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ANALYSIS

Managing without growth

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ABSTRACT

There are three main arguments why developed countries should consider managing without growth: 1) continued economic growth worldwide is not an option owing to environmental and resource constraints, and so developed countries should leave room for growth in developing countries where the benefits of growth are evident; 2) in developed countries growth has become uneconomic in the sense that it detracts more from well-being than it adds; and 3) economic growth in developed countries is neither necessary nor sufficient for meeting specific policy objectives such as full employment, no poverty and protection of the environment.

This paper explores various growth scenarios for Canada over the medium range to 2020 using LOWGROW, a dynamic simulation model. After describing LOWGROW, a scenario is presented that shows conditions under which the rate of unemployment in Canada could be reduced to historically low levels, poverty eliminated and greenhouse gas emissions reduced to comply with Canada's commitment under the Kyoto Protocol, without relying on economic growth. This is not to say that zero growth should itself become a policy objective. Rather that the dependence on and defence of economic growth should not be an obstacle to fulfilling more specific welfare enhancing objectives of full employment, eliminating poverty, and protecting the environment. The paper concludes with some policy implications for managing without growth followed by an annex which provides a technical description of LOWGROW.

1. Introduction

There are three main lines of argument why the pursuit of economic growth should lose its position as the number one economic policy objective in developed countries and why these countries should consider managing without growth: 1) continued economic growth worldwide is not an option owing to environmental and resource constraints, and so developed countries should leave room for growth in developing countries where the benefits of growth are evident; 2) in developed countries growth has become uneconomic in the sense that it detracts more from well-being than it adds; and 3) economic growth in developed countries is neither necessary nor sufficient for meeting specific policy objectives such as full employment, no poverty and protection of the environment.

There is an extensive literature exploring these arguments much of which is summarized in Common and Stagl (2005, chapters 6 and 7). The arguments will not be rehearsed here though readers interested in the major primary sources will find them in the bibliography.

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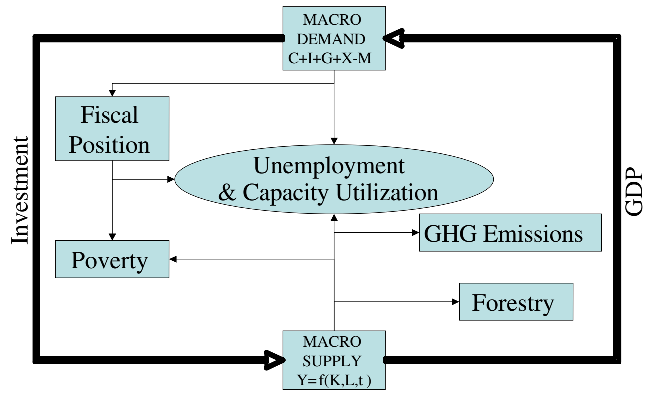

Fig. 1 – Simplified structure of LOWGROW.

The purpose of this paper is explore no and low growth scenarios for Canada over the medium range to 2020 using LOWGROW, a dynamic simulation model. After describing LOWGROW, a scenario is presented that shows conditions under which the rate of unemployment in Canada could be reduced to historically low levels, poverty eliminated and greenhouse gas emissions reduced to comply with Canada's commitment under the Kyoto Protocol, without relying on economic growth. This is not to say that zero growth should itself become a policy objective. Rather that the dependence on and defence of economic growth should not be an obstacle to fulfilling more specific welfare enhancing objectives of full employment, eliminating poverty, and protecting the environment.

The paper concludes with some policy implications for managing without growth followed by an annex which provides a technical description of LOWGROW.

2. Simulating low/no growth in the Canadian economy

LOWGROW has been built using STELLA chosen for its flexibility (it can accommodate quantitative and qualitative variables), its facility for simulating change over time (STELLA is well-suited for solving systems of difference equations), the ease with which it can handle 'what if' analysis for exploring the implications of policy options and different assumptions, the transparency of the models (all flow diagrams and equations are accessible) and its attractive user interface. Fig. 1 shows the simplified structure of the simulation model. Key assumptions, equations and data sources used in LOWGROW are detailed in the Appendix. All monetary values in LOWGROW are in constant 1997 dollars unless otherwise specified.

LOWGROW includes a Cobb–Douglas aggregate production function (macro supply in Fig. 1) in which GDP Supplied is a function of the employed stock of produced capital (i.e. the stock of produced capital multiplied by a capacity utilization factor), the employed labour force (i.e. the labour force multiplied by the rate of employment) and time (to account for productivity gains in the use of capital and labour.).[1]

LOWGROW also includes equations for consumption, business investment, government expenditure, exports and imports that are the components of GDP Demanded (macro demand in Fig. 1). GDP Supplied is an independent variable in the equations for these components of aggregate demand. If the aggregate demand exceeds the aggregate supply the rate of unemployment declines and the rate of capacity utilization increases and if the aggregate supply exceeds the aggregate demand the rate of unemployment rises and the rate of capacity utilization declines.

There is no explicit monetary sector in LOWGROW. The assumption is made that the Bank of Canada will continue to implement a monetary policy focussed on containing the rate of inflation at about 2%/year. The prime rate of interest is determined exogenously in LOWGROW.

Poverty is represented in LOWGROW as the number and percentage of Canadians below the Low Income Cutoff (LICO). LICO is "a threshold below which a family is likely to spend significantly more of its income on food, shelter, and clothing than the average family." (Giles, 2004, p.10) In 1992 the average Canadian family spent 43.6% of after-tax income on food, shelter and clothing (Giles, 2004, p.10). The LICO methodology adds 20 percentage points to this average, representing the situation of a family that is spending a significantly higher proportion of income than the average on necessities. A family with an income below the cutoff is counted as being in poverty.

In LOWGROW the number of people living below LICO is affected by two factors. First, starting from an initial value of 3.55 million in 2003 (Statistics Canada, 2003, Table 8.1-1), LOWGROW allows income to be redistributed to bring people

[1] The Cobb–Douglas production function is a highly simplified representation of a complex and complicated national production system. Cobb–Douglas production functions have been criticized by ecological economists such as Georgescu-Roegen (1971) and Daly (1997) for inconsistency with the laws of thermodynamics. However, their main concern is with the use of a Cobb–Douglas production function for describing substitution possibilities among inputs over the long-term. This important issue is outside the scope of this paper.

up to LICO as a result of a policy intervention ($5900 per individual and $7000 per family below LICO in current dollars, Statistics Canada, 2003, Table 8.3-3). LOWGROW computes the cost of raising any specified proportion of people living below LICO up to LICO. In practice there are many forms of direct and indirect ways of providing income support. The 'additional transfers' computed in LOWGROW are a proxy for any and all of these.

