1. Introduction

The Government of Canada is presently examining options for promoting 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 privately owned land. One component of the initiative involved compiling spatially explicit information about the location, extent, and characteristics of afforestation projects that have occurred on private lands since 1990 that would qualify as afforestation or reforestation as these terms are defined in the Kyoto Protocol. This information is essential for the development of credible estimates of carbon sequestration from afforestation/reforestation, which are required as part of Canada's international reporting commitments under the UNFCCC and the Kyoto Protocol. It also provides useful insights about the scope and scale of recent afforestation activity in Canada.

The Kyoto Protocol, and its parent treaty, the United Nations Framework Convention on Climate Change (UNFCCC), seek to reduce the rate of carbon-dioxide (CO_2) accumulation in the global atmosphere by encouraging signatory nations to decrease their greenhouse gas (GHG) emissions from fossil fuel use and increase their net uptake of carbon (C) from the atmosphere in terrestrial systems (e.g., forests and agricultural lands). The Kyoto Protocol sets country-specific targets for GHG emissions reductions relative to 1990, without specifying how the target must be reached. The protocol recognizes the establishment of new forests on areas that have not recently or ever contained forests –activities referred to as afforestation or reforestation- as 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[1]. Under article 3.3 of the protocol, a new plantation is eligible for credit if it originated through human activity since 1990 on land that was not forested, or not in a forest use, prior to 1990. A plantation is termed afforestation or reforestation according to 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 regeneration following harvest. In this paper, no distinction is made between the two activities; both are referred to as afforestation.

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[1] Decision 11/CP.7: Land use, land-use change and forestry. Publication FCCC/CP/2001/13/Add.1 (http://unfccc.int).

2. Data collection

2.1. Scope

The FAACS backcast focused on identifying tree planting activities that would be eligible under article 3.3 of Kyoto Protocol. 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 0.05-1.0 hectares that has at least 10-30% tree crown cover, with trees that have the potential to reach 2-5 m height at maturity. Land is eligible for afforestation if it is at least 0.05-1.0 hectares in size and has less than 10-30% tree crown cover, with trees that have the potential to reach 2-5 m height at maturity, prior to planting. Signatory countries must specify a single value within these ranges that they will use to define their forests.

Canada has not finalized the values it will use to define its forests. The FAACS backcast adopted a provisional definition of forest as an area 0.05-1.0 hectares 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. Regardless of the minimum size considered, eligible plantations had to have been planted in a block configuration. Information on linear plantations such as shelterbelts was collected when available. It is uncertain whether shelterbelts would qualify as afforestation as defined under article 3.3 of the Kyoto Protocol. Data on shelterbelts were excluded from the results presented here.

2.2. 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 was available for the provinces of Prince Edward Island, Nova Scotia and New Brunswick[2] 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 circa 1990 but were classified as forested at a later date.

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[2] Crown land only

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

In New Brunswick, records were available from the Canada/New Brunswick Forest Renewal Agreement which was active from 1990-1995. 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 – 1997-98 no program was in place to assist private woodlot owners in conducting silviculture.

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

In Ontario, data were obtained from Conservation Authorities, two municipalities and a forest products company.

Afforestation plantation data from across the three prairie provinces was collected by accessing information through a large network of contacts in the prairies that are involved in the implementation of afforestation plantations. The primary contacts are the proponents, suppliers, promoters and service organizations that have direct involvement with area-based outplantings on agriculture land since 1990.

In British Columbia, data was available from the files of the Canada – British Columbia partnership agreement on Forest Resource Development (FRDA II) which was active from 1991-1996 and targeted backlog reforestation on areas that were harvested before 1985 (Crane Manegement Consultants, 1996).

The definitions of afforestation/reforestation relevant to the Kyoto Protocol weren't finalized until 2001. Although the potential for afforestation to sequester carbon has long been recognized, Canada's interest in tracking afforestation independently from other forest management activities is comparatively recent. Many of these datasets do not distinguish explicitly between tree planting on abandoned agricultural lands and tree planting following harvest, as does the Kyoto Protocol. However, most 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 was prepared for each outlining how specific issues were dealt with. Every record in the source

datasets was assigned a confidence value indicating how certain the reviewer was that a site would qualify as afforestation using the Kyoto Protocol definitions.

