

# Afforestation on private land in Canada from 1990 to 2002 estimated from historical records

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## ABSTRACT

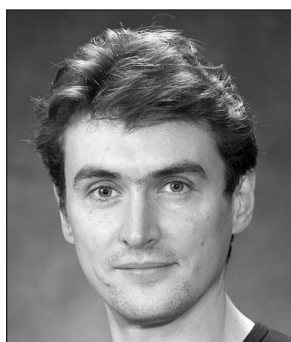
Information on afforestation on private lands in Canada from 1990 to 2002 was compiled from a variety of sources in support of the Government of Canada's Feasibility Assessment of Afforestation for Carbon Sequestration (FAACS) initiative. Data collection focused on afforestation that was verifiable and consistent with definitions in the Kyoto Protocol. Analysis of the dataset provides insight into the scale, scope and trends in afforestation activity in Canada. Most of the planting occurred in Quebec and Ontario. Ninety-five percent of the afforestation events were smaller than 10 ha. The national average area planted in an afforestation event is 2 ha. Regional averages were higher in the west than in the east. The annual area planted declined from 1990 to 2002 in most provinces, though the Prairie Provinces were an exception. The data agree with other sources of information on afforestation activity in Canada. An analysis of carbon sequestration in the plantations documented in the FAACS database is presently underway and will be reported in the near future.

**Key words:** afforestation, reforestation, climate change, carbon sequestration, Kyoto Protocol, private forest lands

## RÉSUMÉ

L'information sur le reboisement des terres privées au Canada de 1990 à 2002 a été compilée à partir de plusieurs sources appuyant l'initiative du Gouvernement du Canada portant sur l'évaluation de la faisabilité du reboisement à des fins de séquestration du carbone (FAACS). La cueillette de données s'est concentrée sur le reboisement qui était vérifiable et constant avec les définitions du Protocole de Kyoto. L'analyse des ensembles de données a permis une vision de l'étendue, des objectifs et des tendances au niveau des activités de reboisement au Canada. La plupart des plantations ont été effectuées au Québec et en Ontario. Quatre vingt quinze pour cent des travaux de reboisement couvraient une superficie inférieure à 10 ha. La moyenne nationale des superficies reboisées est de 2 ha. Les moyennes régionales sont plus élevées dans l'ouest que dans l'est. La superficie annuelle reboisée a diminué de 1990 à 2002 dans la plupart des provinces, à l'exception des Prairies. Les données sont en concordance avec d'autres sources d'information sur les activités de reboisement au Canada. Une analyse de la séquestration du carbone dans les plantations relevées dans les données du FAACS est actuellement en cours et fera l'objet d'un rapport sous peu.

**Mots clés :** reboisement, changements climatiques, séquestration du carbone, Protocole de Kyoto, terrains privés



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## Introduction

The Government of Canada is presently examining options for promoting carbon uptake through afforestation as a strategy for mitigating domestic greenhouse gas emissions. The federal government established the Feasibility Assessment of Afforestation for Carbon Sequestration (FAACS) initiative to explore the feasibility of large-scale afforestation on private land. One component of the initiative involved compiling spatially explicit information about the location, extent, and characteristics of afforestation projects on private lands since 1990.

Information about afforestation activities is essential for the development of credible estimates of carbon sequestration, which are required as part of Canada's international reporting commitments under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The Kyoto Protocol and its parent treaty, the UNFCCC, seek to reduce the rate of carbon dioxide (CO<sub>2</sub>) accumulation in the global atmosphere by encouraging signatory nations to decrease their greenhouse gas emissions from fossil fuel use and increase their net uptake of carbon from the atmosphere in terrestrial systems (e.g., forests and agricultural lands). The Kyoto Protocol sets country-

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**Table 1. Categories of landcover before afforestation. Each planted site was assigned to one of these categories to allow a future assessment of carbon sequestration on the site.**

