CANADA

INFORMAL SUBMISSION TO THE AWG-KP
Information and Data on Land Use, Land-Use Change and Forestry (LULUCF)

September 2009

1. INTRODUCTION

Canada believes that improvements to LULUCF rules should be guided by three objectives: 1) an improved incentive structure for sustainable land management, 2) an accurate reflection of emissions to and removals from the atmosphere, and 3) a focus on anthropogenic emissions and removals. Improved rules will need to accommodate the diversity of national LULUCF characteristics while ensuring environmental effectiveness.

Canada is pleased to provide this informal submission of information and data to enable Parties to better understand the characteristics and contribution of its LULUCF sector and the implications of options for the treatment of LULUCF. The next section provides a general overview of Canada's LULUCF emissions and removals. The third section discusses in greater detail emissions and removals for forest management.

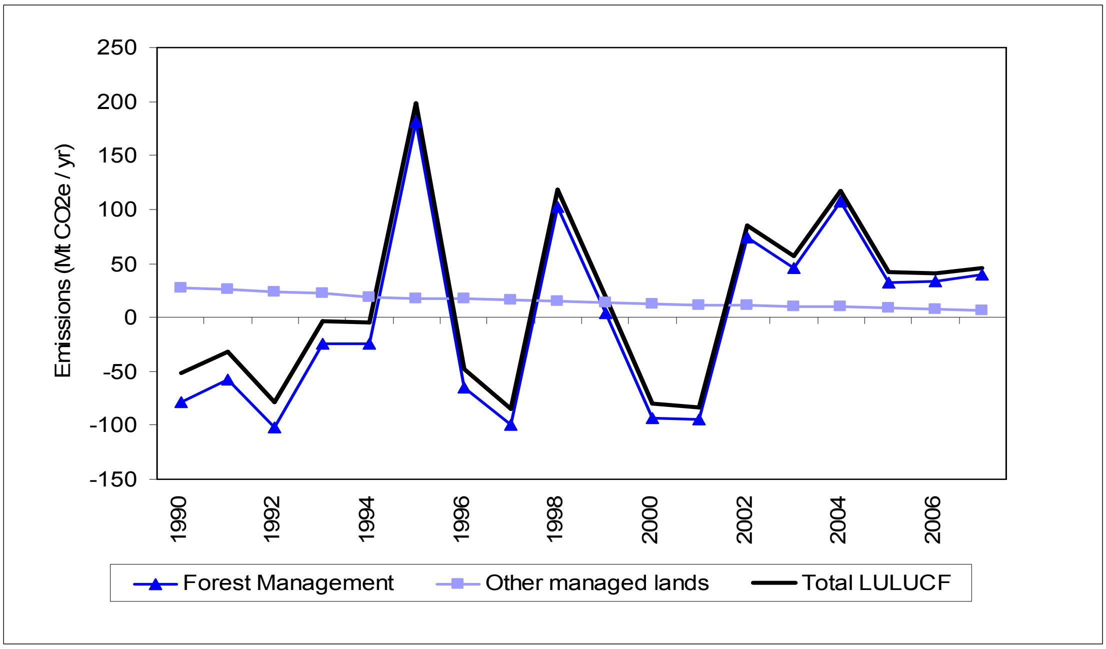
2. LULUCF EMISSIONS AND REMOVALS

Table 1 shows emissions and removals for land categories as reported in Canada's 2009 GHG Inventory Submission for 1990-2007. Methodological details and discussion of uncertainties can be found in the National Inventory Report, available on the UNFCCC website. The table also shows data for emissions and removals for specific activities: afforestation/reforestation, deforestation, cropland management and forest management.

Canada's LULUCF estimates are dominated by the Forest Land category which in turn is dominated by forest management (see Figure 1). Estimates for Canada's forest management display both the largest and the most variable emissions/removals of any LULUCF land category or activity – a range of almost 300 Mt CO_2e over the 1990-2007 period. This variability, as explained below, is a result of natural disturbances (fire and insect infestations) rather than human activity. As a result of this variability the LULUCF sector has fluctuated from a 13 percent offset to a 31 percent addition to Canada's total anthropogenic emissions from other sectors since 1990. Thus emissions and removals in the LULUCF sector cannot be meaningfully compared or combined with emissions from other sectors because the LULUCF estimates include the impact of natural disturbances.