2.3. FAACS National Database

The resulting datasets were compiled into a single Microsoft Access 2000 database. 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 in Canada where a tree planting event occurred at a particular point in 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;

- The year the site was planted.

The provincial information is used to produce summary statistics. The detailed cadastral information enables independent verification of the authenticity of afforestation events. It also provides quality control for reporting of afforestation statistics from the database. Because this information uniquely identifies a property, it can be used as a check against double counting of events. The spatial coordinate information facilitates the use of ancillary GIS resources.

Since one important purpose of the database is to enable estimates of carbon sequestration to be made using the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3), additional information about the ecological characteristics of planted sites was collected. 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 collected.

A full description of the database tables is included in the appendices to this report.TABLES

Table 1 Pre-planting landcover and Table 2 Site preparation intensity 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.

Additional information about the ecological characteristics of the site and the target management regime was also collected to facilitate an assessment of long-term carbon sequestration from the plantations identified in the this exercise.

Each site is 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 (reference CBM papers). Stratification by ecological region may also be used to link afforestation events with growth and yield information. At a minimum, all sites are referenced to Ecozones from the Ecoclimatic Regions of Canada[3].

Information about the management regime includes the species planted, the spacing or stem density on a per unit area basis and a management factor – managed or unmanaged – indicating the expected management regime following plantation establishment.

3. Results and Discussion

The FAACS national database contains just under 55,000 planting events identified as afforestation - having an area 0.05-1.0 hectares that has at least 30% tree crown cover, with trees that have the potential to reach 5 m height at maturity – for the period 1990-2002. The corresponding area planted is approximately 110,000 hectares.

Table 3 shows the proportion of plantings and area planted by province. Quebec and Ontario together account for more than 65% of the plantings and 83% of the area planted. Although

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[3] Ecoregions Working Group of the Canada Committee on Ecological Land Classification. Ecological Land Classification Series, No. 23, Sustainable Development Branch, Canadian Wildlife Service, Environment Canada, Ottawa, Ontario. 119p. and map at 1:7,500,000 scale.

Prince Edward Island accounts for 33% of the plantings, this figure is not directly comparable to those of other provinces because different methods were used to estimate afforestation activity in PEI. PEI accounted for 7% of the area afforested. New Brunswick accounted for 5% of the total area planted.

The average area planted in a single afforestation event is significantly higher in the western provinces than in the other provinces. In British Columbia and Alberta the mean planting size was greater than 10 hectares, compared with an average size of 5 hectares 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.

Table 4 shows the number of plantings and the total area planted by size class for the period 1990-2003 for all provinces for which estimates were compiled from historical planting records. 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.

Plantings less than 10 hectares account for more than 95% of the number of plantings and 70% of the total area afforested. Plantings less than 1 hectare account for 40 percent of the number of plantings, but only 7 percent of the total area afforested. These plantations would be excluded from accounting under article 3.3 of the Kyoto Protocol if Canada chooses 1 hectare as the minimum size unit for defining its forests. Plantings larger than 10 hectares are relatively rare – less than 5% of the number of plantings - but account for 30% of the area afforested.

From 1990 to 2002 the annual area afforested in Canada declined consistently as seen in Figure 1[4]. Figure 2 shows the percentage by which the number of plantings in a given year differs from the average annual number of plantings for the period 1990-2002, broken down by size class. The decline in the annual number of plantings over the period 1990-2002 is principally manifested as a reduction in the number of plantings between 1-10 and 10-25 hectares. There are no clear trends over the period in the number of plantings less than 1 hectare or greater than 25 hectares.

