COMPARATIVE LIFE CYCLE ASSESSMENT (LCA) OF ARTIFICIAL VS NATURAL CHRISTMAS TREE

Sylvain Couillard, ing. M.Sc.

Gontran Bage, ing. Ph.D.

Jean-Sébastien Trudel, B.Com B.Sc.Soc. M.Env.

February 2009

1043-RF3-09

ellipsos

Strategists in Sustainable Development

ellipsos

1030 Beaubien E. Suite 305
Montreal Quebec H2S 1T4

514.463.9336

i@ellipsos.ca
www.ellipsos.ca

ellipsos is a consulting firm based in Montreal. We offer solid professional expertise in sustainable development. We help business leaders build a competitive advantage using Life Cycle Management. This approach is used by the most qualified teams of executives in large corporations worldwide, recognized by the United Nations and supported by the International standardization Organization (ISO 14040).

We are different. We exist to help businesses evolve into sustainable organizations. We believe solutions are available. We believe that businesses, governments and people are part of the solution. We believe in human creativity, innovation and action. For leaders to make better decisions, they need credible indicators that take into account all stages of a product or service life cycle. Life Cycle Management tools provide such indicators, and we assist organizations to make the most out of it.

About the Authors

Sylvain Couillard ing. M.Sc.

Sylvain Couillard graduated as a Mechanical Engineer from École Polytechnique de Montréal (1998). He obtained his Master's Degree in Biomedical Engineering from the University of Calgary (2002). He specialized in Quality Assurance (QA) of medical devices and was QA Manager at SCL Medtech. As a professional and team member of ellipsos inc., Mr. Couillard has performed Life Cycle Analysis (LCA) studies. They include those delivered to the bovine industry and the ISO 14040 compliant study on Christmas trees. Mr. Couillard is recognized for his strong analytical skills that focus on practical solutions to sustainable development projects.

Gontran Bage ing. Ph.D.

Gontran Bage is an expert in sustainable development and life cycle management. Prior to joining ellipsos, Mr Bage worked for 6 years (2002-2008) at the CIRAIG (Interuniversity Research Centre for the Life Cycle of Products, Processes and Services) as the scientific coordinator and researcher specialized in life cycle inventory (data estimation, uncertainty management) and life cycle tools development. As the CIRAIG's scientific coordinator, he had to manage the scientific progress of more than 35 research projects, write scientific proposal grants and supervise graduate students. Mr Bage holds a PhD in chemical engineering (Ecole Polytechnique of Montreal) for which he has developed a tool for the selection of the most appropriate technology for contaminated site remediation based on both environmental, technical and economic aspects.

Jean-Sébastien Trudel B.Com B.Sc.Soc. M.Env.

Founder of ellipsos, Jean-Sébastien Trudel helps executives and management deal with and benefit from the ever changing conditions of emerging markets, a process that he's called the "new industrial evolution". In the last five years he's acted as adviser on the topic of sustainable development for corporations and governments. Jean-Sébastien Trudel is also a well known author in the business community. He is the author of a book on sustainable business practises, titled "Arrêtons de pisser dans de l'eau embouteillée", published by Transcontinental. HEC Montreal School of Management has called it one of the "must read book of 2007 for executives", and it has been been awarded the "Entrepreneurship Book France-Québec 2008" prize, handed by the Paris Chamber of Commerce and Industry, in France. Mr Trudel holds a Bachelor of Commerce, a Bachelor of Economics, both from the University of Ottawa, and a Masters of Environment specialized in Life Cycle Management, from the University of Sherbrooke in partnership with CIRAIG–Ecole Polytechnique of Montréal.

Executive Summary

Every year, when comes the time to prepare for the Christmas Holidays, one question seems to come back time and time again: Should one buy a natural or an artificial Christmas tree? From an environmental perspective, this question raises many passions, since both type of trees seem to have advantages and drawbacks. Most people think that the traditional fir is better. For one, they say, the natural tree is... natural! It is often argued that it contributes to fighting global warming through carbon sequestration. Others argue that the artificial tree can be reused year after year, and it does not need fertilizers and pesticides. Some say that the true environmentalist go in the wood to cut down his wild seedling. The most radicals have even suggested to stop using Christmas trees altogether.