The Table 1 estimates are based on a consistent definitional framework with the differences in estimates for UNFCCC land categories and Kyoto activities reflecting the Kyoto accounting rules. This means that estimates for afforestation/reforestation and deforestation include only emissions and removals from activity that occurred since 1990. Relatively little afforestation has occurred in Canada – an average of about 9 thousand hectares per year since 1990 – so that removals are low but slowly rising as plantations grow.

Figure 1: Canada's LULUCF emissions and removals.



The area affected by deforestation annually has fallen since 1990 and in 2007 affected 49 thousand hectares, with just over half resulting from conversion of forest to agricultural land. Emissions from a deforestation event occur in the year of forest conversion and in subsequent years as biomass decays: Canada's emissions from deforestation since 1990 have risen slightly not due to an increase in deforestation rates but because delayed emissions (i.e. emissions that occur over time as biomass decays) have grown.

Canada's 48 million hectares of Cropland includes areas of field crops, summerfallow, hayland and tame or seeded pasture. The estimates for cropland management in Table 1 differ from those for the Cropland category because, in keeping with Kyoto rules, cropland management does not include emissions resulting from conversion of forest to Cropland since 1990 – these emissions are included under deforestation. However, cropland management does include delayed emissions resulting from conversion of forest to Cropland (i.e. deforestation) before 1990, as well as emissions and removals resulting from grassland converted to Cropland. Cropland emissions and removals are affected by changes in soil organic carbon reflecting changes in management practices: changes in the proportion of annual and perennial crops, the intensity of tillage practices and the proportion of area in summerfallow. Also included in the estimates are emissions and removals from mineral soils, emissions from agricultural lime application and cultivation of organic soils, and emissions and removals due to changes in woody biomass from specialty crops.

Table 1: Canada's emissions and removals from LULUCF land categories and activities (Mt CO_2e) (1).

Year	LULUCF Land Categories (2)					LULUCF Activities (based on Kyoto definitions)			
	Forest Land	Cropland	Wetland	Settlements	Total LULUCF	Afforestation/ Reforestation	Deforestation	Cropland Management (3)	Forest Management (4)
1990	-78.7	12.7	5.0	9.5	-51.6	0.0	13.5	4.3	-78.7
1991	-57.8	12.1	4.9	9.3	-31.5	0.0	13.9	3.7	-57.8
1992	-102.2	10.3	4.2	8.5	-79.2	0.0	13.0	2.6	-102.2
1993	-25.1	9.2	4.0	8.7	-3.3	-0.1	13.3	1.6	-25.0
1994	-24.0	7.6	2.6	8.6	-5.3	-0.1	12.9	0.6	-24.0
1995	180.6	5.8	3.3	8.6	198.4	-0.1	12.6	-0.3	180.7
1996	-65.5	5.3	3.3	8.5	-48.3	-0.1	13.3	-1.2	-65.4
1997	-99.9	4.2	3.3	8.2	-84.2	-0.1	13.1	-2.2	-99.8
1998	102.6	3.9	3.6	8.2	118.3	-0.2	14.4	-3.1	102.8
1999	3.6	2.6	3.7	8.1	18.0	-0.2	14.3	-4.0	3.8
2000	-93.5	1.9	3.1	8.1	-80.3	-0.2	14.2	-4.9	-93.2
2001	-95.5	0.9	3.0	7.9	-83.8	-0.3	13.9	-5.8	-95.2
2002	73.3	0.5	2.9	8.0	84.6	-0.3	14.6	-6.7	73.6
2003	45.6	-0.5	3.3	7.9	56.3	-0.3	15.0	-7.5	45.9
2004	107.0	-1.0	3.2	8.0	117.3	-0.4	15.7	-8.4	107.4
2005	32.3	-2.1	3.0	8.1	41.4	-0.4	15.7	-9.2	32.8
2006	32.9	-2.3	2.8	8.0	41.4	-0.6	15.9	-9.9	33.5
2007	38.3	-3.4	2.7	7.8	45.5	-0.7	15.5	-10.7	39.0
2010						-1	16	-11	55-190
2015						-1	16	-11	55-190
2020						-2	16	-11	55-190

(1) 1990-2007 values for LULUCF land categories are from Canada's 2009 GHG Inventory Submission. 1990-2007 values for LULUCF activities are consistent with the 2009 GHG Inventory Submission. Activity projections are for business-as-usual.