The national trend shown in Figure 1 for the period 1990-2002 essentially mirrors the trends in Quebec and Ontario. Figure 3 shows the percentage by which the annual area planted in a given year differs from the average annual area planted for the period 1990-2002, broken down

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[4] Data from PEI are not included. Although they correspond with the period 1990-2000, it was not possible to determine the specific years in which individual plantings occurred.

by region. 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 operating 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 from British Columbia are not shown because they were limited to years 1992-1996.

Table 6 shows the occurrence of hardwoods and softwoods in afforestation plantings in each province. Nationally, softwoods were planted more frequently than hardwoods by a ratio of 3 to 1. Softwood plantings are dominant in most regions, except the prairie provinces, where hardwood plantings are more common.

Table 7 shows the most frequently planted trees by genus for afforestation events recorded in the FAACS database. The ten tree types listed are represented in 95% of the recorded afforestation plantings. Spruce and pine are the most commonly planted softwoods and maple the most commonly planted hardwood. The rankings in Table 7 can be compared to those in the National Survey of Rural Landwoners (Environics Research Group, 2003). 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 Environics survey.

4. Discussion

The majority of the data contained in the FAACS database were collated from records maintained by agencies that sponsored afforestation on private lands –typically using public funds- and for which records have been maintained. Though it is probable that information on some privately funded efforts – particularly small plantings by individual landowners- is missing from the dataset, such data, were it available, would not materially affect the trends presented here, except to effect minor changes the absolute levels of activity.

A clear picture emerges regarding the nature of the afforestation activities between 1990 and 2002. Afforestation happens on a small scale, relative to other land management activities. The 110,000 hectares afforested between 1990 and 2002 represents a small fraction of the 28 million hectares of privately owned forest in Canada (NRCAN, 2004). When viewed in terms of activity levels, the relative importance of afforestation increases.   The 55,000 afforestation events recorded in the FAACS database compare with 247,000 farms reported in 2001 (Stastcan, 2001) and 425 000 private woodlot owners in 2000 (NRCAN, 2000).   Approximately 16 percent of rural landowners have planted trees in the past five years, according to a survey or rural landowners

(Environics, 2003). As an activity, afforestation has affected the lives or more Canadians than one might infer based on the area planted alone.

It is difficult to attribute causes to the observed decline in area planted from 1990-2002. This decline could be due to a reduced availability of public funding targeted directly at afforestation, landowners' diminishing interest in planting larger blocks of land, or some combination of both of these factors. Further analysis of the factors motivating landowner interest in afforestation might provide more insight.

Although the annual area planted has declined from 1990-2002, , there will clearly be ongoing afforestation programs in several parts of Canada as a result of the initiatives of provinces, NGOs and the private sector. In order to ensure that the benefits from these initiatives are maximized – particularly to recognize the positive contributions of these activities towards mitigating climate change- it is important to take account of ongoing developments in international negotiations relating to climate change measures. Afforestation incentive measures should target areas greater than 1 hectare that are consistent with the definitions of afforestation elaborated under the Kyoto Protocol. Records of all activities should be maintained; where an entity has responsibility for managing data about afforestation and forest management, these two activities should be distinguished. These measures will facilitate the inclusion of afforested areas in the national forest carbon budget.

This paper has described the methods used to compile information on afforestation activities in Canada from 1990 to 2002 and the resulting dataset. Analysis of the dataset provides some useful insights into the scale and scope of afforestation activity in Canada. This information is can inform the development of policy measures to promote afforestation as a climate change mitigation strategy. These data will also be used in the preparation of Canada's national forest carbon budget.

5. Acknowledgements

FAACS Technical Team – see Table 8.

6. TABLES

Table 1 Pre-planting landcover

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, gramminoids). Includes forage, pasture, native grassland.
Forest	Lands with a with tree crown cover (or equivalent stocking level) greater than 30 per cent 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 Site preparation intensity

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

Site Preparation Intensity	definition
	practices occurring on a limited portion of the site).
Burn	Biomass burning or removal from site.

