activities related to seed forecasting, seed collection and tree nurseries. In addition to this, various ancillary economic activities are also supported, such as staff training, education programs, management activities and other professional services necessary to the tree planting industry. Tree planting leads to economic gains as nurseries, landowners and CAs engage in tree planting activities. Tree planting also provides ecosystem services, including recreation opportunities, pollination and dispersal, carbon sequestration and storage and water and air filtration to surrounding residents and municipalities.

Between 2008 and 2018, over 24 million trees were planted through the Government of Ontario's 50 Million Tree Program in Southern Ontario covering an area of almost 15,000 hectares. On average, 2.316 million trees were planted annually between 2009 and 2018 at an average cost of $2.81 per tree. This is in addition to expenditure of $0.30 per tree by Forests Ontario for ancillary activities such as marketing and communications. The result is a total direct spending stimulus of $7.2 million per year. The GDP impact of tree planting in Southern Ontario is thus estimated to be over $12.7 million annually. This equates to $5.49 in GDP for every tree planted, which, at a cost of $1.80 per tree from Forests Ontario, is a 305% return on investment. The number of full-time-equivalent jobs generated from Forests Ontario's tree planting efforts in Southern Ontario is 103.8. This does not include trees planted over the same time period that were leveraged by the 50 Million Tree Program but were supported by other programs. The average annual trees planted through other programs is 181,815. These additional activities generate an expenditure stimulus of $564,974 per year. This generates $994,359 in annual GDP and 8.1 full-time-equivalent jobs per year.

The value of ES derived from the trees planted through Forest Ontario's efforts totals $82.7 million annually with significant benefits derived from pollination and dispersal, recreation opportunities, aesthetic/amenity benefits and nutrient and waste regulation. For every $1.80 that Forests Ontario spends to support tree planting, no less than $19.85 in ES value is derived. The ES value of planted trees can also be put into the context of full-time-equivalent jobs. In this case, every full-time-equivalent job is associated with $796,671 in ES benefits. The value of the services derived from tree planting has increased over time and will continue to do so as the trees mature and the goal of planting 50 million trees in Ontario draws nearer. Some benefits derived from tree planting, such as the existence value for biodiversity and the mental and physical health benefits of spending time in nature, are not captured in the above estimate.

5 Appendix A: Framework for Conducting the Economic Impact Assessment

Economic impact analyses represent conditional predictive assessment models that provide quantitative estimates of economic phenomenon.[30] They are predictive in that they forecast direct and indirect effects on the economy from stimulus imputed into the model by the researcher, and conditional in that they hinge on certain theoretical assumptions. These types of studies produce statements of the form: "if, under assumption *a*, *b*, and *c*, a stimulus *x* is applied to the local economy, then impacts *y* and *z* are likely to result."[31] The sections below outline the structure, data and components of the analysis, while the modelling specifications are presented in Appendix B.

5.1 Direct and Indirect Impacts

Due to the interconnectedness of markets, a stimulus or disruption to one industry sector will affect other sectors directly linked to it. Following this reasoning, through a complex network of linkages, industries that are indirectly linked to the affected sector will also be affected. Sectors are directly linked if an economic transaction occurs between them, for example, a purchase or sale. When an industry manufactures a good, it must purchase its inputs from other firms, whom concurrently sell their outputs to the purchasing sector. An indirect linkage occurs when sectors are reliant on each other, but not directly. For example, if sector *A* purchases from *B*, and *B* purchases from *C*, it is said that *A* and *C* are indirectly linked. In this hypothetical three-sector economy, if sector *C* undergoes an output disruption, sector *B* will experience an impact to its production process, which will create an economic ripple effect to the production of sector *A*.

5.2 Input-Output Analysis

We utilize input-output (I-O) models to calculate provincial economic impacts. I-O models are inter-industry impact models that capture economy-wide output effects from a shock to any one sector. These models link all industries into a complex network of sales and purchase linkages, allowing both indirect and direct effects to be captured from exogenous changes in final demand. The information of sectoral linkages is contained within a symmetric matrix that accounts for inputs and outputs of all industries.

The I-O approach is based on the idea that most industries of an economy are interconnected—either directly through transactions, or indirectly through competition for labour, capital, and land in the production process. By accounting for the economy-wide effects, as opposed to the effects of only the directly affected sector, a more complete picture of economic impacts is made available. No matter the initial disturbance (negative impact) or stimulus (positive impact), industries realign their inputs and outputs interdependently to adjust to new economic equilibrium.