(2) Estimates for land categories include emissions and removals from land converted to the category in accordance with IPCC guidance. Canada defines Grassland as rangeland on which the only management activity has been grazing domestic livestock (the land was never cultivated). There is no evidence that these lands have been losing or gaining soil organic carbon due to human activity and Canada does not prepare estimates for this land.

(3) Estimates include emissions from grassland converted to Cropland, and delayed emissions from pre-1990 conversion of forest to Cropland. Emissions from forests converted to Cropland or other land uses since 1990 are included under deforestation.

(4) Estimates include removals from pre-1990 conversion of land to forest. Removals from conversion of land to forest since 1990 are included under afforestation. The projection range is the average of the annual 10th to 90th percentile probability range for 2010-20 based on analysis using probability distributions for natural disturbances, which are highly variable and unpredictable. See Kurz, W.A. et al (2008), Risk of natural disturbances makes future contribution of Canada's forests to the global carbon cycle highly uncertain. *Proceedings of the National Academy of Sciences*, 105, 1551-1555.

Projections for afforestation/reforestation, deforestation and cropland management shown in Table 1 are extrapolations based on current trends and expectations about future business-as-usual activity. For forest management the projection is also based on a forecast of future management activity but the projection shows a range reflecting the variability of natural disturbance impacts: these disturbances are too variable and unpredictable in Canada to allow meaningful single projections of their impact.

3. FOREST MANAGEMENT EMISSIONS AND REMOVALS

Current rules for forest management are in particular need of improvement. Canada believes that achieving the objectives outlined above for improved LULUCF rules requires the following rules for forest management accounting.

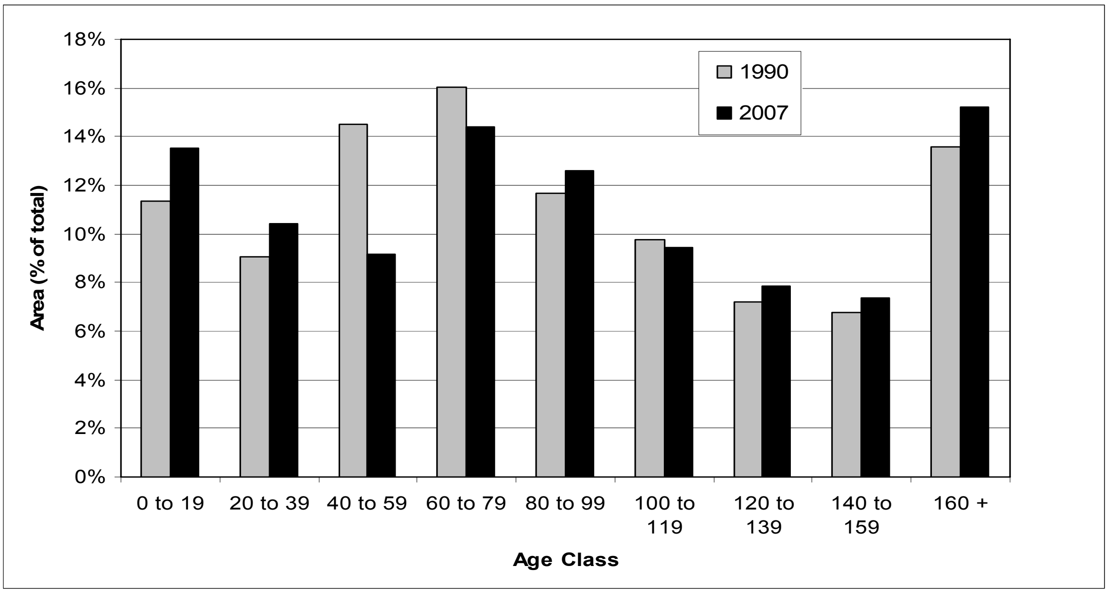
- To ensure improved incentives, accounting should compare commitment period emissions/removals with a reference level that reflects business-as-usual activity and allows natural and indirect human impacts (e.g. CO_2 fertilization, nitrogen deposition) to be factored out.
- To improve accuracy, emissions associated with harvested wood products should be accounted as they occur.
- To focus the accounting on anthropogenic emissions and removals, the impacts of natural disturbances in the commitment period should be removed from accounting.