Table 3 Afforestation activity by Province

Province	Percent of plantings	Percent of total area	Mean area planted (ha)
Alberta	<1%	2%	16.5
British Columbia	<1%	2%	11.0
Manitoba	<1%	<1%	2.7
New Brunswick	DK	5%	DK
Nova Scotia	<1%	<1%	2.0
Ontario	15%	17%	2.3
Prince Edward Island	33%	7%	0.5
Quebec	50%	66%	2.7
Saskatchewan	<1%	<1%	5.7

Table 4 Number of plantings and total area by size class

Size Class (ha)	Number of plantings	Total Area (ha)	Percentage of plantings	Percentage of area
<1	13985	6692	40%	7%
1-10	19443	58939	56%	63%
11-25	1219	17172	3%	18%
25-50	137	4455	0%	5%
50-100	28	1916	0%	2%
> 100	17	4780	0%	5%

Table 5 Expected future plantings estimated from national survey

Size Class (ha)	Percentage of plantings

<1	43%
1-10	47%
11-25	7%
25-50	<1%
50-100	0%
> 100	0%

Table 6 Proprotion of Hardwood and Softwood plantings by Region

Province	Hardwood	Softwood
Alberta	67%	33%
British Columbia	3%	97%
Manitoba	98%	2%
New Brunswick	0%	100%
Nova Scotia	0%	100%
Ontario	33%	67%
Prince Edward Island	52%	48%
Quebec	7%	93%
Sakatchewan	93%	7%
National	23%	77%

Table 7 Tree Species Planted

Genus	Observed frequencies	Rank in FAACS database	Rankings in Environics survey
Spruce	53%	1	1
Pine	15%	2	2
Maple	8%	3	3
Larch	4%	4	15

Alder	3%	5	not ranked
Cedar	3%	6	6
Oak	3%	7	8
Ash	3%	8	5
Poplar	3%	9	4
Juglandacea	1%	10	11
Other	<5%		

Table 8 CFS-FAACS Backcast Working Group members

John Henderson	Atlantic Forestry Centre
Sylvain Masse	Laurentian Forestry Centre
Guy Larochelle	Laurentian Forestry Centre
Gaston Joncas	Laurentian Forestry Centre
Robert Morisset	Laurentian Forestry Centre
Steve Dominy	Great Lakes Forestry Centre
Darren Allen	Great Lakes Forestry Centre
James Froese	Great Lakes Forestry Centre
Derek Sidders	Northern Forestry Centre
Tim Keddy	Northern Forestry Centre
Brent Joss	Northern Forestry Centre
Brian Simpson	Northern Forestry Centre
Nello Cataldo	Pacific Forestry Centre
Randy Butcher	Pacific Forestry Centre
Thomas White	Pacific Forestry Centre