Second, poverty is related to the prevalence of unemployment. In LOWGROW the simplifying assumption is made that an unemployed person who becomes employed receives an income equal to or greater than LICO and that an employed person who becomes unemployed experiences a reduction in income that takes them below LICO. This assumption is consistent with the close correlation between unemployment and poverty in Canada between 1994 and 2003, the longest period for which consistent measures of both variables is available.

LOWGROW also calculates the UN's Human Poverty Index, HPI (United Nations Development Programme, 2005). The HPI defined for developed countries is based on four variables: the probability at birth of not surviving to age 60, the percent of adults lacking functional literacy skills, the percent of the population below the income poverty line (defined as 50% of the median income which is highly correlated with LICO, the variable used in LOWGROW), and the long-term unemployment rate (lasting 12 months or more.) In 2005 the HPI-2 for Canada was 9th lowest (i.e. 9th best) among 17 selected OECD countries (United Nations Development Programme, 2005).

LOWGROW keeps track of the fiscal position (i.e. surplus/deficit and debt) of the three levels of government combined in Canada: federal, provincial and municipal. According to data from Statistics Canada the change in net debt of all three levels of government is not equal to the reported annual surplus or deficit, defined as outlay minus income. (Statistics Canada, 2004; Department of Finance, 2004). This discrepancy is probably due to accounting rules and conventions that are not well explained in the relevant government documents. For the purposes of LOWGROW, a regression equation was estimated that relates the change in net debt to the annual surplus or deficit.

Finally, LOWGROW has an environmental dimension through the inclusion of greenhouse gas emissions (GHG), a Kyoto compliance module, and a sub-model of Canada's forestry sector.

LOWGROW runs from the start of 2000 to the start of 2020, a total of 20 years. For the years 2000–2003 LOWGROW reports values from Statistics Canada of the key economic variables. The model's equations take over at the start of 2004. The 'base case' scenario in which government policies regarding spending, taxes, and services delivered are unchanged from 2003 with no policy interventions by the model user), is shown in Fig. 2 below.

Running simulations with LOWGROW is facilitated by STELLA's interface function that allows a 'dashboard' to be created giving the user the power to change key variables and assumptions in the model. Fig. 2 shows the dashboard used to operate LOWGROW, and results of the base case for real GDP (1), the rate of unemployment (2), the debt to GDP ratio (3), GHG emissions (4), and poverty (5). All of the variables in Fig. 2 are converted to indexes with their actual values at the start of 2000 as 100 for ease of comparison. A companion graph (not shown) gives the actual data for each variable. The model reports results from the start of 2000 to 2020.

Some of the buttons on the "dashboard" screen shown in Fig. 2 take the user to more information about LOWGROW (i.e. Instructions, Welcome Page). Other buttons (i.e. GDP, Fiscal,

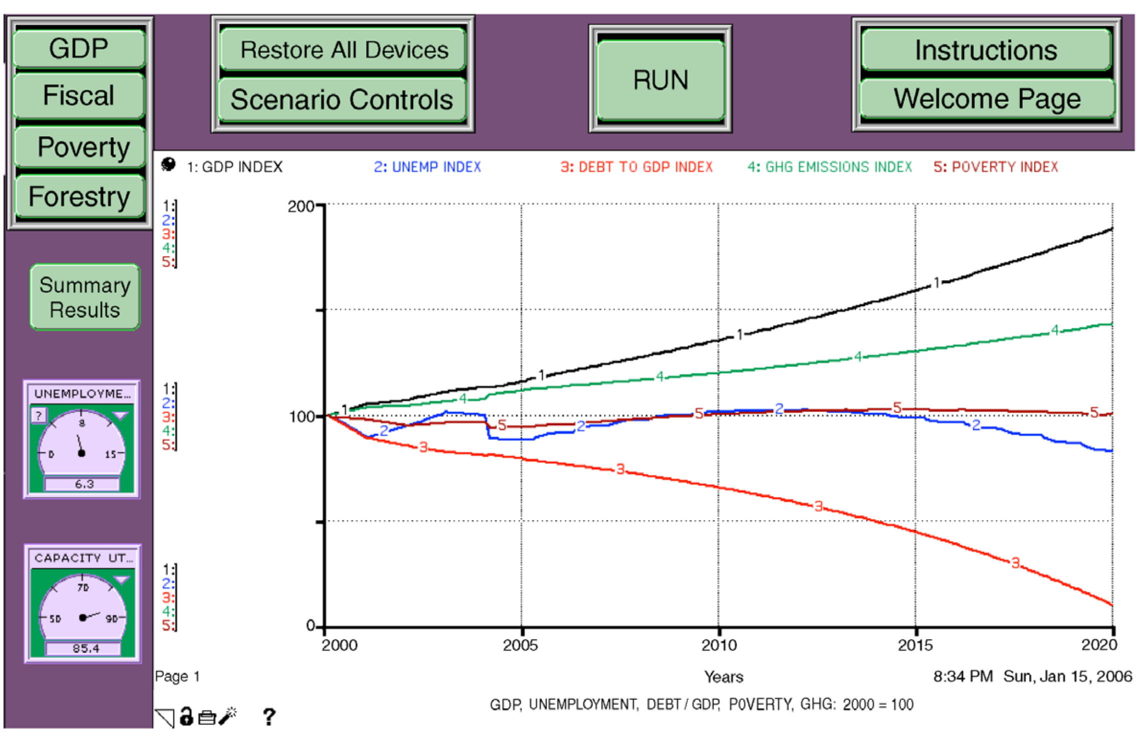

Fig. 2 – LOWGROW'S dashboard and base case scenario.

Poverty, Forestry, Summary Results) link directly to more detailed results for the scenario under examination. The remaining buttons allow the user to operate the model (i.e. Run, Scenario Controls, Restore all Devices). Finally, in addition to the main output graph there are two dials that operate during the simulation and which show the final values at the end of the simulation (unemployment rate and the rate of capacity utilization).

In the base case scenario shown in Fig. 2 real Canadian GDP is projected to increase by 88% from the start of 2000 to the start of 2020, with an average annual growth rate of 3.2% (the average annual rate of growth from 1982 to 2003 was 3.1%). The projected average annual rate of increase in per capita GDP is 2.4%. In the absence of new initiatives to reduce Canadian greenhouse gas emissions, they are projected to rise by 43% over the same period (GHG emissions rise less than GDP on the assumption that GHG/GDP declines by the rate of productivity increase in the macro production function, (nearly 1% per year) which is consistent with the 13% decline in emissions per unit of GDP from 1990 to 2003 (Environment Canada, 2005, p.ii).