Canada's managed forest of 230 million hectares – the area subject to forest management – covers about 75% of the country's forest and includes all areas managed for sustainable harvest of fibre and/or under protection from fire. Emissions and removals since 1990 are influenced by the age structure of the forest, harvesting and other management activities and natural disturbances, each of which is discussed below, followed by a discussion of the impact of natural disturbances on forest management estimates. The final part of this section outlines implications for forest management accounting.

3.1. Age Structure

Figure 2 shows the age structure of Canada's managed forest drawn from forest inventory data used in compiling emissions and removals estimates for Canada's GHG inventory. The managed forest is composed of relatively old stands with about 40 percent being 100 years or older in 2007, slightly more than in 1990. This age structure reflects past natural disturbances and management. Having a relatively old forest has a number of implications. One is that older stands grow more slowly have than younger stands and are a smaller sink. Moreover, through natural processes they are more likely than younger stands to be converted to sources, for example as a result of insect infestation, and it will take several decades before they become sinks again. Thus relative to a younger forest Canada's forest has less capacity for removals and mitigation potential is lower. In addition to being a relatively old forest, Canada's forest also has relatively low productivity compared to many other countries characterized by warmer climates. This too lowers mitigation potential.

Figure 2: The age-class structure of Canada's managed forest, 1990 and 2007.



3.2 Harvesting

Table 2 shows harvesting data drawn from the Canadian Council of Forest Ministers' National Forestry Database (available at http://nfdp.ccfm.org/). Harvest volumes typically vary from year to year by less than 10%, with the larger changes usually related to changes in broader economic activity in Canada and abroad (e.g. as occurred in the early 1990s and is occurring now). Table 2 also shows the emissions resulting from harvested wood using the IPCC default and production approaches for harvest wood product (HWP) emissions, derived from analysis for Canada's 2009 GHG Inventory Submission. The production approach more accurately estimates actual emissions to the atmosphere as they occur.

3.3 Forest Natural Disturbances

Table 3 provides data on the area affected by natural disturbances in Canada's managed forest and the emissions that result. Wildfires and insects are an important natural part of Canada's forest ecosystems that help renew the forest but they also affect a valuable resource and the livelihood of communities and, in the case of fire, threaten people's safety. It is neither ecologically desirable nor economically feasible to completely suppress them (see the Annex for a summary of natural disturbance management in Canada). The managed forest is strongly affected by these unpredictable and difficult to manage disturbances, with large inter-annual variability in the area affected. Moreover, vulnerability to natural disturbances is expected to increase in the future due to climate change – areas impacted are likely to increase, and timing, severity and frequency of disturbances are likely to change[1].

[1] Lemprière et al (2009). *The importance of forest sector adaptation to climate change*. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre. Edmonton, Alberta. Information Report NOR-X-416E.

Table 2: Harvesting in Canada's managed forest.

Year	Harvest (million m^3)	HWP Emissions (Mt CO_2e)	
		IPCC Default Approach (1)	Production Approach (2)
1990	163	147.2	135.7
1991	161	145.8	135.5
1992	170	154.4	141.1
1993	176	159.2	144.2
1994	183	167.0	148.5
1995	188	172.1	151.5
1996	183	167.2	145.7
1997	189	171.0	147.3
1998	177	162.2	139.1
1999	198	181.8	153.3
2000	202	184.2	154.8
2001	186	170.0	141.3
2002	196	179.1	148.8
2003	181	165.5	136.0
2004	208	190.0	158.8
2005	203	186.0	155.4
2006	187	171.1	144.0
2007	180	165.4	144.7

(1) Estimated using an assumption of instant oxidization of harvested carbon. In reality, HWP emissions occur over time depending on the product, its use and disposal.
(2) Estimated emissions from HWPs produced by Canada, including the pool of HWPs created since 1961, assuming the fate of exported HWPs is similar to the fate of HWPs in Canada.

Table 3: Impact of natural disturbances since 1990 in Canada's managed forest.