After all these years, the question remains. ellipsos has undertaken to put an end to this dilemma using a scientific approach.

Goal and Scope

The purpose of this study is to compare the environmental impacts of a natural vs. artificial Christmas tree using Life Cycle Assessment methodology. Since the trees are to be used in Montreal, Canada, for the holiday season, data representative of the trees sold in Montreal was preferred. The modelled natural tree is harvested in a plantation located 150 km south of Montreal. The artificial tree is manufactured in China and shipped by boat and train to Montreal via Vancouver.

The Life Cycle Assessment (LCA) method was chosen to perform this study. It follows the recognized ISO 14040 and 14044 standards and it was reviewed by an independent third-party of peers. The LCA method allows for the evaluation of potential environmental impacts of a product or an activity over its entire life cycle. It is therefore a holistic approach that takes into account the extraction and processing of raw materials, the manufacturing processes, transport and distribution, use, reuse and, finally, recycling and disposal at the end of life.

This study is aimed at guiding the general public for the selection of the best type of Christmas tree based on environmental considerations. It is an independent study with no funding (direct or indirect) by any of the concerned stakeholders.

Considering the function of the trees -decorating the interior of a house - one natural tree with one artificial tree for one Holiday period are compared. Both trees are assumed to be 7 foot high. For better comparison purposes, the lights and decorations are excluded from the analysis. Since the artificial tree can be reused multiple times, calculations are based on a 6-year life span, the average time an artificial tree is kept in North America. The data was collected from primary and secondary sources: direct contact using surveys, literature and life cycle inventory databases.

Methodology

An LCA consists of four major phases:

Phase 1: Definition of the objectives and the scope of the study;

Phase 2: Data collection and calculation procedures to quantify relevant inputs and outputs of a product system;

Phase 3: Evaluation of the significant potential environmental impacts from the various inputs and outputs of a product system;

Phase 4: Interpretation of the inventory data and results of the impact assessment in relation with the goal and scope of the study.

Natural Christmas tree: The primary data for the natural tree was collected from two main sources. First, one tree nursery provided data (nursery is confidential). This data may not represent the entire production in Quebec, but no other data was available. Second, the Centre de Recherche en Agriculture et Agroalimentaire du Québec provided an economic model of natural Christmas tree production in field, which was revised in March 2007. This model represents the activities and inputs for an average Quebec producer with a good experience in Christmas tree production. A detailed description of the natural Christmas tree model is given in the full report. Briefly, the life cycle of the natural Christmas tree is divided into four steps: production in a nursery for 4 years, production in a field for 11 years, use at home and end of life (Figure A).

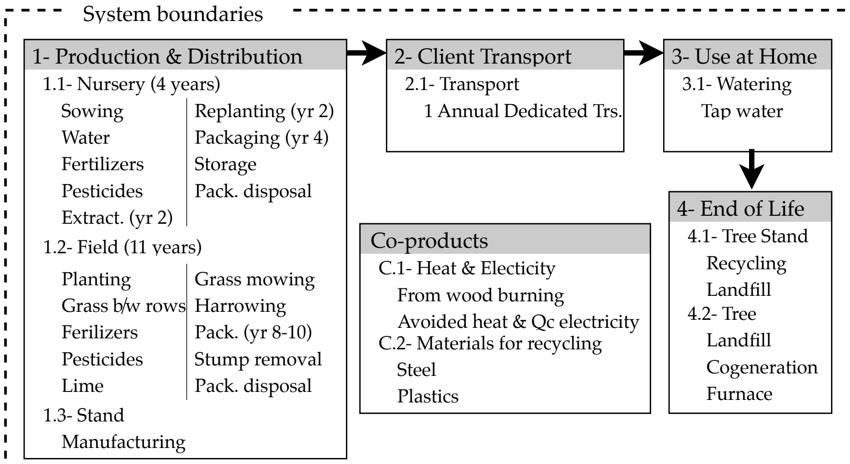

Figure A – The Product system for the natural Christmas tree includes all processes from production, transport, use and end of life.