The rate of unemployment is projected to fall to 6.7% in 2005, rise slowly to 7.8% by 2011 and then decline to 6.3% by 2020, 80% of its value in 2000. The debt to GDP index is projected to decline to 8% as Canadian governments continue to pay off their debt over this period. Canadian governments combined, have been running substantial budget surpluses for several years and using some of the surplus to redeem outstanding debt. In the base case it is assumed that this pattern will continue until all the debt is redeemed.

The fifth index shown in Fig. 2, the HPI for Canada, changes little over the period 2000 to 2020. It declines slightly until 2005 and then rises slowly back to 3% above its initial value by 2014, declining back to its value in 2000 by 2020. This is despite the projected increase in GDP and decline in unemployment. The reason for this is that even though the rate of unemployment is projected to decline by the end of the period, the number of unemployed people is projected to increase as a proportion of the growing population because of a projected rise in the labour force participation rate. These factors largely balance out over the period of 2000–2020 in the base case scenario. Since no changes are assumed in the other components of the HPI: i.e. the infant mortality rate, the literacy rate and the rate of long-term unemployment, the HPI shows little change despite significant increases in GDP per capita.

Pressing the Scenario Controls button on the dashboard takes the user to a set of sliders and dials to create a variety of scenarios. It is here that low and no growth scenarios can be generated by overriding the endogenously determined values in the model for each and all of the following growth-determining variables.

2.1. *Net investment*

Net investment is gross business investment plus gross government investment minus depreciation and demolition. Gross business investment is estimated as a linear function of the interest rate, GDP, and the average rate of corporation profits tax, all lagged one year. Government investment is taken as a constant proportion of business investment based on 2004 values. The depreciation and demolition rate of the capital stock is set at 4%, the average rate from 1981 to 2003. To simulate no and low growth scenarios net investment is multiplied by a factor that can be set exogenously at any value from 0 to 1. For the "no growth" scenario this factor is set to 0 so that gross investment equals depreciation and demolition and net investment is zero.

2.2. *Growth in productivity*

The coefficient for time (*t*) in the production function is multiplied by a factor that varies from 0 to 1. If this factor is set at 0 there are no gains in productivity over time.

2.3. *Growth in population and the labour force*

The annual increase in population as projected by Statistics Canada is multiplied by a factor that varies from 0 to 1. If this factor is set at 0 there is no increase in population. This effect carries over to the labour force which is estimated as a linear function of population and GDP.

2.4. *Net trade balance*

Imports are estimated as a linear function of GDP per capita and population and exports as a linear function of US GDP and the Canada/US exchange rate. The model reduces the gap between exports and imports by reducing exports by the trade surplus multiplied by a factor that varies from 0 to 1. If this factor is set at 1 the trade surplus is zero.

2.5. *Shorter work week*

Increases in unemployment, other things equal, can be "compensated" by a reduction in the length of the work week so that more people are employed for any level of labour input. LOWGROW allows the user to reduce the average work week to 97% of its value in 2004.

2.6. *Active labour management policies (ALMP)*

ALMP refers to measures designed to assist re-employment. Such measures include: improvements to the functioning of the Public Employment service (e.g. placement and counselling services), enhanced training programs for the unemployed, targeted job creation measure for workers where joblessness is particularly harmful to future prospects (e.g. long-term unemployed youth), employment subsidies, employment programs in the public sector. LOWGROW provides the option of increasing Government expenditures on ALMP and reducing the rate of unemployment.

The user can also set the date when the selected scenario values start to take effect and the rate at which they are phased in. This rate is calculated in the model for each value affected in a scenario by taking the difference between the endogenously determined value and the user determined value and dividing by the number of years for phasing in.

In the absence of user intervention the model assumes that government expenditure will remain the same proportion of GDP as in 2003. As Fig. 2 shows, in the base case the Canadian governments (all three levels combined) build very large budget surpluses over the projection period allowing the elimination of the national debt. Scenario Controls allows the user to select several Government expenditure strategies: a balanced budget, a countercyclical investment program that is based on the rate of unemployment and a stabilizing expenditure program that equates aggregate demand and supply. If a balanced budget is selected the model sets total government expenditure equal to the endogenously determined government income (the user can change the rates of corporation profits tax and the rate of personal tax and transfers which affect government income). If the countercyclical investment program is selected the model automatically increases government expenditure by $0.16 billion per percentage point by which the rate of unemployment exceeds 4%, and reduces government expenditure correspondingly when unemployment is less than 4%. (The expenditure per percentage point can also be varied by the user. The default value is based on Okun's 'law' for Canada in which 1.6% of GDP is lost per 1% increase in unemployment (Dornbusch, 1999). If the stabilization option is selected LOWGROW calculates the difference between aggregate demand and aggregate supply and subtracts it from or adds it to total government expenditure in the following year. This strategy is a proxy for all of the possible fiscal and monetary measures that governments employ to maintain a balance between aggregate demand and supply. The user can also select the proportion of these stabilizing expenditures spent by government on goods and services or investment (the default assumption is 50% on each of these).

The final policy option available to the user from Scenario Controls is compliance with the Kyoto Protocol. The model estimates the generation of greenhouse gases (GHGs) by multiplying GDP by tonnes of GHGs per $million of GDP based on values for 2002 (Environment Canada, 2004). This emission factor is then multiplied by the coefficient for time in the production function to reflect expected improvements in productivity throughout the economy. (If the effective value of this coefficient is reduced to simulate the effects of a lower rate of increase in productivity, it has a similar effect on the expected reduction in GHGs/$m GDP.)

Compliance with the Kyoto Protocol is simulated in the model based upon the Canadian Federal government's plan (Government of Canada, 2005). Table 1 summarizes the costs and total expected average annual GHG emissions reductions in 2008–2012 as interpreted from this report. All costs are assumed to be in 2005 dollars. No conversion to 1997 $ is made in LOWGROW because the cost estimates in the plan (Government of Canada, 2005) are very approximate and difficult to decipher.

Table 1 – Summary of Canada's plan to meet its Kyoto commitments 2008–2012

Sector	Expenditure
Federal government	$10.0b
Provincial government (partnership fund and contribution)	$1.01b
Large emitters	$0.68b
Cost per year all government	$1.57b
Cost per year business	$0.10b
Reduction in GHG Mt, 2008–2012	270 Mt
Cost per tonne reduction	$43

Source: Based on Annex 1 in (Government of Canada, 2005).