Static I-O models ignore issues of productivity and resource allocation, and are entirely demand driven. Fixed proportion technology precludes substitution possibilities in production, consumption, exports, and

[30] Davis, H. Craig. 1990. Regional Economic Impact Analysis and Project Evaluation. Vancouver, BC: University of British Columbia Press.
[31] Davis, H. Craig. 1990. Regional Economic Impact Analysis and Project Evaluation. Vancouver, BC: University of British Columbia Press.

imports. Finally, shifts in factor input prices fail to act as market signals that can induce behavioural responses in economic agents. I-O modelling is relatively cheap and effective, with the capacity to yield powerful and informative results. It is for this reason that it has become one of the chief approaches in the arsenal of regional analytic tools over the past four decades.[32] I-O modelling specifications are included in Appendix B.

5.3 Input-Output Multipliers

I-O models capture industrial interdependencies within an economy. An impact to one economic sector generates a series of ripple effects that induce a long chain of inter-industry interactions. This closed-loop effect continues until the economy returns to equilibrium[33]. In an open I-O model, two effects are derived from these spending rounds: direct impacts and indirect impacts. The calculation of these two effects produces Type I multipliers. In the closed I-O model, an additional effect is also calculated: induced impacts. The calculation of direct, indirect and induced effects produces Type II multipliers.

Direct effects are those associated with the initial industry expanding output to meet the new demand, or contracting output to account for the new economic disruption. This initial industry must purchase its factor inputs from other sectors in order to manufacture its commodity—for example, automobile producers must first purchase steel. Indirect effects are those associated with the "other" sectors: as they expand or contract output to meet the requirements of the principal industry's demand, they must too purchase inputs from other sectors. This chain of interactions continues until infinity.[34] For example, if the automobile sector contracted output, it would purchase less steel from the steel manufacturer, whom in turn would purchase less iron ore to account for the decreased steel production, and so on.

Induced effects are calculated when the household sector is incorporated into the model. This process is referred to as endogenizing the model in respect to households, and involves linking household sales (in the form of labour) and household purchases (in the form of consumer activity) to the inter-industry system. This effectively allows the household sector to behave like an industry sector, partaking in both selling (labour) and purchasing (consumption). Returning to the simplified example of an automotive industry, if output is reduced, steel consumption will also be reduced; this will result in both sectors decreasing output, and decreasing their input of labour into manufacturing. In effect, the household sector will receive less wage and salary income, and spend less in the economy on consumer goods. This is the essence of the induced economic effect.

These Type I and II output effects are yielded in the form of output multipliers. An output multiplier denotes the increase or decrease in sector *A*'s output, from a final demand disruption or stimulus to sector *C*. For example, if *C*'s output increased by $1,000, an output multiplier of 1.27 for *A* would mean *A*'s output would increase by $1,270.

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[32] ten Raa, Thijs. 2005. The Economics of Input-Output Analysis. New York, NY: Cambridge University Press.
[33] Schaffer, William. 1999. "Regional Impact Models." Ed. Scott Loveridge. The Web Book of Regional Science. Morgantown, WV: Regional Research Institute, West Virginia University. Accessed 10 Feb. 2009. <http://www.rri.wvu.edu/regscweb.htm>
[34] United Nations. 1999. Handbook of Input-Output Table Compilation and Analysis, Studies in Methods, Series F, No. 74. New York: United Nations.

In addition to output multipliers, the I-O model can also calculate income multipliers, namely: industry GDP, labour income, returns to capital, and taxes collected by government. Extending the existing example, a GDP multiplier of 1.67 from a $1,000 demand stimulus to industry *C* would mean GDP increases by $1,670. The table below outlines the types of economic impacts the I-O system calculates, according to category.

Overview of the types of Input-Output model results

Output Effects	**Income Effects**
• Direct impacts • Indirect impacts • Induced impacts	• Industry GDP • Labour income • Returns to capital • Taxes collected by government

5.4 Data

The I-O models are constructed using information from Statistics Canada's 2014 Ontario input-output tables. All values in the published tables are in 2014 Canadian dollars, at modified basic price. Statistics Canada's input-output accounts are published in a series of three data tables: the supply table, the use table, and the final demand table. Updated tables are published annually, but because of the volume of information involved, yearly publications are lagged by 28 months from the reference year.[35]

The supply and use tables are commodity-by-industry tables, and the final demand table is a commodity-by-final-demand table. Due to the immense number of Canadian industries producing diverse arrays of goods and services, both industries and commodities are agglomerated into groups for the purpose of organization. Similarly, final demand is aggregated into categories.

All tables, irrespective of aggregation levels, contain more commodities than either industries or final demand categories. The rationale for the rectangular commodity-by-industry I-O format is because real-world industry sectors—classified groupings of firms—consume and produce numerous inputs and outputs. This asymmetric format allows industries to produce more than one commodity as output, and purchase more than one commodity as input.

[35] Lal, Kishori. 2000. Evolution of the Canadian Input-Output Tables, 1961 to Date. Ottawa, ON: Statistics Canada System of National Accounts. Accessed 20 March. 2011. <http://www.statcan.gc.ca/pub/13-598-x/2006001/pdf/4220292-eng.pdf>

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