Pre-planting landcover	Definition
Shrub	Cover predominantly of plants with woody stems (shrubs and non-commercial tree species not meeting the Kyoto definition of forest).
Agricultural	Lands dedicated to the production of annual herbaceous crops, that may be temporarily without cover.
Perennial Herbaceous	Cover predominantly of perennial vascular plants without woody stem (grasses, forbs, graminoids). Includes forage, pasture, native grassland.
Forest	Lands with tree crown cover (or equivalent stocking level) greater than 30% with trees with the potential to reach a minimum height of 5 metres at maturity in situ.
Exposed	River sediments, exposed soils, pond or lake sediments, reservoir margins, beaches, landings, burned areas, road surfaces, mudflat sediments, cutbanks, moraines, gravel pits, tailings, railway surfaces, buildings and parking or other non-vegetated surface.

**Table 2. Categories of site-preparation intensity. Each planted site was assigned to one of these categories to allow a future assessment of carbon sequestration on the site.**

Site-preparation Intensity	Definition
High	Significant disturbance to vegetation and soil (ripping, mounding, scarification etc., occurring on the majority of the site).
Medium	Broadcast chemical or mechanical control of existing vegetation on a large portion of the site, no major soil disturbance. Residues remain on site.
Low	Negligible disturbance (e.g., spot applications of pesticides or manual clearing around the base of trees but not between rows, manual planting or other practices occurring on a limited portion of the site).
Burn	Biomass burning or removal from site.

specific targets for reducing greenhouse gas emissions relative to 1990, without specifying how the target must be reached. The protocol recognizes that establishment of new forests on areas that have not ever or have not recently (prior to January 1st, 1990) contained forests — activities referred to as afforestation or reforestation — is one means by which countries can reduce their net emissions of greenhouse gases.

The formal definitions of afforestation and reforestation applicable to the Kyoto Protocol were finalized at the 7th Conference of Parties to the UNFCCC in Marrakesh, Morocco, in 2001 (UNFCCC 2001). Afforestation “is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources.” Reforestation is “the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land [prior to] 31 December 1989.” A plantation is termed afforestation or reforestation according to differences in historical land use, but the reporting requirements are the same. Because of the requirement for a non-forest land use prior to 1990, reforestation, as defined by the protocol, is not equivalent to regener-

ation following harvest. In this paper, both activities are referred to as afforestation.

## Data Collection

### Scope

The FAACS backcast focused on identifying verifiable tree planting activities that would be eligible under Kyoto Protocol Article 3.3. The activity must have begun after December 31st, 1989, and resulted in the deliberate human-induced conversion of non-forested land — typically abandoned farmland — into forest. In the protocol, forest is defined as any land area covering at least 0.05 to 1.0 ha that has at least 10 to 30% tree crown cover, with trees that have the potential to reach 2 to 5 m height at maturity. (Signatory countries must choose how they define their forests by specifying a single value within these ranges for each of the three parameters.) Land is eligible for afforestation if, prior to planting, it is at least 0.05 to 1.0 ha in size and has less than 10 to 30% tree crown cover, with trees that have the potential to reach 2 to 5 m height at maturity at that location.

Canada has not finalized the values it will use to define its forests. The values of 1 ha minimum size, with 25% crown cover closure and 5 m height at maturity are currently under consideration. The FAACS backcast adopted a provisional

**Table 3. Distribution of historical afforestation activity by province**

Province	Percent of Plantings	Percent of Area Planted	Average size of plantings (ha)
Alberta	< 1%	2%	16
British Columbia	< 1%	2%	11
Manitoba	< 1%	< 1%	3
New Brunswick	DKa	5%	DK
Nova Scotia	< 1%	0%	2
Ontario	15%	14%	2
Prince Edward Island	34%b	8%	<1
Quebec	50%	67%	2
Saskatchewan	<1%	<1%	6

<sup>a</sup>Data from New Brunswick were reported on an aggregated basis and therefore the percent of plantings in New Brunswick could not be determined.

<sup>b</sup>Different methods were used for PEI than for other provinces and this estimate may be high.

definition of forest as an area 0.05 to 1.0 ha that has at least 30% tree crown cover, with trees that have the potential to reach 5 m height at maturity. The actual choice of the parameter value for minimum area depended on the richness of the available data in each province.