7. FIGURES

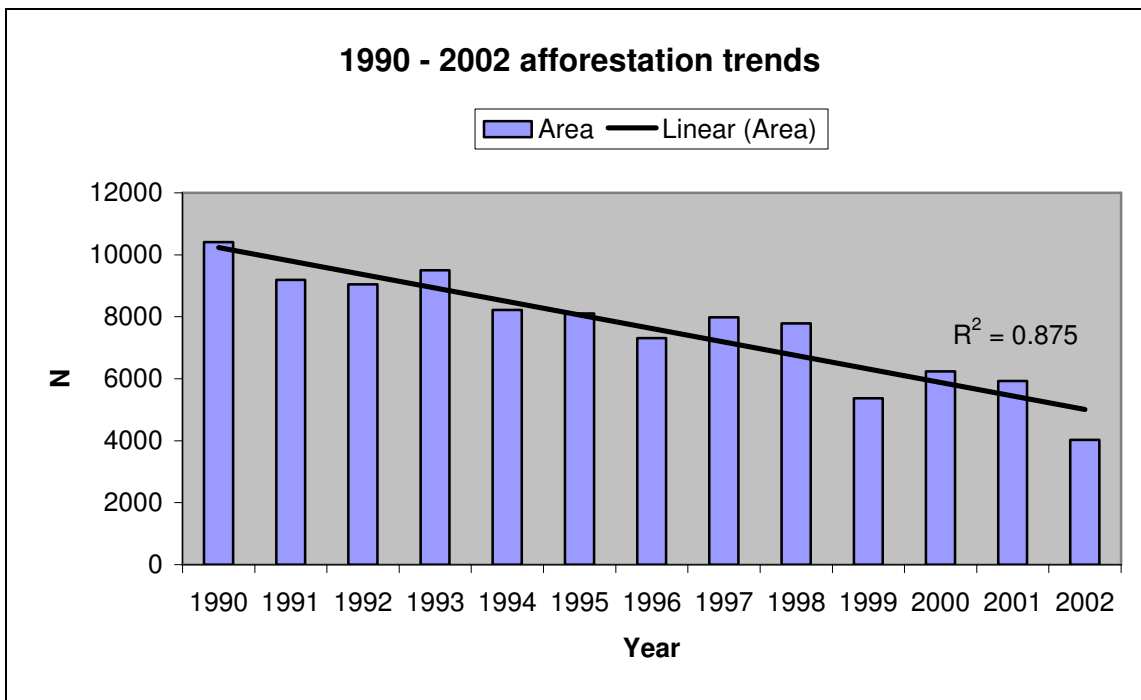**1990 - 2002 afforestation trends**

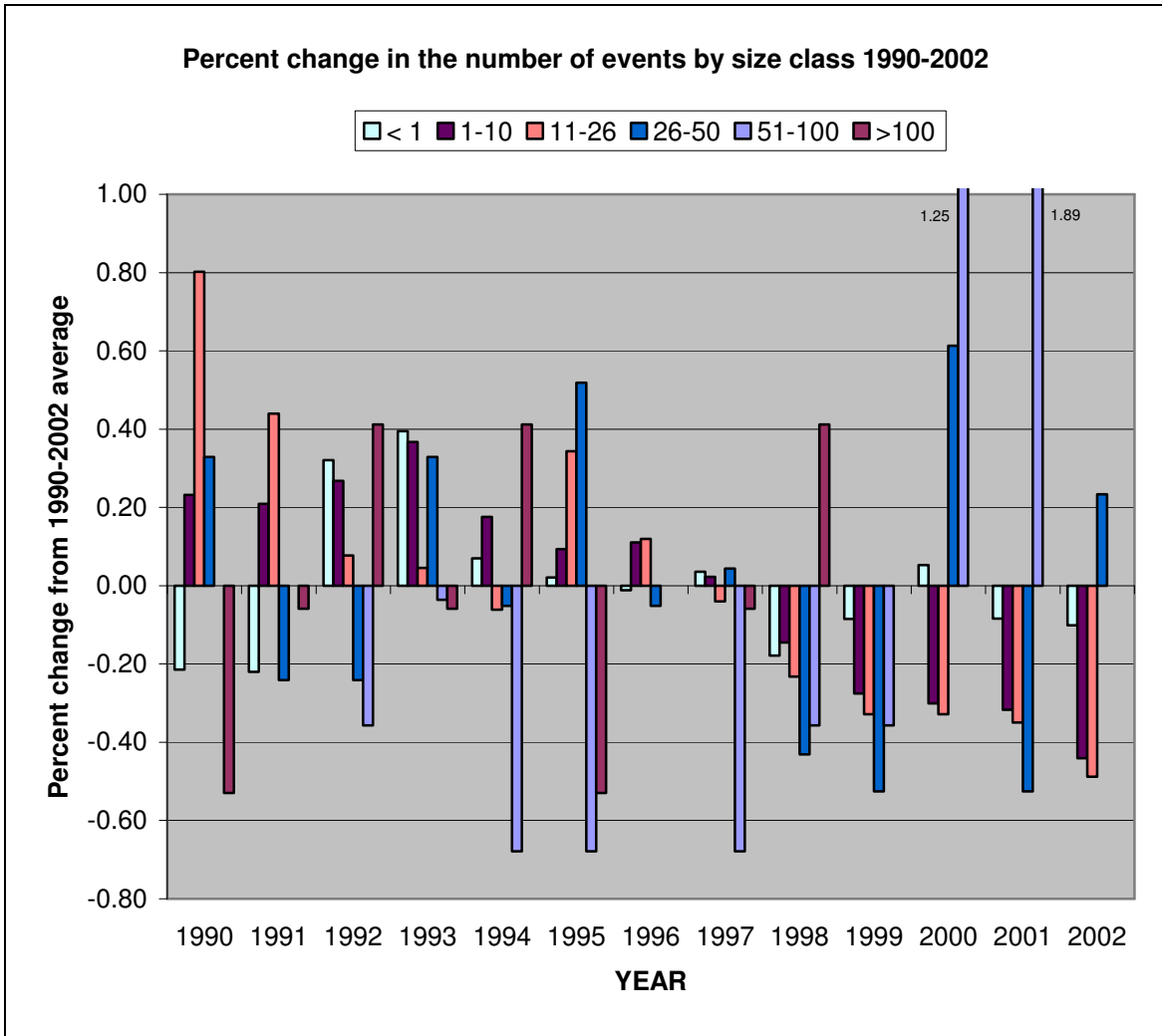Figure 1 National Trends in Afforestation Plantings 1990-2002

