COMMUNITY TREE PLANTING: EARLY SURVIVAL AND CARBON SEQUESTERING POTENTIAL

by David W. Ip

Abstract. Canada's national tree planting program, Tree Plan Canada, recently underwent a major change. In 1995, funding ended for tree planting projects by small groups and local organizations. This paper summarizes the Northwest Region's planting of 8.5 million trees in 347 projects. After 1 to 3 years, 74% of the trees per project were in healthy condition. The program involved 93,000 people directly in new tree planting activities. The maximum potential for sequestering carbon with this program was estimated to be 4000 tonnes per year.

In 1992, the United Nations Conference on Environment and Development examined environmental issues of international concern, including the threat of global warming and potential climate change. This conference catalyzed the Canadian government to unite many of its environmental activities and new initiatives under one umbrella program, Canada's Green Plan. One of the goals of the Green Plan was to stabilize national emissions of carbon dioxide and other greenhouse gases at 1990 levels by the year 2000 (2).

The Green Plan provided a home for a nationwide community tree planting initiative that came to be called Tree Plan Canada (TPC). Created in response to widespread concerns about the threat of climate change, the TPC program took on the following goals 1) to educate Canadians on the role of trees in the environment; 2) to provide the opportunity for ordinary citizens to take direct action to address these environmental concerns; and 3) to take concrete action to counter the potential effects of global warming.

To this end, the major objective of TPC was to directly assist in the planting of 170 million trees across Canada and to encourage the planting of another 90 million (8). The program was restricted to nonprofit projects without a legal obligation to reforest. It was hoped that the tree planting inspired by this program would reduce by 1% Canada's emissions of atmospheric CO_2 by the year 2000, thereby contributing to the reduction of 15% from the 1990 CO_2 emission levels.

The program was delivered jointly by the Canadian Forest Service and the Tree Canada Foundation (formerly the National Community Tree Foundation), a private foundation established by the Canadian Forest Service to operate at arm's length from the government.

Tree Plan Canada representatives promoted the program in each province, contacted potential partners, provided technical advice, and submitted applications to the Foundation for approval. Foundation approval depended upon the quality of the application and availability of funds. Upon financial approval, partners agreed to be responsible for the planted trees and to report details of completion, including actual number of trees planted, costs, and value of all inputs.

Partners were advised to have an arborist, landscaper, forestry technician, or other tree professional involved. While most partners complied, over 80% of participants would be considered amateurs, and thus, they were learning about trees through their involvement in TPC.

The program was divided into 6 components, each with a tree-planting target. Each component identified a type of project that would be sponsored or coordinated through the TPC program.

Regional Partners: support small organizations and local projects; target 50 million trees.

National Partners: support national organizations that do tree planting or environmental activities; target 40 million trees.

Green Streets Canada: award grants by competition to municipalities for urban forestry projects; funding skewed for large trees; target 0.5 million trees.

Marketing/sponsorship: solicit corporate sponsorship for tree planting; donations to be awarded to candidate partners; target 56 million trees.

Education: distribute seed kits to forestry associations, schools, public education groups, and fundraising groups; target 9.5 million trees.

Provincial governments: seek donations from provincial government tree nurseries; target 15 million trees.

Success of the program was to be measured in both direct and indirect tree planting. Direct planting comprised trees planted through TPC-sponsored and coordinated projects in which all costs, values, and numbers of trees were recorded in a national database. Indirect planting comprised estimates of trees planted in response to TPC advertising, but not recorded by TPC or otherwise reported. In its first 3 years, TPC contributed to the direct planting of 44.2 million trees (9), of which an estimated 62% were planted through the Regional Partners component. The Regional Partner component, which was the most successful in numbers of trees planted, value of projects, publicity, and public involvement, ended in 1995. At that time, the Northwest Region (Alberta, Saskatchewan, Manitoba, and Northwest Territories) assessed tree survival in its Regional Partner projects. This paper summarizes program achievements in this region and reports estimates of early survival and potential for carbon sequestration. All financial values are in Canadian dollars; all measurements are in Système Internationale (SI) metric units.