The expenditures in Table 1 are assumed to be incremental costs required to fulfill Canada's Kyoto plan, i.e. the costs over and above what would be spent anyway in Canada on activities that will reduce greenhouse gas emissions. LOWGROW allows the user to vary the government's share of these incremental costs from the value of 94% implied in Table 1. In LOWGROW, the expenditures by government and business in Table 1 are not treated as additions to aggregate demand but as a reallocation from other expenditures (the user can decide what proportion of the government expenditures come from investment and what from goods and services. All expenditures by business are assumed to come from investment). Also, these expenditures are assumed not to add to productive assets in the economy. These are conservative assumptions in the sense that they are likely to overstate the negative macroeconomic impacts which, in any case, are projected to be minimal in LOWGROW.

When the base case scenario is run in LOWGROW without the expenditures shown in Table 1 and the associated reduction in emissions, LOWGROW projects that Canadian GHG emissions will exceed the Canadian Kyoto target of 560 Mt per year averaged over 2008–2012 by 269 Mt. Even with the expenditures and reductions set out in Table 1, LOWGROW projects Canada will miss its Kyoto target by an estimated 86 Mt. For the level of expenditure in Table 1 to generate a sufficient level of GHG reduction the average cost per tonne of GHG reduction would have to be about $29, not the $43 implied by the Federal government's plan.

LOWGROW also assumes that the Federal government will purchase emission credits at $10 per tonne of GHG in 1997 dollars to cover any excess of Canadian GHG emissions during the first Kyoto compliance period 2008–2012 (Government of Canada, 2005). This price can be changed by the user. Any expenditure on GHG emission credits is added to Canadian imports, reducing the net trade balance. In the base case scenario with the Federal government's plan in place, the projected cost of emission credits that Canada will have to purchase to meet its Kyoto target is $853 million (i.e. the average annual emissions 2008–2012 minus Canada's Kyoto target, multiplied by $10 per tonne).

The forestry sub-model in LOWGROW simulates the change in Canadian timber assets over time. Starting in 2000, timber assets are reduced by harvesting (as a function of GDP), natural mortality (the average mortality rate from 1981 to 1997 is assumed), road building (a constant proportion of harvesting), and fire (a random function within the range experienced 1981 to 1997). In the base case the annual harvest increases as does the amount of regeneration but not sufficient to prevent a decline in the volume of standing timber.

3. Managing without growth — exploring no/low growth scenarios

LOWGROW can be used to generate a wide variety of low growth or no growth scenarios by altering the assumptions that are used in the base case scenario. Starting in 2007 and phased in over 10 years, a no growth scenario in which net investment, productivity growth, population and labour force growth, and the positive trade balance all decline to zero yields very unpalatable results. Aggregate demand falls far short of the aggregate supply and the economy enters a disastrous downward spiral. Even so, Canada's greenhouse gas emissions far exceed its Kyoto target. Clearly no growth is not a panacea. Specific policy interventions are required to achieve the desired objectives.

When the counter cyclical government expenditure program is activated as part of the no growth scenario GDP rises slightly (5% from 2007 to 2020) because the capital stock is increased (assuming 50% of the expenditures are spent on investment and 50% on goods and services) raising aggregate supply. Counter cyclical expenditure also raises aggregate demand. The result is much improved but the unemployment rate is still above 10% by the start of 2020. The HPI which is related to unemployment ends up 15% higher than its value in 2000. The debt to GDP ratio declines not quite as much as in the base case scenario but greenhouse gas emissions rise as there are no productivity gains in this scenario.

Unemployment only rises to 9.1% by 2020 when the stabilization option for government expenditures is also activated to more effectively ensure a balance between aggregate demand and supply, the HPI stands 7% above its value in 2000 and greenhouse gas emissions continue to exceed the Kyoto target. Something else is required to meet the employment, poverty alleviation and environmental objectives.

The results of a more attractive illustrative scenario is shown in Fig. 3 in which the objectives of low unemployment, a declining debt to GDP ratio, the elimination of poverty and compliance with Canada's Kyoto target for greenhouse gas emissions are achieved.

In this scenario net investment, growth in population and the labour force, growth in productivity and the net trade balance decline to zero starting in 2007 over a 10-year phase in period and the average work week declines 3%.

The Government adopts the stabilization budget option, redistributes income so that by the end of the phase in period no Canadian is living below the LICO poverty line and implements its Kyoto plan. Also, the Government increases expenditures on Active Labour Management Policies by \$2 billion per year and raises the average rate of personal taxes and transfers from 23% to 33% and the average rate of corporations profits tax from 27% to 30%, phased in over 10 years from 2007. Fig. 3 shows the time path of GDP, unemployment, ratio of debt to GDP, poverty and GHG emissions in this no growth scenario.

By 2012 GDP is about 36% above its level in 2000 and remains stable after that through 2020 (GDP rises for a while because the no growth measures are phased in over a 10 year period). The debt to GDP ratio declines steadily to 11% of its level in 2000 by 2020. The rate of unemployment declines to 5.5% by 2020. The number of Canadians living below the Low Income Cutoff declines to zero while the Human Poverty Index stabilizes at 86% of the level in 2000 (this is as low as the HPI can go with a decline in the number of poor people without changes in the other variables that enter the index which are unchanged in this scenario). Greenhouse gas emissions decline and meet Canada's Kyoto target in the 2008–2012 compliance period (i.e. average annual GHG emissions of 560 Mt) but only on the assumption that these reductions can be achieved at an average cost of \$30/tonne and not at \$43/tonne as assumed in the Federal government's plan (see Fig. 3 above).