The Intergovernmental Panel on Climate Change's Good Practice Guidance for Land Use, Land-Use Change and Forestry recommends that countries further specify a minimum width for the definition of forest, and that this be consistently applied to reporting of afforestation, reforestation, and deforestation (IPCC 2003). By way of example, a 1 ha minimum area could apply to a 100 m by 100 m square or a rectangle 20 m wide by 500 m long. The choice of minimum width will determine whether certain linear activities — shelterbelt planting and linear corridors associated with seismic line or right-of-way clearing — are included in reporting under Article 3.3. In order to comply with this recommendation, data collection was structured to distinguish block plantations from shelterbelts. Information on linear plantations such as shelterbelts was collected when available and varied in quality. Nonetheless, it is excluded from the results presented here, largely because it is uncertain whether Canada will define its forests in such a way that shelterbelt planting is included. Even if the contribution of shelterbelt planting is ultimately not included in land-use change reported under Article 3.3 of the Kyoto Protocol, it may still be reported under Article 3.4 which includes cropland and grazing land management and re-vegetation activities. Similarly, linear disturbances such as seismic lines could be reported under forest management activities if Canada selects forest management reporting under Article 3.4.

## Methods

Data collection was coordinated by each of the five regional Canadian Forest Service centres in partnership with provinces, municipalities, NGOs and forest companies that had been involved in afforestation since 1990. The primary sources of data were land cover data sets, historical records, and local knowledge.

Land cover data in a GIS-compatible format were available for the provinces of Prince Edward Island, Nova Scotia, and for crown lands in New Brunswick for dates corresponding with the beginning and the end of the assessment period. The data were processed in a geographic information system to identify areas that were not forested in 1990 but were classified as forested at a later date.

Historical records from various publicly funded tree planting programs that were active during the assessment period were available in paper or digital format for the provinces of British Columbia, Ontario, Quebec, and New Brunswick.

In New Brunswick, records were available from the Canada/New Brunswick Forest Renewal Agreement, which was active from 1990 to 1995. The New Brunswick Private Woodlot Silviculture Program was initiated by the Department of Natural Resources and Energy in 1998–99. Summary statistics from this program were acquired from the year it was initiated to 2001–02. Between 1995–96 and 1997–98 no program was in place to assist private woodlot owners to conduct silviculture.

Quebec has had an active program of supporting investments in silviculture, including afforestation, on private lands since the early 1970s. Electronic files were available spanning the period 1993 to 2002 and paper files for 1990 to 1992, from 17 regional agencies tasked with enhancing private forest management in Quebec.

In Ontario, data were obtained from conservation authorities, Ontario Ministry of Natural Resources, Ontario Forestry Association, Tree Plan Canada, private consultants, municipalities and a forest products company.

Afforestation plantation data from across the three Prairie Provinces were compiled by the Northern Forestry Centre, through a network of contacts in the prairies that were involved in the implementation of afforestation plantations. The primary contacts were the proponents, suppliers, promoters, and service organizations that have had direct involvement in afforestation on agricultural land since 1990. An analysis of spatial and temporal trends specific to the Prairie Provinces can be found in Hall *et al.* (2004).

In British Columbia, data were available from the files of the Canada–British Columbia partnership agreement on Forest Resource Development (FRDA II), which was active from 1991 to 1996 and which targeted backlog reforestation on areas that were harvested before 1985 (Crane Management Consultants. Assessment of Impacts of FRDA II's Private Woodlands Sub-program. FRDA. 1996). Although these areas were devoid of forest cover on December 31st, 1989, they do not necessarily qualify as afforestation or reforestation. Countries must distinguish areas that lacked forest cover on December 31st, 1989 because of a recent harvest or natural disturbance from areas that were not expected to revert to forest because a land-use change had occurred (IPCC 2003). This distinction is consistent with countries' obligations to report how they distinguish forest cover removal due to deforestation from that due to harvesting. Countries could use a temporal criterion such as time since harvest to distinguish between deforestation and harvesting. A forested area would be considered deforested if it has not regenerated satisfactorily within a specified period of years of being cleared. If a temporal approach is chosen, then areas that were non-forest on December 31st, 1989 would have to satisfy the condition of having been in that state for a yet-to-