Methods

A total of 347 Regional Partner projects in the Northwest Region were approved by the Tree Canada Foundation. Numbers of trees, costs, people, and value of work were tracked by program coordinators in a FoxPro database called TRee Information System (TRIS) (7). Data summaries were used to tally the numbers of projects, value, funds provided, and trees planted. This report summarizes project value by program funding (funds contributed by TPC), and total project value (TPC funds, cash contributed by partners, and value of volunteer labor and donations, estimated at minimum wage levels or industry standards for professional contributions). The latter example includes consultants, machinery, advertising, etc. The difference between the program funding and total project value was considered leveraged value.

The projects were subdivided into 2 groups: noncommercial, nonindustrial forest land projects, which accounted for 63% of all trees planted, and urban, rural, or agricultural community projects comprising 37% of all trees. Twelve forest land projects and 80 urban/rural ones (27% of all projects) were selected for evaluation using a random number generator. These projects were to be visited between June and September 1995.

TPC records detailed the location of the plantings, the numbers, sizes and species of trees planted, and problems noted at time of planting. In some cases, problems with maintenance were also known. Project partners were asked to accompany the assessor and to provide background information on causes of poor health or mortality.

The method of survey sampling was site dependent, but always followed several parameters (Table 1). The basic criterion of random or total sampling in each case was paramount (6). At least 30 of each species and size of tree had to be sampled.

Occasionally, heavy competition impeded discovery of all trees. In this case, every tree, living or dead, that could be located was tallied; the number of trees located represented the sample proportion of the total planted. It was assumed that unlocated trees had the same proportion of living to dead as the located trees unless there was evidence to the contrary, e.g., snowmobile trails. Trees were evaluated as healthy, unhealthy (likely to die within 1 year), dead, or missing. Health was assessed according to 6 factors: foliage size and form, shoot length and form, foliage color, total foliage and density, apical bud health, and stem form. A tree rated poor on at least 3 factors was called unhealthy.

Program partners were also required to report on their projects, including comments on awareness and benefits to the community. The information, much of which was general or anecdotal, was

Table 1. Details of assessment surveys.

Project size (No. of trees)	Examples of project types	Sampling method
< 100	Residential plantings; Small property beautification	100% of trees planted or all trees located
100–1000	Shelterbelts; Nursery care plots	Stratified sample plots
> 1000	Industrial-type forest land plantings	Stratified sample plots

adapted to TRIS parameters. The percentage of responses to these reports and a survey of media outlets were used to assess the success of the program in promoting awareness of the role of trees in climate and environmental benefits.

Freedman and Keith (5) estimated carbon sequestration potential using provincial yield tables for volume or biomass and unspecified carbon conversion models. They listed estimates by "good, medium, and poor" site types without qualification. However, growth estimates and their derivatives (MAI, volume per ha, etc.) were not standardized among provinces. Furthermore, the precision of Freedman and Keith's (5) estimates varies with the data available to them. For example, some species are summarized by provincial management unit, and others by the entire province.

Tree Plan Canada records do not include site type. Growth estimates used in this report are based on Freedman and Keith's "good" sites, thus representing maximum possible accumulations, and are likely to be over-optimistic. The average annual carbon per tree was calculated from total mature tree carbon, by species and location, and then multiplied by the number of trees estimated to survive past the first 1 to 3 years.

Results and Discussion

With a land surface area of 5 million km^2, the Northwest Region (NWR) constitutes more than half of Canada's land base and has the largest area of land capable of supporting tree growth. With only 4 million people, it is also the most sparsely populated region, offering unique challenges for communication and program delivery.

Project establishment and funding. Over the 4-year program, the NWR received 539 applications, of which the Foundation approved 347 projects with a total value of $10.9 million (Tables 2 and 3). Actual cost to the program was $2.8 million. Thus, the average ratio of additional value leveraged to funds provided was 2.9:1. The average funding per project was $8166, with 80% of the projects receiving less than $10,000 each.

Trees planted. The cost of planting in the NWR was $0.33 per tree, 9% less than budgeted ($0.36 per tree) (Table 3), and well below the national average for the TPC program of $0.42 (unpublished data). Project partners were often able to raise support for planting from sources other than TPC. For example, Indian bands, which planted over half of the TPC trees in this region, were also funded by federal lands forestry programs.

Table 4 reflects how costs increase exponentially with the size of tree planted. While a major thrust of the program was to get large numbers of

Table 2. Tree Plan Canada projects by sponsorship level and planting organization in the Northwest Region.