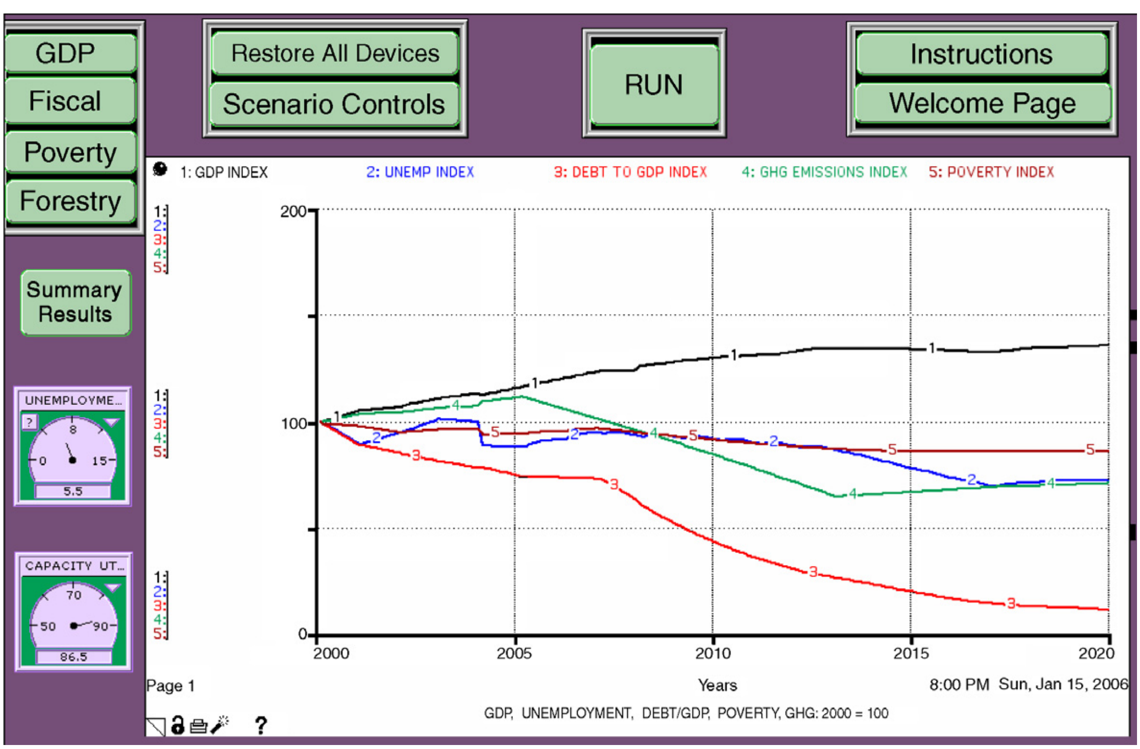

Fig. 3 – A no growth scenario for Canada.

A twenty-year horizon is too short for a no or low growth scenario to have much impact on Canadian forests in which the typical rotation is between 70 and 100 years depending on the species. Consequently, in this scenario Canada's timber assets continue to decline as losses from harvesting (now lower than in the base case scenario), road building and fire, and natural mortality continue to exceed regeneration.

4. Managing without growth — some policy implications

The previous section presented some results from LOWGROW suggesting that much can accomplished without reliance on growth in a country such as Canada that has already achieved a very high material standard of living. Poverty can be eliminated, unemployment can be reduced to historically low levels, the government debt to GDP ratio can be reduced and international environmental commitments can be fulfilled with a zero rate of growth. However, to do so requires some significant departures from the policy status quo, the details and implications of which remain to be fully explored. In brief, these departures include.

4.1. *Poverty*

Reliance on the gains from growth to trickle down to the poorest members of society should be replaced with programs that redistribute income directly and which provide support for the most important items of consumptions such as food, clothing and shelter.

4.2. *Consumption*

The disconnect between consumption and well-being has been documented in the literature (see Galbraith, 1958; Mishan, 1967; Leiss, 1976; Scitovsky, 1976; Hirsch, 1976; Daly, 1996; Douthwaite, 1999; Layard, 2005). It provides a basis for suggesting that welfare can be enhanced by redirecting consumption from private, positional goods which confer lower benefits the greater is the number of people who have them, to public goods, including a less contaminated environment and fewer threatened species, which are of value to many simultaneously.

4.3. *Investment*

The construction of infrastructure, buildings and the installation of new equipment has long been recognized as an important engine of economic growth. Such investment should continue at least at a level required to replace physical capital that wears out. Replacement of worn out capital provides opportunities for continual improvements in efficiency. However, to mirror the changes in consumption patterns just described the mix of investment should change so that the production of public goods is enhanced and the production of positional goods is stabilized or reduced.

4.4. *Productivity*

Increases in the productivity of capital and labour can be realized as increases in production or increases in leisure, or a combination of the two. There is much to be said for a greater proportion of any future gains in productivity being taken as an increase in leisure than in the past. It lowers the rate of unemployment, which alleviates poverty, and it places less stress on the environment and scarce natural resources.

4.5. *Exports*

Export-led growth has become the mercantilism of the 20th and 21st centuries. Globally net exports must be zero. Countries that can benefit the most from increasing exports, that is those that have seen little of the gains from economic growth, should be permitted to pursue this goal more freely. Hence, countries such as Canada should moderate their efforts to export more than they import.

4.6. *Population growth*

Canada is one of many developed countries where the fertility rate has fallen below 2.1, the rate required to at least maintain a constant population. Without immigration in the range of 200–300,000 per year, the Canadian population would cease to grow. Moreover, there would be an increasing proportion of elderly people in the population who would have to rely on a proportionately smaller labour force to support them after retirement (thereby reducing the rate of unemployment). The conventional response to this state of affairs is to encourage immigration, but not just any immigration. Usually countries such as Canada try to attract the most educated and wealthiest people from other countries. When these people come from developing countries, as has become more common (Centre for Canadian Studies at Mount Allison University website) it may help Canada but it weakens the capacity of the countries from which the immigrants come. A more satisfactory approach would be to come to terms with a stable population and address the income distribution implications of an aging population through pensions and other income support programs. The low growth scenario described earlier in this paper suggests that this is a very real option.

4.7. *Environment*

Throughout this paper economic growth has been used synonymously with growth in GDP. However, GDP is a measure of value that is related to but not identical with growth in the physical inputs and outputs of the economy. Indeed, there are some encouraging signs that the value of economic output and the material and energy required to produce it have become somewhat decoupled. (The picture is less clear when international trade is factored in since developed countries import material intensive products that they previously manufactured themselves.) Yet it is these parameters: the physical inputs and outputs of the economy and the impact by humans on the habitats of other species, that put pressure on the environment and on scarce natural resources. Very gradually, these problems are being addressed by the explicit introduction of quantitative limits on inputs, outputs and land use. The Montreal Protocol limiting the production and release of ozone depleting substances and the Kyoto Protocol limiting the release of greenhouse gases are two examples of quantitative limits designed to protect the environment from the impacts of economy. Other such limits in the Canadian context include fishing bans and quotas to protect what is left of the East coast fisheries, the provisions of the Canada–US Agreement on the Great Lakes requiring the virtual elimination of toxic substances, the prohibition of bulk water exports from the Great Lakes, the establishment of a green belt around the Greater Toronto Area to contain urban sprawl, and the establishment of a comprehensive system of national and provincial parks.

These types of quantitative, physical limits on throughput and land use offer the best way forward for ensuring that economies do not compromise the environment in which they are embedded and on which they depend.