Artificial Christmas tree: The data for artificial trees came from two main sources: a manufacturer of premium Christmas trees in the United States (confidential) and a student report that was provided by the Centre interuniversitaire de recherche sur la gestion du cycle de vie des produits et services (CIRAIG), which studied the typical artificial tree made in China. Data obtained directly from Chinese manufacturers was generally incomplete or unreliable.

The data from the premium tree was used as a basis for the typical Chinese tree, knowing that the premium trees are generally sturdier and last longer. A detailed description of the artificial tree model is given in the full report. Briefly, the life cycle of the artificial Christmas tree is divided into four steps: production at a plant in Beijing (including distribution), client transport, use at home and end of life (Figure B).

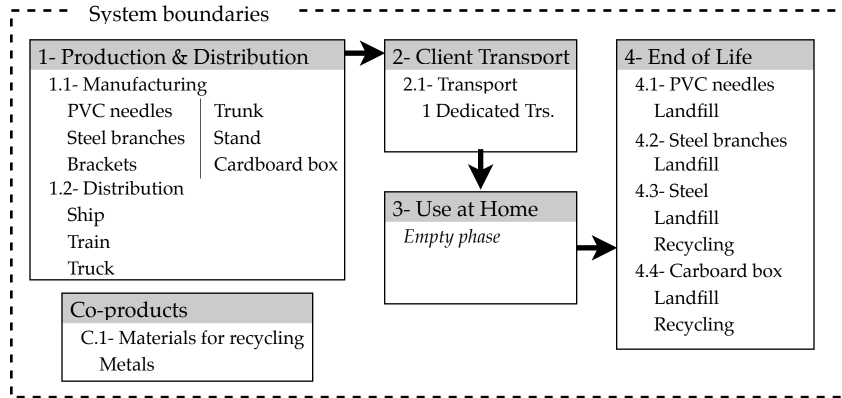

Figure B – The Product system for the artificial Christmas tree includes all processes from resources extraction and manufacturing, transport, use and end of life.

Impact Assessment

The primary impact assessment method used in this study is Impact 2002+ (Jolliet et al., 2003). This choice is justified from the need to present the understandable and important results to the general public. The Impact 2002+ method was slightly modified to include the effects of biogenic gases on climate change.

Impact 2002+ is an impact assessment method of the life cycle that allows the grouping of problem oriented-impacts into four damage-oriented impacts on the environment. These categories are: human health, ecosystem quality, climate change and resource depletion. Figure C shows the fourteen problem-oriented (Midpoint categories) that contribute to the damage categories. To evaluate the result sensitivity to the impact assessment method, a second analysis was conducted with the North American method TRACI2.

Results and Discussion

As mentioned above, this study uses an artificial tree with a life span of six (6) years. The results for this tree are normalized on an annual basis and compared to one natural tree. We are therefore comparing the impacts of one year of an artificial tree (1/6th of its life span) with one natural tree.

The environmental impacts of the natural and artificial trees are shown in Figure D. These results show the relative impacts of each tree for the four damage categories: human health, ecosystem quality, climate change and resources. The impacts are presented in relative terms for each category, where the tree with the most impacts is the reference.

When compared on an annual basis, the artificial tree, which has a life span of six years, has three times more impacts on climate change and resource depletion than the natural tree. It is roughly equivalent in terms of human health impacts, but almost four times better on ecosystem quality compared to the natural tree.