**Table 4. Distribution of historical afforestation activity by size class (excluding PEI and NBa)**

Size Class (ha)	Number of plantings	Total Area (ha)	Percentage of Historical Plantings	Percentage of Historical area
< 1	14015	6710	41%	8%
1–10	19122	57233	56%	68%
11–25	1096	15295	3%	18%
25–50	102	3265	< 1%	4%
50–100	21	1346	< 1%	2%
> 100	4	446	< 1%	1%

\*Data from New Brunswick were excluded as these were reported on an aggregated basis and therefore could not be separated into size classes. Data for Prince Edward Island, which were collected using spatial overlay methods in a GIS, are not directly comparable with data compiled from historical records and were also excluded.

be specified period of time prior to this date, or have been demonstrably converted to another land-use, in order to be eligible for inclusion under Article 3.3. reporting.

Most of these regional datasets do not distinguish explicitly between tree planting on abandoned agricultural lands and tree planting following harvest, a distinction required by the Kyoto Protocol. However, most datasets contain enough detail to be able to infer the difference based on indicators such as the land cover prior to planting, the intensity of site preparation, or the ratio of planted to target stocking. All of these datasets were scrutinized in detail and a metadata report outlining how specific issues were addressed was prepared for each.

#### FAACS National Database

The resulting datasets were compiled into a single Microsoft Access™ 2000 database developed by the Canadian Forest Service Carbon Accounting Team to ensure consistent national standards for reporting on the data. The FAACS National database standardizes data reporting across the many original datasets, while accommodating variation in data accuracy and preserving, as closely as possible, the logic of the original data.

The business object of interest is an “afforestation event” — defined as a location where tree planting occurred at a particular time. The database contains information about the species and area planted and the location of the plantation in Canada. Location information includes the following:

- Province, and in some cases a sub-provincial administrative region such as a forest region;
- Land descriptions commonly used to uniquely identify parcels in a cadastral survey in each province;
- Where available, UTM or geographic coordinates; and
- The year the site was planted.

The provincial information was used to produce summary statistics. The detailed cadastral information enables independent verification of afforestation events, and also provides quality control. Because this information uniquely identifies a property, it can be used to prevent double counting of events. In addition, the spatial coordinate information facilitates the use of ancillary GIS resources.

Since one important purpose of the project was to enable estimation of carbon sequestration using the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3), additional information about the ecological characteristics of planted sites was necessary. Information about the carbon stocks

present in soils, dead organic matter and biomass typically was not available from the sources compiled. Hence, indirect approaches were necessary.

Carbon stock trajectories in recently afforested stands can be influenced by vegetation cover and vegetation and soil disturbance associated with historical land-management practices such as long-term cultivation and by site preparation activities immediately preceding the event. In the short term, site history could have an effect on the carbon budget of an afforestation event, as carbon emissions following afforestation — e.g., from decomposition or burning of cleared vegetation during site preparation — could temporarily offset some of the carbon sequestered by the growth of the newly planted trees. Consequently, information about the previous land use, the method, and intensity of site preparation was recorded in the database.

Tables 1 and 2 list the categories used to characterize the pre-planting land-cover and the intensity of site preparation. A more detailed description of the site preparation treatment accompanies each record, whenever such information was available in the original dataset.

In addition, each site was assigned to an ecological region from either a national- or provincial- scale ecological stratification. Stratification by ecological region is used to link afforestation events with climate information, such as long-term mean annual temperature and precipitation, which determines the rate of dead organic matter cycling in forests (Kurz *et al.* 1992, Kurz and Apps 1999). Stratification by ecological region may also be used to link afforestation events with growth and yield information. At a minimum, all sites were referenced to Ecozones from the Ecoclimatic Regions of Canada (Ecological Stratification Working Group 1996).

Information about the management regime included the species planted, the spacing or stem density and a management factor — managed or unmanaged — indicating the expected management regime following plantation establishment.