5. Conclusion

This paper began by noting three arguments why the possibility of developed countries such as Canada should entertain the possibility of managing without growth: 1) global economic growth is not an option because of environmental and resource constraints, so developed countries should leave room for those that benefit the most from growth; 2) beyond a point that has been passed in developed countries, growth does not bring happiness; and 3) in developed countries growth is neither a necessary nor a sufficient condition for achieving such objectives as full employment, elimination of poverty and environmental protection.

The paper then described LOWGROW, a simulation model designed to explore a wide range of low growth scenarios in Canada. Results from LOWGROW comparing a base case scenario with a low growth scenario were presented that suggest that much can be accomplished in developed countries without relying on economic growth. Many other low or no growth scenarios can be explored with LOWGROW (see www.yorku.ca/pvictor). The scenario presented here is illustrative and intended to provoke further discussion about growth in developed countries. Finally, the paper set out the kind of policy directions that would have to be adopted to steer the Canadian economy towards lower growth while, at the same time, achieving desirable employment, anti-poverty and environmental objectives.

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Appendix A. Annex

A.1. *LOWGROW — technical description*

LOWGROW is an interactive dynamic model of the Canadian economy developed in STELLA, a systems dynamics modelling language. LOWGROW simulates the response of the Canadian economy to a wide range of policy interventions up to 2020. Results are reported as year end values but simulations with LOWGROW are calculated using a time interval of a tenth of a year. This description of LOWGROW is divided into two sections. The first section describes the macroeconomic model in LOWGROW. The second section describes the other components of LOWGROW: employment, fiscal, redistribution, Human Poverty Index, Kyoto, forestry.

A.2. *The macroeconomic model*

The macroeconomic model consists of a set of linear equations that determine GDP as aggregate demand and a Cobb–Douglas production function that determines GDP as aggregate supply. The model calculates GDP from the production function using initial values for: produced assets, capacity utilization rate, labour force, rate of unemployment, and time (which is a proxy for technical change). The value of GDP so derived is an independent variable in the demand equations which are then used to compute aggregate demand. If aggregate demand exceeds aggregate supply, the rates of unemployment and capacity utilization decrease in the next time period. If aggregate supply exceeds aggregate demand the rates of unemployment and capacity utilization increase in the next time period. All monetary values are in constant 1997 $.

The following equations were estimated using data for 1981–2003 from Statistics Canada. The estimation method was either ordinary least squares (ols) or two stage least squares (2 sls). t statistics for the coefficients are shown beneath in parentheses and the R-squared value is shown as well.

A.2.1. *Consumption (ols)*

$$c/p = \underset{(73.8)}{0.56731}{}^{*}g/p + \underset{(7.3)}{0.0038375}{}^{*}d/g - \underset{(-4.2)}{0.0000516}{}^{*}i - \underset{(-5.2)}{0.0014986}{}^{*}x \qquad (1)$$

R-squared 0.995

where:

c	consumption expenditure in millions of $97
p	population in millions
g	GDP in millions of $97
d	disposable income in millions of $97
i	interest rate, prime 3-month corporate paper [in %?]
x	exchange rate, $Can per $US

This equation was estimated with the added restriction that the estimated value of c/p for 2003 be at its actual value when the independent variables in the equation are at their 2003 values. The purpose of this constraint was to ensure that the simulation of future values in LOWGROW would start from their actual values in 2003. This approach did not work perfectly because the model simulations start from 2000 and despite the incorporation of many actual values for variables between 2000 and 2003, not all variables in the model are predicted to be exactly at their 2003 values.

Eq. (1) states that consumption per capita is a positive function of GDP per capita and disposable income per capita, and a negative function of the interest rate and the Canada/US exchange rate. Division of consumption by population in Eq.(1) is intended to eliminate common trend attributable to population.

A.2.2. Private investment (2sls)

$$I = 72576 - 2552.5^{*}\mathrm{li} + 0.15881^{*}\mathrm{lg} - 0.12952^{*}\mathrm{lc} \qquad (2)$$
$$(3.2) \quad (-3.5) \quad (10.0) \quad (-2.7)$$

R-squared = 0.926

where:

I	business gross investment in structures, machinery, equipment and net investment in inventories in millions of $97
li	interest rate, lagged one year
lg	GDP lagged one year
lc	average rate of corporation profits tax, lagged one year

Investment decisions are generally made on assumptions and expectations about the future. These assumptions and expectations are inevitably influenced by past experience which is captured to some extent by the inclusion of lagged variables in the investment equation.

A.2.3. Imports (ols)

$$M = -804800 + 11099000^{*}g/p + 26000^{*}p \qquad (3)$$
$$(-14.3) \quad (4.5) \quad (6.0)$$

R-squared = 0.975

where:

M = imports of goods and services in millions of $97

Eq. (3) states that imports of goods and services are a function of per capita GDP and population. Imports seemed to be positively related to the Canada/US exchange rate, contrary to theory and assumed elasticities. Using 2 sls and imports per capita to eliminate common trend did not help and so the exchange rate was excluded from the equation.

A.2.4. Exports (ols)

$$X = -417620 + 58.809^{*}\mathrm{usgdp} + 17880^{*}x \qquad (4)$$
$$(-12.0) \quad (42.8) \quad (5.7)$$

R-squared = 0.986

where:

X	exports of goods and services in millions of $97
usgdp	US GDP in millions of US$2000

The predominance of the United States as a market for Canadian exports has risen steadily over the past 25 years, so that the US now accounts for over 80% of Canada's exports. (Hessing et al., 2005, Table 2.4). This focus is captured in Eq. (4) in which Canadian exports are estimated as a positive function of US GDP and the Canada/US exchange rate.

A.2.5. Government expenditure

Government expenditure here consists of expenditure of goods and services and government investment in fixed capital and inventories. In LOWGROW the expenditure and income of the federal, provincial and municipal levels of government are combined. LOWGROW allows several user-controlled options for government expenditures:

1. Constant share — The default assumptions used in the base case scenario are that government expenditure on goods and services is maintained at the same share of GDP as in 2003 (i.e. 0.1883) and that government investment is maintained at the same proportion of private business investment as in 2003 (i.e. 0.15).
2. Balanced budget — if this option is selected LOWGROW sets total government expenditure on investment and goods and services equal to total government income.
3. Countercyclical — if this option is selected, government investment is increased by 0.016 of GDP for each percentage point that the unemployment rate exceeds 4% (based on Okun's Law for Canada Dornbusch, 1999, p.43). It is reduced by the same amount for each percentage point that unemployment falls below 4%. The amount of incremental investment expenditure can be varied by the user.
4. Stabilization — under this option the difference between aggregate demand and aggregate supply is calculated (under the constant share assumption or the countercyclical assumption) and the difference is subtracted from or added to government expenditure in the following year (50% as government expenditure on goods and services and 50% on government investment unless changed by the user). This pattern of government expenditure is a proxy for all of the possible fiscal and monetary measures that governments employ to maintain a balance between aggregate demand and supply.