Year	Area Affected (1) (thousand hectares)			Emissions (2) (Mt CO_2e)			
	Fire	Mountain Pine Beetle	Other Insects	Fire Immediate Emissions	Fire Delayed Emissions / Removals	Insect Delayed Emissions / Removals	Total
1990	268	38	1,317	43.2	2.1	4.6	49.9
1991	551	47	270	65.7	5.3	3.8	74.8
1992	95	43	27	14.3	5.7	3.6	23.6
1993	767	44	11	89.0	6.9	3.7	99.6
1994	514	31	124	86.2	8.9	3.5	98.6
1995	2,183	27	184	291.4	18.8	4.2	314.4
1996	531	44	102	61.6	22.8	4.2	88.6
1997	148	70	103	17.0	22.7	4.0	43.7
1998	1,503	96	295	224.0	30	4.0	258.0
1999	638	146	485	89.1	31.8	2.9	123.8
2000	92	230	530	11.1	30.6	6.4	48.2
2001	191	670	1,571	36.7	30.8	9.5	77.0
2002	1,174	1,789	1,923	166.5	35.5	18.9	220.9
2003	755	3,451	2,454	136.2	41.5	26.2	203.9
2004	743	4,453	369	150.9	44.9	39.5	235.3
2005	635	6,335	68	73.9	44.7	48.0	166.6
2006	552	7,806	-	82.8	44.8	51.9	179.4
2007	572	6,965	-	77.6	47.1	63.7	188.4

(1) Areas are for all fires and insect infestations included in Canada's Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) used to produce estimates for Canada's GHG Inventory Submission.
(2) Preliminary emission and removal estimates for the areas affected by natural disturbance since 1990, including immediate combustion emissions, delayed emissions due to decay of trees killed since 1990, and subsequent removals as forest re-grows. Emissions from slash burning and subsequent decay are not included.

Since 1990, the annual area burned in the managed forest has fluctuated from about 95 thousand to 2,200 thousand hectares. There has been an upward trend in area burned since the 1970s and scientists forecast that it will increase substantially in coming decades[2]. Forest fires in Canada have a number of key characteristics.

- In a severe fire year many thousands of fires can be recorded but even in low fire years several thousand fires will occur. However, typically it is a relatively small number of large fires (e.g. over 200 hectares in size) that contribute most of the area burned.
- Over 90 percent of the area burned results from naturally ignited fires. Irrespective of the ignition source, the area that burns annually in Canada does so after significant efforts to control fire (more than $400 million is spent on average each year on suppression). The frequency, severity and size of fires, and the ability to control them, are highly dependent on weather conditions.
- Fire causes an immediate and significant release of GHGs in the year of the fire (see Table 3), but the amount of carbon in the dead organic matter that remains is significant. It decays over a period of time and contributes to additional, delayed fire-related emissions. Thus many years may pass before removals resulting from forest re-growth begin to exceed the emissions from decay.

Since 1990 the area affected by insects has increased substantially mainly due to a mountain pine beetle infestation in western Canada though other major infestations have also occurred. The mountain pine beetle infestation has been triggered by warmer climate, while an emerging major spruce budworm is a natural cyclic phenomenon in Canada's eastern boreal forest. Insect infestations can cause growth reductions or can kill trees, resulting in emissions over decades as they slowly decay. The impact on emissions depends on the extent of stand mortality, which can range from relatively little to very substantial.

The estimates in Table 3 of emissions and removals due to natural disturbances since 1990 are preliminary, and include removals on forest areas re-growing after disturbance since 1990. These emissions fluctuated tremendously and annually were equivalent to between 5 and 50 percent of Canada's total emissions excluding LULUCF. In recent years they have consistently been over 20 percent. It is important to note that these are emissions that occur after significant efforts to protect the forest from natural disturbances.