#### Results

The FAACS national database contains just under 52 000 planting events identified as afforestation — having an area of at least 0.05 ha that has at least 30% tree crown cover, with trees that have the potential to reach 5 m height at maturity — for the period 1990 to 2002. The corresponding area planted is approximately 100 000 ha. The average area planted in one afforestation event is 2 ha.



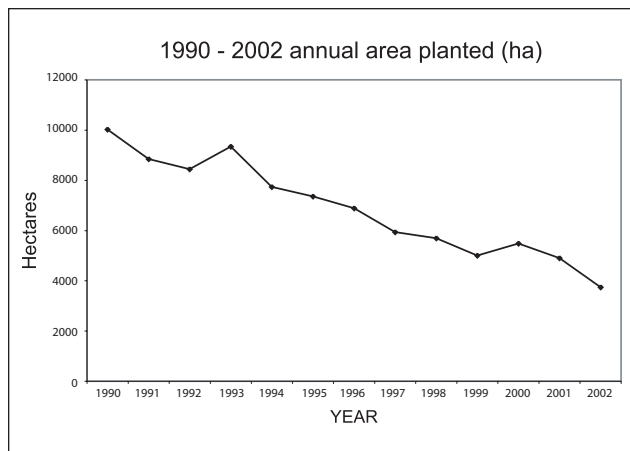


Fig. 1. Annual area planted 1990–2002

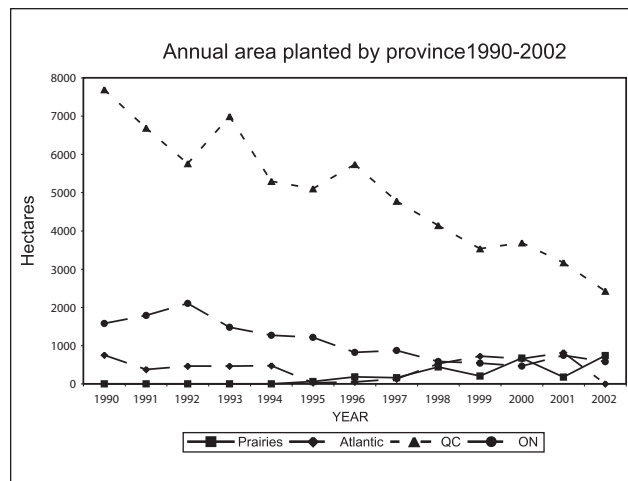


Fig. 3. Annual area planted by province 1990–2002

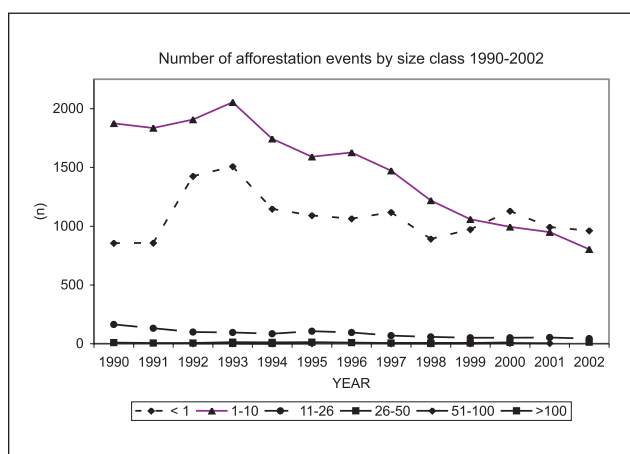


Fig. 2. Number of events by size class 1990–2002

Quebec and Ontario together account for more than 65% of the plantings and 84% of the area planted in Canada (Table 3). Although Prince Edward Island accounted for 34% of the plantings, this figure was not directly comparable to those of other provinces. The spatial overlay methods that were used to estimate afforestation activity in PEI may have overstated the actual number of plantations when compared with a records-based approach. An accuracy assessment of land-use change estimates for PEI is presently being conducted and will result in improved estimates for PEI. New Brunswick accounted for 5% of the total area planted. The remaining provinces accounted for less than 5% of the total area planted.