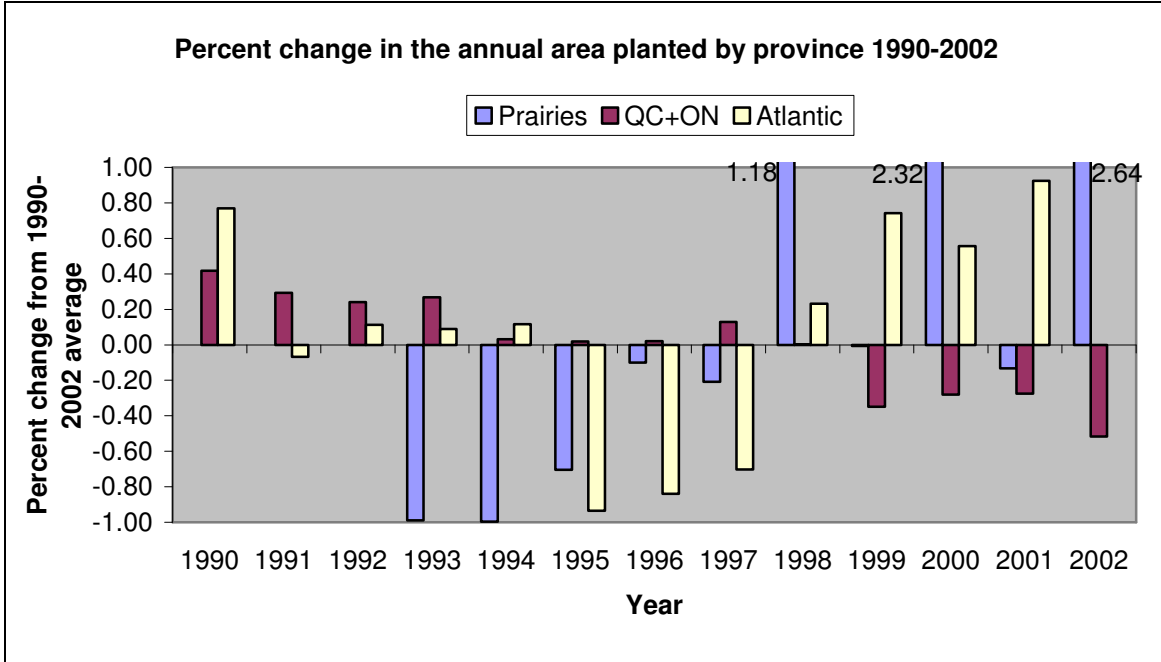**Figure 2 Percent change in the number of events by size class 1990-2002**

Figure 3 Percent change in the annual area planted by province 1990-2002

8. References

Crane Management Consultants. Assessment of Impacts of FRDA II's Private Woodlands Sub-program. FRDA. 1996.

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