The equations for consumption, private investment, exports and imports described above, combined with any one of the options for government expenditures, estimate aggregate demand in LOWGROW.

A.2.6. Production function (2sls)

LOWGROW employs a conventional Cobb–Douglas production function. Output (GDP) is a positive function of capital employed, labour employed, and time.

$$\ln(g) = 1.2797 + 0.00993^{*}T + 0.28281^{*}\ln(\mathrm{cut}) + 0.71812^{*}\ln(emp)$$
$$(1.1) \quad (4.1) \quad (1.7) \quad (2.0)$$
$$(5)$$

R-squared = 0.996

where:

ln(*g*)	natural log of GDP
T	time in years
ln(cut)	natural log of produced assets in millions \$97 plus natural log of capacity utilization rate
ln(emp)	natural log of employment in thousands

In its non-log form the production function is:

$$g = 3.5956^{*}1.00993^{t*}(K^{*}\mathrm{CU})^{28281*}\mathrm{LE}^{71821} \quad (6)$$

where:

t	time in years
K	produced assets in millions of \$97
CU	the capacity utilization rate of manufacturing assets in percent
LE	employed labour in thousands

The exponents for capital and labour add up to unity, signifying constant returns to scale (this was not a constraint imposed in the estimation procedure). It is possible that some returns to scale have been captured in the coefficient that is raised to the power *t*. For the purposes of this study, this coefficient is interpreted as the effects of technical change over time (capturing all improvements in efficiency in capital and labour) and is estimated to raise GDP by almost 1% per year.

LOWGROW allows the user to reduce the length of the average workweek by up to 3% so that a given amount of labour input corresponds to a lower rate of unemployment.

The capital stock in each time period increases as a result of business and government investment expenditures, net of depreciation and demolition in the previous time period (set at 4% of the stock of produced assets, the average rate from 1981 to 2003). Similarly, the labour force changes from one period to the next as shown in Eq. (7).

A.2.7. *Labour force (ols)*

$$L = \underset{(1.6)}{1592.61} + \underset{(5.7)}{342.5^{*}p} + \underset{(4.2)}{0.00388^{*}g} \quad (7)$$

R-squared = 0.987

where:

L = labour force in thousands

Eq. (8) models the labour force as a positive function of the population and of GDP. Population in LOWGROW is based on a projection by Statistics Canada for each year from 2000 to 2026 (Statistics Canada, Cansim Table 052-0001).

A.2.8. *Capacity utilization (ols)*

$$\mathrm{CU} = \underset{(32.7)}{93.7} - \underset{(-4.3)}{1.32^{*}\mathrm{ur}} \quad (8)$$

R-squared = 0.46

Where:

ur = the rate of unemployment in percent

In Eq. (7) the rate of capacity utilization is a negative function of the rate of unemployment signifying that when unemployment rises the rate of capacity utilization declines. This equation has a much lower *R*-squared than the other equations in the macroeconomic model. It is included in the model to recognize that both the employment of labour and the employment of capital can change in the economy in response to changes in aggregate demand.

A.2.9. *Employment*

Eq. (7) above shows how the labour force is modelled in LOWGROW, as a function of population and GDP. The labour force is divided between employed and unemployed labour. Workers move between employment and unemployment depending on the rates of job finding (i.e. 52/average time unemployed in weeks) and job separation (i.e. 52/average time employed in weeks). In LOWGROW these rates are a function of the excess demand ratio, that is the ratio of aggregate demand to aggregate supply. The rate of job finding is divided by the excess demand ratio and the rate of job separation is multiplied by the excess demand ratio. When this ratio is unity the rates of job finding and job separation are unchanged (i.e. the economy is in a state of macro equilibrium) and the rates of unemployment and capacity utilization are constant. When the excess demand ratio is above unity, (that is, when aggregate demand exceeds aggregate supply) the rate of job finding rises and the rate of job separation falls so that the unemployment and capacity utilization rates decline. When the excess demand ratio is less than unity the opposite happens. New entrants to the labour force and those who exit are assumed to experience the same rate of unemployment as the rest of the labour force.

The number of employed persons is an independent variable in the production function so when unemployment changes, aggregate supply changes in the opposite direction bringing the excess demand ratio back towards unity. Since GDP as aggregate supply is an independent variable in some of the aggregate demand equations, aggregate demand also increases if the rate of unemployment declines and declines if the rate of unemployment rises.

LOWGROW allows for employment to be affected by Active Labour Management Policies (ALMP) which increase labour mobility. Expenditures by government on these policies reduce the time on average that a person is unemployed which is related directly to the rate of job finding. In 2002 and 2003 Canada spent US \$3135.3 on ALMP per unemployed person (Brandt et al., 2005, Table A2.7). This is below average for OECD countries as a percentage of GDP per member of the labour force (Boone and van Ours, 2004, Table 2). There is an extensive literature on the effectiveness of expenditures on ALMP for reducing the rate of unemployment. Analyzing data for 20 OECD countries Boone and van Ours estimate that an increase in expenditures on labour market training from 0.2% to 0.25% of GDP reduces the rate of unemployment from 8% to 7.7% in the short run and 7.6% in the long run (Boone and van Ours, 2004, p15). This effect is captured in LOWGROW through an assumed graphical relationship between additional ALMP expenditures and the average time of unemployment that gives similar results.

A.2.10. Fiscal policies

LOWGROW keeps track of the consolidated accounts of the three levels of government. Government expenditures on goods, services and investment were described above. In addition to these, LOWGROW calculates the interest paid by government on accumulated debt (using the prime interest rate), and transfers paid by Government to business and households. Transfers to business are kept at the level they were in 2004. Transfers to households are calculated using Eq. (9) which was estimated using ols.

$$\underset{(-15.6)}{TH = -165472} + \underset{(3.9)}{21.53UL} + \underset{(23.9)}{0.008p} \tag{9}$$

R-squared=0.97

Where:

TH transfers to households in millions of $97
UL number of unemployed in thousands

One of the options available to the user is to increase transfer payments to people living below the poverty line (defined as the Low Income Cut-Off or LICO, (Statistics Canada, 2003). LOWGROW calculates the required amount based on the number of families and individuals living in poverty and the average amount in constant 1997 dollars required to bring individuals and families up to the poverty line (Statistics Canada, 2003, Table 8-3-3). The number of people living in poverty is calculated using the number for 2004 plus or minus any increase or decrease in the number of unemployed (based on the assumption that unemployment reduces incomes to a level below the poverty line).