The average area planted in single afforestation events was higher in the western provinces than in the other provinces. In British Columbia, Alberta and Saskatchewan, the mean planting size was greater than 5 hectares, compared with an average size of 5 ha or less in the other provinces. The percent of plantings and mean area planted in New Brunswick could not be determined because some data were reported on an aggregated basis.

Plantings of 10 ha or less accounted for more than 95% of the number of plantings and 75% of the total area afforested in Canada from 1990 to 2002 (Table 4). Plantings less than

Table 5. Proportion of area planted with hardwood and softwood species by province

Province	Hardwood	Softwood
Alberta	39%	61%
British Columbia	3%	97%
Manitoba	100%	0%
New Brunswick	0%	100%
Nova Scotia	0%	100%
Ontario	16%	84%
Prince Edward Island	47%	53%
Quebec	4%	96%
Saskatchewan	94%	6%
National	10%	90%

1 ha accounted for 41% of the number of plantings, but only 8% of the total area afforested. These plantations would be excluded from accounting under Kyoto Protocol Article 3.3 if 1 ha is used as the minimum area for defining forests. Plantings larger than 10 ha were relatively rare — less than 5% of the number of plantings — but accounted for 25% of the area afforested. Interestingly, a recent survey of afforestation plans of private landowners (EnviroNics Research Group 2003) indicated that the preference for planting on small plots would continue in the future.

From 1990 to 2002 the annual area afforested in Canada declined consistently (Fig. 1). This decline is principally manifested as a reduction in the number of plantings between 1 and 25 ha (Fig. 2). There were no clear trends over the period in the number of plantings less than 1 ha or greater than 25 ha.

The national trend shown in Fig. 1 for the period 1990 to 2002 essentially reflects the planting trends in Quebec and Ontario (Fig. 3). While the annual area planted has decreased in Quebec and Ontario, it has increased in the Prairie Provinces, largely due to the activities of two forest products companies interested in boosting fibre supply close to their mills (Hall *et al.* 2004). There is no apparent trend in the annual number of plantings in the Atlantic Provinces. Data

**Table 6. Proportion of plantings by tree species determined from historical plantings documented in the FAACS database**

Genus	Proportion of plantings	Proportion of area	Rank (by count) in FAACS database	Rank (by count) in Environics survey
Spruce	54%	63%	1	1
Pine	14%	16%	2	2
Maple	8%	2%	3	3
Larch	4%	2%	4	15
Alder	4%	2%	5	not ranked
Cedar	3%	2%	6	6
Ash	3%	1%	7	5
Poplar	3%	3%	8	4
Oak	3%	1%	9	8
Juglandacea	1%	0%	10	11
Other	< 5%	< 8%		

from British Columbia were not shown because they were limited to years 1992 to 1996.

Nationally, softwoods accounted for 90% of area planted (Table 5). The ratio varied for different regions of the country, but softwood plantings were dominant in most regions. Spruce and pine were the most commonly planted softwoods, and maple was the most commonly planted hardwood, based on the number of plantations in which these species appeared (Table 6). When expressed on an area basis, the proportions differed; however, the relative ranking did not change significantly. The 10 tree types listed in Table 6 were present in 95% of the recorded afforestation plantings.

The rankings in Table 6 can be compared to those in the National Survey of Rural Landowners (Environics Research Group 2003), which included a question asking respondents who indicated that they had planted trees between 1990 and 2002 to identify which species they had planted. The top three most commonly planted species in the survey and the FAACS database are the same. Of the remaining seven, four are also ranked in the top ten in the survey.

## Discussion

A clear picture emerges regarding the nature of afforestation on private lands between 1990 and 2002. Afforestation happens on a small scale, relative to other land management activities. The 100 000 ha of documented afforestation between 1990 and 2002 represents a small fraction of the 28 million ha of privately owned forest in Canada (NRCAN 2003). However, when viewed in terms of activity levels, the relative importance of afforestation increases. The 52 000 afforestation events having areas greater than 0.05 hectares that were recorded in the FAACS database compare with 247 000 farms reported in 2001 (Statistics Canada 2001) and 425 000 private woodlot owners in 2000 (NRCAN 2000). Approximately 16% of rural landowners have planted trees in the past five years, according to a survey of rural landowners (Environics Research Group 2003). The survey did not distinguish area-based plantings from linear plantings. As an activity, afforestation has involved more private landowners than would be inferred based on the area planted.