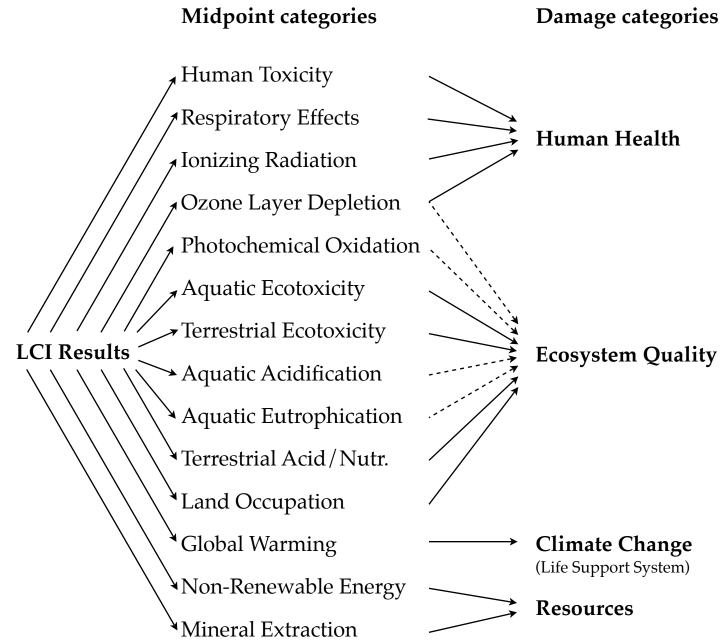

Figure C – General outline of the Impact 2002+ assessment method for problem-oriented and damage categories.

The hot topic these days is climate change. When looking at these impacts, the natural tree contributes to significantly less carbon dioxide emission (39%) than the artificial tree. Nevertheless, because the impacts of the artificial tree occur at the production stage, and since it can be reused multiple times, if the artificial tree were kept longer, it would become a better solution than the natural tree (Figure E). It would take, however, approximately 20 years before the artificial tree would become a better solution regarding climate change.

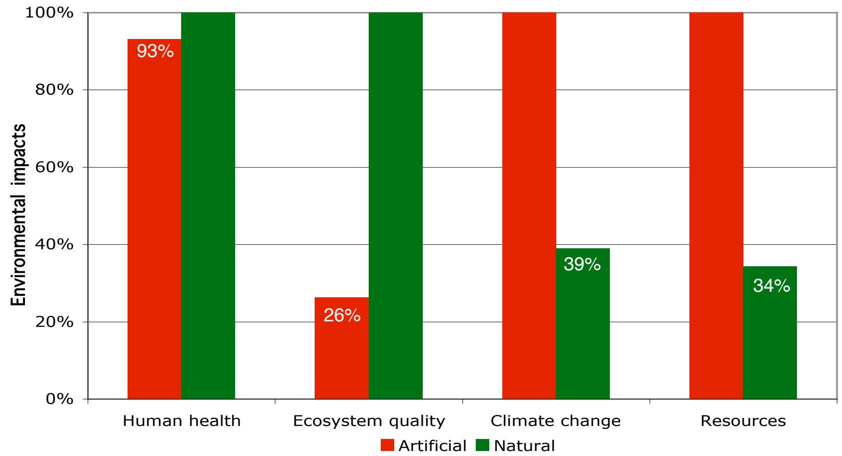

Figure D – LCA results comparing relative impacts for four damage categories comparing main life cycle stages of an artificial tree (red) and a natural tree (green) for one year using a modified IMPACT 2002+ method to include biogenic CO_2 emissions.