Type of organization	No. of projects by Tree Plan Canada dollars (in thousands of dollars)					
	< $1	$1–10	$10–50	$50–100	> $100	Total
Municipalities	28	59	12			99
Nongov. environ. orgs.	14	57	17			88
Service clubs, etc.	13	18	5			36
Corporations	8	10	2	1		21
Indian bands and Metis settlements	5	14	17	3	3	42
Schools/ youth grps.	5	14	1			20
Other	20	11	10			41
Total	*93*	*183*	*64*	*4*	*3*	*347*

Table 3. Planned versus actual planting and funding by type of organization.

Type of organization	No. of projs.	No. of trees planted	No. of trees actually planted	Cost per tree ($)[1] planned	actual	Total project value ($)
Municipalities	99	540911	624720	0.88	0.73	2050615
Nongov. environ. orgs.	88	2142151	1827415	0.33	0.37	2675287
Service clubs/ comm. orgs	36	387442	362039	0.67	0.68	983857
Corporations	21	276249	266048	0.47	0.27	311247
Indian bands and Metis settlements	42	4449366	4719311	0.27	0.23	2885495
Schools/ youth grps.	20	14068	31569	4.51	1.94	307014
Other	41	727917	700570	0.35	0.35	1712140
Total	*347*	*8538104*	*8531672*	*0.36*	*0.33*	*10925655*

[1]TPC program contribution, excluding value of partner contribution.

Table 4. Proportions of material planted and associated costs.

Material planted	Percentage of total plantings	Percentage of total costs
Tree seedlings	77	48
Shrub seedlings	16.5	29
Whips and saplings	6	29
Caliper trees	0.5	23

trees planted, many participants were only interested in planting larger trees and shrubs. Approximately 19% of the plants were shrubs and small fruit or ornamental trees. This component was introduced in recognition of some partners having goals for which optimal growth was not the main objective, such as aesthetics, soil stabilization, wildlife habitat, or education.

The 305 small-to-medium urban, rural, and agricultural projects accounted for 37% of all the planted trees. The 42 forest land projects accounted for 63% of all the trees that were planted in typical forestry settings, i.e., thousands of trees per ha.

Survival survey. Eighty-six of the 92 selected projects were actually visited. Results are presented on a per project basis. The average incidence of trees in healthy condition was 74%, with another 11% unhealthy (expected to die within a year).

In urban and rural projects, 77% of the planted trees were in healthy condition at the time of the survey (Table 5) with S.E. of estimates = 18%. Approximately 11% were dead and the remaining 12% unhealthy. Analysis of variance indicated that health of the trees did not vary significantly ($p = .09$) with age.

In forest land projects, only 52% were in healthy condition (Table 5). A very high standard error of 39% indicates great uncertainty as to the true level of survival among projects. The skewness of the sample is evident in that the total trees (as opposed to the number of trees per project) in healthy condition on forest land projects was 67%. This difference between average project survival and total tree survival is partly due to the project sizes ranging from 20,000 to 367,000 trees, averaging 94,000 trees per project. Further, 3 projects

Table 5. Tree condition in urban, rural, and agricultural community projects by number of years since planting (sample = 1.2% of trees planted) and in forest land projects (sample = 0.4%).

Type and age of planting	# of projects inspected	Tree condition (%)			Range of survival (%)
		healthy	unhealthy	dead	
Urban/rural/ agricultural					
1 year old	13	78	12	10	42–94
2 years old	40	74	13	13	38–93
3 years old	22	82	10	8	42–96
Forest land					
All ages	11	52	7	41	<1–90
All plantings		*74*	*11*	*15*	

(20,000 to 35,000 trees) were complete failures. In each of these projects, trees were planted without proper planning, appropriate maintenance, or protection from damage. In contrast, in the projects with trained supervisors and planners involved, survival was always greater than 50%.

This survey revealed an interesting aspect of tree size. Damage to seedlings by mowers and other equipment, snowmobiles, and pedestrians was a factor in half of the urban and rural projects for which cause of death and damage was known. On at least 2 such projects, this type of damage contributed to the loss of 20,000 and 22,500 seedlings. This outcome has led many groups to decline to plant seedlings, even when free.

Public awareness. An estimated 93,000 people were involved in the 347 projects in the region, with group sizes ranging from 1 to 12,000 participants. At least 48,000 people received seedlings at giveaways and displays. Thus, the average number of people per project, excluding major seedling giveaways, was estimated to be 108. The actual number of people who learned about TPC through project participation was lower because many people participated more than once. About 7200 participants were children in schools, which addressed a major target group of the program's educational component.