3.4 Forest Management Emissions/Removals

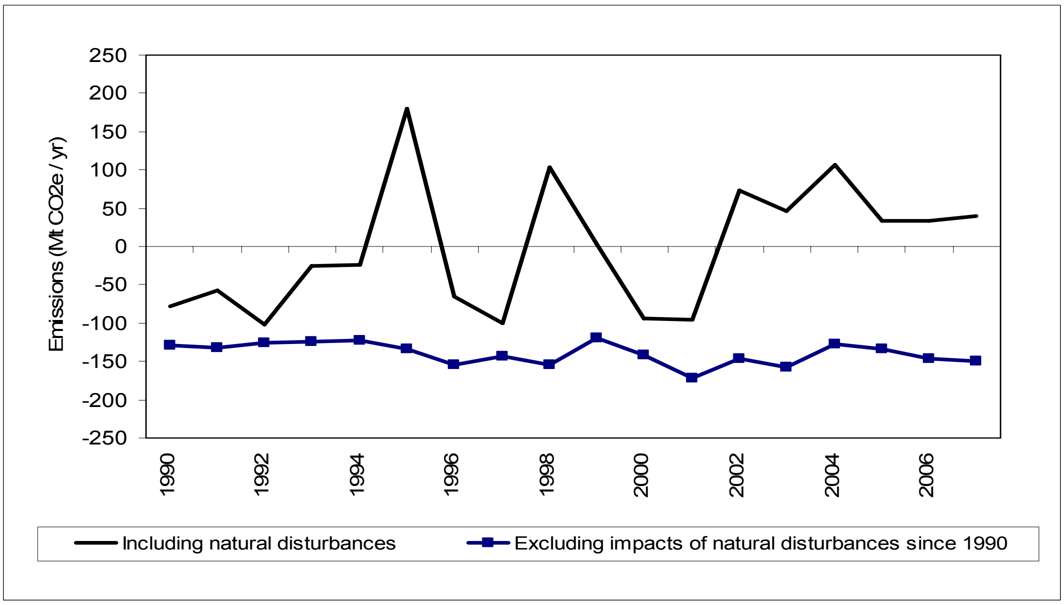
Table 1 showed that Canada's reported emissions for forest management are highly variable and dominate the LULUCF sector. Table 2 showed that harvesting, the major management practice that affects carbon, displays relatively little variation from year to year: the substantial variation in emissions and years of large emissions are not due to management. Table 3 highlighted the size and variability of natural disturbances. Emissions and removals in the managed forest have been highly correlated with the area of forest that burns each year, an influence that is unpredictable and uncontrollable. Thus Canada's managed forest has fluctuated between being a large source and a large sink from year to year depending on the amount of wildfire that occurs. More recently it has become a source

[2] Flannigan, M.D. et al (2005) Future area burned in Canada. *Climatic Change*, 72, 1-16. Balshi, M.S. et al (2009). Assessing the response of area burned to changing climate in western boreal North America using a Multivariate Adaptive Regression Splines (MARS) approach. *Global Change Biology*, 15, 578-600.

due mainly to the mountain pine beetle infestation since 1999[3]. We predict that the managed forest will be a net source for many years due to the combination of fires, the long-term impact of the mountain pine beetle infestation in western Canada and the emerging spruce budworm infestation in eastern Canada[4].

Figure 3 shows the impact of natural disturbances by comparing Canada's emissions for forest management from Table 1 with preliminary estimates which exclude the impact of natural disturbances that occurred since 1990. It is important to note that the latter estimates are approximate and based on a land base that is declining in size over the period as areas subject to natural disturbances are removed. These estimates are NOT meant to represent a forest management reference level – they are shown here only to indicate the substantial impact of natural disturbances. Canada believes a reference level is most appropriately obtained by projecting business-as-usual emissions and removals in the commitment period and making no assumption about future natural disturbances (Canada's forward-looking baseline proposal). After the commitment period the actual natural disturbances would be known and their impact could be removed from estimated emissions and removals in the commitment period. This would then provide commitment period estimates that can be compared to the reference level (since neither includes natural disturbance impacts).

Figure 3: GHG emissions/removals in Canada's managed forest showing the impact of natural disturbances that occurred since 1990



Estimates including natural disturbance emissions are based on information reported in Canada's GHG Inventory Submission and shown in Table 1. Estimates excluding natural disturbance impacts are preliminary and exclude all emissions (and subsequent removals as forest re-grows) that result from natural disturbances that occurred since 1990. Over the period these preliminary estimates are based on a land base that is declining in size as areas that are subject to natural disturbances (and converted to carbon sources for many years or decades as dead biomass decays) are removed from the estimates.

[3] Kurz, W.A. et al. (2008). Mountain pine beetle and forest carbon feedback to climate change. *Nature,* 452, 987-990.

[4] Kurz, W.A. et al (2008). Risk of natural disturbances makes future contribution of Canada's forests to the global carbon cycle highly uncertain. *Proceedings of the National Academy of Sciences*, 105, 1551-1555.

3.5 Implications for Accounting

The implications of unpredictable, highly variable and large natural disturbance impacts for accounting include the following.

1. Because GHG accounting should focus on anthropogenic emissions the impacts of natural disturbances should be removed from the accounting. This would ensure that accounting provides clear incentives to reduce emissions and increase removals through changes in human activity.