Possible explanations for the observed decline in area planted from 1990 to 2002 include reduced availability of

public funding targeted directly at afforestation, a diminishing supply of lands that private landowners consider economically attractive to plant, and — with localized exceptions — waning interest from the forest industry in establishing new sources of fibre supply on unforested private lands. The principal causes for the decline differ by geographic region. In Quebec, competition from other uses for unforested lands is thought to be a major contributor. The main competing use there is for the disposal of wastes from industrial hog operations (G. Joncas, Canadian Forest Service, St. Foy, Quebec, personal communication). In Ontario, the disengagement of the Ontario Ministry of Natural Resources from operational tree planting programs appears to have had an effect on tree planting in the province (Puttock 2001).

Most data contained in the FAACS database were collected from records maintained by agencies that sponsored afforestation on private lands — typically using public funds — and for which records have been maintained. These data provide a partial picture of afforestation activity in Canada from 1990 to 2002, and may under-represent the total area afforested during this period. It is probable that information on some privately financed efforts is missing from the dataset — particularly small plantings by private landowners that would easily escape general notice. Were data about these undocumented plantings available, it would likely not materially affect the trends presented here unless the preferences of landowners whose plantations were documented differed significantly from the preferences of landowners whose plantations were not documented. The close agreement between the FAACS dataset and the National Survey of Rural Landowners conducted by Environics suggests that these two populations would behave similarly. The degree to which undocumented plantings on private lands change the absolute levels of activity presented here is unknown. However, the dataset does provide a reasonable estimate of the scale, scope and trends in afforestation activity on private lands in Canada from 1990 to 2002.

The primary focus of the FAACS initiative was afforestation on private lands. The data presented here for the most part reflect tree planting activities on privately held abandoned agricultural lands. They exclude planting activities on public lands that may have qualified as afforestation or refor-

estation. In particular, re-planting after 1990 of areas that were deemed not sufficiently regenerated prior to 1990 might qualify as reforestation and could be reported under Kyoto Protocol Article 3.3. Consistent with the IPCC Good Practice Guidance, a decision is required on the length of time following harvest after which an unregenerated forest area would be considered deforested. This decision will determine how much backlog reforestation of public lands could qualify as afforestation or reforestation. It will also affect how much harvested land that does not regenerate would be considered deforestation.

Under the UNFCCC and the Kyoto Protocol, Canada is required to report on carbon sequestration on land subject to afforestation, reforestation and deforestation since 1990. Even though the annual area planted has declined from 1990 to 2002, there will clearly be ongoing afforestation programs as a result of the initiatives of governments, NGOs and the private sector. In order to obtain recognition for the positive contributions these initiatives make towards mitigating climate change, it is important that they be consistent with rules elaborated under the Kyoto Protocol and that adequate documentation be maintained to facilitate the compilation of statistics for national reporting. The Canadian Forest Service has developed an internet-based reporting system to track afforestation projects established as part of the federal government's Forest 2020 initiative. Organizations involved in the delivery of the Forest 2020 Plantation Demonstration and Assessment initiative are able to report their planting activities via the Internet. The system, called the National Afforestation Inventory (NAI) (<http://nai.nfis.org>), facilitates the compilation, verification and reporting of afforestation information. It could easily be expanded into a national framework for Internet-based reporting of afforestation activity in Canada.

This paper has described the methods used to compile information on afforestation activities in Canada from 1990 to 2002 and the resulting dataset. Preliminary analysis of the dataset provides some useful insights into the scale and scope of afforestation activity in Canada from 1990 to 2002. This information can inform the development of policy measures to promote afforestation as a climate change-mitigation strategy. An analysis of CO<sub>2</sub> sequestration in the plantations documented in the FAACS database is presently underway and will be reported in the near future.

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