Unknown numbers of people were informed through the media. Fifteen percent of partners reported public media coverage, excluding newsletters. A separate survey based on news clipping services of approximately 250 local and regional newspapers revealed that at least 16%

of projects were reported with reference to TPC. By comparison, 100% of the 25 municipalities funded under the Green Streets Canada component received media coverage (Ip: Unpublished data).

It is unclear how many people actually understood the TPC objectives or how they related to the activity at hand. The TPC program was commended for assisting in the planting of trees and increasing the number or sizes of trees that partners could plant (24% of respondents) (Table 6). Many partners also noted the improvements in aesthetics or beautification (13%), or awareness of environmental benefits such as wind protection and erosion control (23%). However, no respondent stated an increased awareness of the role of trees in climate change.

Potential for carbon sequestering. The TPC program had a goal of planting enough trees to sequester 5.2 million tonnes of CO_2 in 10 years, an average of 0.8 kg per tree per year (8). Given the rates of carbon accumulation of trees, as typified by Freedman and Keith's Alberta estimates (Figure 1), this was an unrealistic goal. Carbon accumulation rates are extremely low in young trees but increase with age and size, following a general J-shape curve (Figure 1). For example,

Table 6. Summary of most frequent comments received from Regional Partners upon completion of their projects (total respondents = 253).

Comment	Percentage of respondents
Project would not have started or scope would have been much less w/o TPC	24
Learned environmental benefits and/or about planting and tree care	23
Beautification or aesthetics recognized	13
Technical support appreciated	9
Problems	
Technical preparation or planting problematic	10
Unavoidable problems, e.g., weather, stock availability	7
Application procedure or funding concerns	6
Technical advice lacking	1

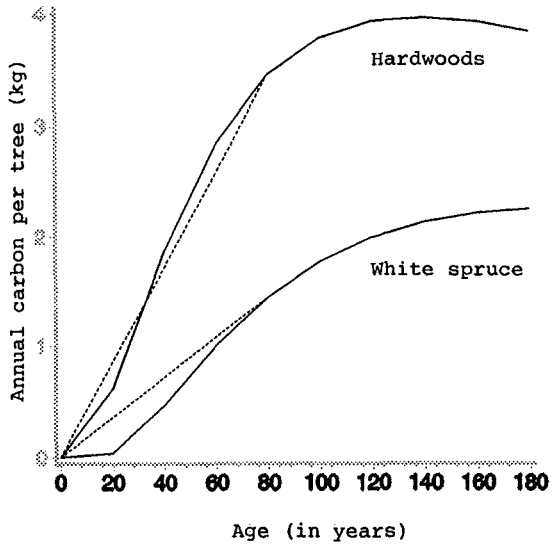

Figure 1. Rate of carbon accumulation per tree per year on "good" Alberta sites [after Freedman and Keith (5)]. Dashed line shows interpolated average accumulation at 80 years. Note the difference relative to actual accumulation in early years.

the carbon gain of white spruce was approximately 0.04 kg per year for 20-year-old trees but 1.46 kg at 80 years (5). The difference between a curve and its straight line is the error inherent in estimating early sequestration based on a later age.

Therefore, estimates of potential carbon accumulation for the NWR were developed for mature trees (Table 7). Information was unavailable for the majority of "other"'species, many of which have a potential to sequester carbon for shorter periods or very little total carbon relative to spruce (*Picea* spp.), pine (*Pinus* spp.), poplar (*Populus* spp.), and ash (*Fraxinus* spp.). Assuming 74% survival, the estimated 4.2 million spruce and pine trees and 0.4 million hardwoods in the NWR could sequester up to 4 $\leftrightarrow 10^6$ kg of carbon annually (Table 7). This is certainly an overestimate, because it assumes that all trees were planted on the best sites for which growth data are available and that all of the trees found to be healthy in the early survey will survive to maturity. Further, while we believe it is the first such estimate for a noncommercial, nonindustrial tree-planting program, it must be recognized that the goal of a 1% CO_2 reduction by the year 2000 could never be met

Table 7. Carbon (C) sequestering potential in NWR planting projects.