Total outlay by government is the sum of government expenditures on goods and services, government investment, interest paid on government debt, transfers to business and transfers to households.

LOWGROW calculates government income as the sum of government investment income (held constant at the 2004 level), taxes on production and imports (the 2004 proportion of GDP), corporation profits tax (the 2003 proportion of GDP but can be changed by the user), taxes and transfers from persons (the 2003 proportion of GDP but can be changed by the user) and income taxes paid by non-residents (the 2003 proportion of GDP).

LOWGROW also calculates the combined net debt of the three levels of government. Starting from an initial value for 2003 the model calculates the change in net debt using Eq. (10) estimated with ols.

$$CND = \underset{(2.7)}{11729.15} - \underset{(-9.0)}{1.1253NI} \tag{10}$$

R-squared=0.81

Where:

CND change in net government debt (all three levels of government combined) in millions of $97
NI government net income defined as government income minus government outlay in millions of $97.

Eq. (10) suggests that government net debt rises on average by $11.7 billion when government outlay and income (as defined in Department of Finance (2004) and incorporated into LOWGROW) are equal, and that this amount is reduced on average by $1.125 for each dollar that government net income is positive. This estimation result implies that under the accounting conventions used by our data source, some government income and outlay results in changes in government assets and liabilities that are not counted as net debt.

A.3. Human poverty index (HPI)

The HPI developed by UNDP (United Nations Development Programme, 2005) is defined by Eq. (11)

$$HPI = (0.25DK^3 + 0.25DL^3 + 0.25DSL^3 + 0.25EX^3)^{1/3} \tag{11}$$

Where :

DK deprivation of knowledge (measured as people lacking functional literacy skills which is defined by the OECD as "whether a person is able to understand and employ printed information in daily life, at home, at work and in the community).
DL percentage of population not expected to survive to age 60
DSL percentage of poor people in the population
EX rate of long-term unemployment (greater than 12 months)

LOWGROW calculates the HPI for Canada. DK and DL are maintained at the values in the Human Development Report, 2005. DL is calculated in LOWGROW using the number of people living below the poverty line. This is a different measure from that used by the UNDP (number of people living below half the median income) but as Giles (2004) shows, the two measures in 2000 were very similar (10.9% and 11.1% respectively) so it may be assumed that any difference between the two measures of poverty in Canada is quite small.

In LOWGROW the rate of long-term unemployment is calculated as a constant share of the number of unemployed. The initial value used in LOWGROW is 11.84% for 1999, calculated by dividing 0.9% of the labour force in long-term unemployment (the value given in the United Nations Development Programme, 2005) by 7.6%, the unemployment rate for Canada in 1999.

A.4. Greenhouse gases and Kyoto compliance

Canadian emissions of greenhouse gases (GHGs) are simulated in LOWGROW by multiplying GDP by a GHG emission coefficient expressed as tonnes of GHG per dollar of GDP (in $97). This coefficient was calculated using data for 2002, the most recent year for which data were available, (Environment Canada, 2004).

To allow for productivity improvements as new capital equipment replaces old and the energy/GDP ratio declines even without any specific GHG reduction programs, the GHG emission coefficient is reduced by an amount each year equal to the rate of productivity growth in the production function, i.e. about 1% per year. If the user of the model reduces the rate of productivity growth in the economy in general then the same lower rate of productivity growth is applied to the GHG emissions coefficient.

The user can select a Kyoto compliance option by setting the total cost of Canada's Kyoto Plan and the share of this cost incurred by Government. Default values for these variables are based on Government of Canada (2005). The user can also select an average cost per tonne reduction in GHG emissions and the cost of any GHG allowances purchased by the Government of Canada to meet Canada's Kyoto target. Default values for these variables are also provided in LOWGROW based, respectively on information in Government of Canada (2005), including a provisional cost of $10/tonne for GHG allowances.

In LOWGROW all expenditures by Government and business for compliance with Kyoto are assumed to be diverted from other expenditures that would otherwise have taken place. For business, the diversion is from investment and for Government the user can select the proportion that comes from investment, with the remainder coming from Government expenditure on goods and services. Hence, it is assumed that expenditures on Kyoto do not add to aggregate demand. This is a conservative assumption in the sense that it will understate the positive impact of such expenditures on GDP and employment. Furthermore, aggregate demand is reduced if the Government buys GHG allowances from abroad to meet Canada's Kyoto target.

To the extent that investment expenditures decline because of the diversion of expenditure to assumed "unproductive" measures to reduce GHG emissions, the capital stock is less than It would otherwise be in the absence of the Kyoto commitment. Again, this is a conservative assumption in that some capital expenditures to reduce GHG emissions might also add to the value of economic output. Overall, the assumptions made in this sub-model are likely to overstate the negative macroeconomic impacts and understate the positive macroeconomic impacts of expenditures required to fulfill Canada's Kyoto commitment.

LOWGROW takes all of this information, calculates average annual GHG emissions for 2008 to 2012, the first Kyoto compliance period, and calculates the cost of purchasing allowances to cover any excess emissions (LOWGROW assumes that the Government only buys allowances for one year to cover any excess over the annual average from 2008 to 2012. Requirement for the 2012 period have yet to be negotiated among the signatory countries to the Kyoto Protocol).

A.5. *Forestry*

LOWGROW tracks changes to the stock of Canada's timber assets starting from an initial value for 2000 (all data for estimating the forestry model come from Statistics Canada, 2001). Deductions from the stock come from harvesting, natural mortality, fire, and road building. Additions to the stock come from regeneration which is assumed constant at 204,720 thousand cubic metres per year.

The equations in the forestry sub-model are:

A.5.1. *Harvest (ols)*

$$H = 76680 + 0.12505g \quad (12)$$
$$\quad\;\; (2.9) \qquad (-3.5)$$

R-squared = 0.44

Where:

H annual harvest in thousand cubic metres
g GDP

A.5.2. *Mortality*

$$M = mT \quad (13)$$

Where:

M annual mortality in thousand cubic metres
m the average annual mortality rate from 1981 to 1997 in cubic metres per cubic metre of timber assets (0.0030861)
T timber assets in thousand cubic metres

A.5.3. *Roads*

$$R = rH \quad (14)$$

Where:

R annual losses in timber assets due to road building
r average annual loss from 1981 to 1997 in cubic metres per cubic metre of harvest (0.03)

A.5.4. *Fire*

LOWGROW simulates losses due to fire by using a random number to generate annual losses in the same range and with similar frequencies as experienced from 1981 to 1997.

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