2. Large inter-annual variations in natural disturbances and a trend toward higher disturbance rates due to climate change mean that:
    a. Natural disturbance impacts on carbon do not average out over time. Uptake from forest regrowth after natural disturbance removes CO_2 from the atmosphere but does not remove non-CO_2 gases emitted by fires – thus even if the carbon balance were to average out over time, the non-CO_2 emissions would not be balanced.
    b. The proposal to "carry-over" emissions from a commitment period characterized by high natural disturbances to another with low natural disturbances will not address the problem.
    c. A simple discounting approach to address the impact of natural disturbances cannot work due to the extreme variability.
    d. It is not possible to use a simple historically-based reference level to remove the impact of natural disturbances from the accounting.

3. Even after substantial protection efforts, significant emissions from natural disturbances occur every year in Canada, not just on an exceptional basis. This means that approaches to natural disturbances based on "extreme" or "major" natural disturbances, *force majeure*, or "compliance risk" may not adequately reflect the nature of natural disturbances in Canada.

4. Reference levels that include natural disturbance impacts may result in undeserved credits or debits when compared to commitment period emissions/removals. This is because natural disturbances in the commitment period are unpredictable and may result in emissions that are lower or higher than the emissions included in the reference level.

Canada's forward-looking baseline proposal, described in its April 2009 submission (http://unfccc.int/resource/docs/2009/awg8/eng/misc11.pdf) and previous submissions, effectively addresses the impacts of natural disturbances and other factoring out issues. It therefore focuses accounting on management and provides incentives to change management in a way that reduces emissions and increases removals.

ANNEX: NATURAL DISTURBANCE MANAGEMENT IN CANADA

Canada spends over $400 million per year fighting forest fires. However, it is neither economically possible nor ecologically desirable to eliminate wildfires – in fact lightening fires are a natural and essential part of forest renewal. This makes managing wildfire a complex task: federal, provincial and territorial governments together have developed the Canadian Wildland Fire Strategy to set out the future of fire management as well as options to mitigate hazards, improve preparedness and recovery activities and maintain response capability (www.ccmf.org/english/coreproducts-cwfs.asp). The Canadian Interagency Forest Fire Centre provides management, information and operational fire-control services to provincial, territorial and federal fire management agencies (www.ciffc.ca). It also coordinates sharing of resources with the United States and other countries. The Canadian Wildland Fire Information System, a computer-based fire management system, is used to monitor fire danger conditions (http://cwfis.cfs.nrcan.gc.ca). Daily weather conditions are collected from across the country and used to produce fire weather and fire behavior maps. In addition, satellites are used to detect fires (hotspots) and to contribute information about the location and size of fires which are then delineated to determine the area annually burned. The knowledge stemming from these tools and strategies is used by forest managers to make decisions in the field about fire response strategies.

Like wildfire, it is not possible to eliminate pest disturbances and in fact they are a necessary component of the forest ecosystem. Pest management experts must balance this with concern about their effect on society and the economy, and take into account the uncertainties associated with a changing climate. Pest species from other countries are of particular concern because, in the absence of predators or other natural forces in Canada to control their population, they may become established and invasive. Canada's federal, provincial and territorial governments have recognized that many methods used to manage insects through interventions, such as pesticide application and accelerated and salvage harvesting, are no longer sufficient. They have developed an evolving National Forest Pest Strategy to address in a proactive and collaborative way the challenges posed by native and alien pests (http://canadaforests.nrcan.gc.ca/articletopic/187). The strategy builds on the existing Invasive Alien Species Strategy and outlines how jurisdictions can better work together to prevent, detect, assess and respond to insect pests (www.ec.gc.ca/eee-ias). It is based on a risk analysis framework involving assessment, response and communication.

In 2007, the National Forest Pest Strategy framework was used to assess whether the mountain pine beetle outbreak in British Columbia presents a threat to Canada's boreal forests. This assessment indicated the need for a response that would at least slow the beetle's spread eastward, giving time for resource managers to try to address the susceptibility of their forests. A large-scale effort has been mounted to address this challenge. Research and programming efforts are focused on forest management options to mitigate impacts, reduce the risk of future epidemics, rehabilitate affected forest lands, and facilitate response options in non-commercial forest lands. Similarly, efforts are underway in eastern Canada to reduce the impact caused by an expected major spruce budworm outbreak in the near future. Tools used include a computer-based decision support system that links inventory data and spruce budworm outbreak information to assist foresters in planning and carrying out response activities.