Species	Province & section	Age at matur.[1]	C per tree (kg)[2]	Mean annual C increm. (kg)	No. of trees planted[3]	Total annual C seques. potential (kg)
Spruce, white	Alta.	80	116.6	1.46	1296637	1889848
	Sask.,	70	116.4	1.66	300950	500437
	Man., Mountain	100	32.0	0.32	47156	15090
	Man., L. Wpg E	100	37.5	0.38	692383	259644
	Man., Sask. R.	100	52.4	0.52	318500	166894
Spruce, black	Man., L. Wpg E	80	15.0	0.19	92077	17264
	Man., Sask. R.	80	15.2	0.19	294647	55983
Pine	Alta.	60	66.1	1.10	386157	425416
	Sask.	65	48.6	0.75	587727	439439
	Man., Mountain	60	57.9	0.97	41339	39892
	Man., L. Wpg E	80	43.1	0.54	93366	50301
	Man., Pineland	60	33.5	0.56	67490	37682
Aspen/ poplar and ash	Alta.	60	171.2	2.85	28364	80932
	Sask.	60	112.1	1.87	116865	218343
	Man., Mountain	55	47.4	0.86	177031	152569
	Man., L. Wpg E	65	47.8	0.74	38185	28081
	Man., Pineland	60	32.3	0.54	88751	47778
Other	All places		<10.0	<0.20	1643014	
Total					*6310639*	*4425593*

[1]Age at peak MAI or only age given in Freedman and Keith (5).

[2]Based on Freedman and Keith (5).

[3]Assumes 74% survival of original trees planted (see text).

by this sort of program without taking into account growth to maturity.

The true value of sequestering carbon by planting trees and the development of other benefits, such as wildlife habitat and soil stabilization, is a function of both the selected age for value calculation (3) and discount rate (4). Tree Plan Canada sponsored only noncommercial projects, i.e., the trees were not to be harvested for wood products. However, planting trees for wood products may extend the sequestration period by preventing the carbon from being released immediately upon death (4). Adams et al. (1) tentatively showed that planting on U.S. agricultural lands was a low-cost method of sequestering carbon, provided that the target was kept to under 20% of annual U.S. CO_2 emissions. The TPC program target of 1% of Canadian CO_2 emissions falls well within this estimate. While it is beyond the scope of this paper to quantify the financial value of the carbon that might be stored in this program, it is important to note that the cost of establishing this carbon sink has been paid now, and the benefits will continue to accrue as long as the trees live.

Conclusions

The first goal of this program was to educate Canadians on the role of trees in the environment. Many people did recognize environmental benefits of tree planting through direct participation, and many more became aware of the program's activities through media coverage. It is also clear that Canadians are making it a priority to educate children about trees. Although it is unclear if people gained an understanding of how trees relate to the potential for changes in our climate, we hope that the combination of identifying benefits and focusing on education will elucidate this relationship. This understanding needs to be emphasized and better evaluated.

The second goal was to provide the opportunity for active participation by ordinary citizens in addressing these environmental concerns. An estimated 93,000 people participated in TPC activities in one form or another, in the NWR. About half of these received tree seedlings for planting wherever they wished. The other half were directly involved in projects, either as planners or participants. The majority of these people were ordinary citizens, not professionals paid to undertake planting activities. In addition, many more people will participate in the care and maintenance of these trees.

The third goal was to take concrete action to counter the potential effects of global warming. In this study, it is estimated that the trees planted in the 4 years of Regional Partner projects could store up to 4000 tonnes of carbon per year over their lifetime, although the actual storage is likely to be lower due to site-related growth constraints.

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Résumé. Le programme national de plantation d'arbres du Canada, le Plan Vert du Canada, a subi des changements profonds en 1995 en mettant un terme aux activités de sa composante principale qui voyait à subventionner les projets de plantation par des petits groupes et des organisations locales au travers tout le Canada.Cet article produit un résuméde la plantation de 8,5 millions d'arbres dans 347 projets différents de la région du Nord-Ouest; il inclut les résultats d'un relevé où on a constaté un taux de survie de 72% de 1 à 3 ans après la plantation.Le programme a directement impliqué 93000 personnes dans les activités de plantation et a permis d'augmenter la conscience collective sur le bénéfice environnemental de la plantation d'arbres.Le potentiel maximum de fixation du carbone grâce à ce programme a été estimé à 2000 tonnes par an.