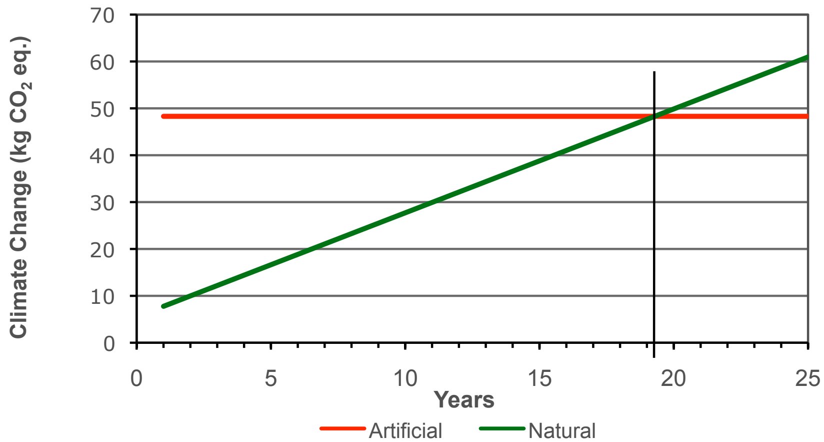

Figure E – The artificial tree can be reused multiple times. This reduces its impacts overtime relative to a natural tree bought every year. The threshold at which point the artificial tree become a better option for climate change impacts is after 20 years.

Impacts on climate change occur at different stages of the life cycle for the natural tree and the artificial tree (Figure F). For the former, the main source of impacts comes from client transport from the house to the Christmas tree store. For the latter, the production stage, which includes manufacturing (85%) and transport from China to Montreal (8%), accounts for almost all of the impacts (93%).

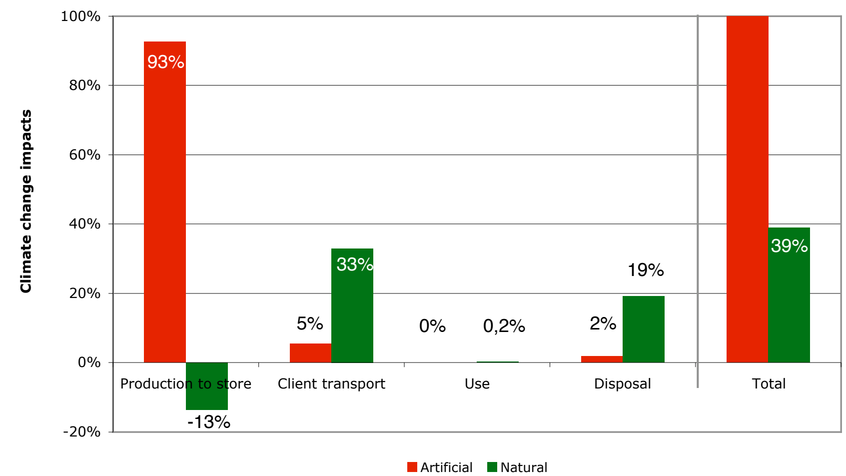

Figure F – LCA results for Climate Change category comparing main life cycle stages of an artificial tree (red) and a natural tree (green) for one year using a modified IMPACT 2002+ method to include biogenic CO_2 emissions.

It is interesting to note that the natural tree production has positive impacts on climate change because natural trees sequester CO_2 during their growth. Besides, the impacts of client transport shown here are for a store located at 5 km from home. These impacts would steeply increase with travelled distance since this activity occurs year after year. Watering the tree in the use stage only has marginal impacts, whereas the disposal of the natural tree is the second largest contributor on climate change. The end of life faith is twofold: 50% is send to a landfill and the remainder is turned into wood chips as a replacement for heavy oil in a paper mill and electricity from Quebec province.

To put things into perspective, the emitted CO_2 over the entire life cycle are approximately 3.1 kg CO_2 per year for the natural tree and 8.1 kg CO_2 per year for the artificial tree (48.3 kg for its entire life span). These CO_2 emissions roughly correspond to driving an average car (150 g/km) 125 km and 322 km, respectively. Therefore, carpooling or biking to work only one to three weeks per year would offset the carbon emissions from both types of Christmas trees.

Another point of view would be to consider the impacts on ecosystem quality as the hot topic. This would shift the advantage of the natural tree to the artificial tree by a factor of approximately five (Figure D). One of the major contributors of ecosystem quality is, for example, land occupation. Tree plantations, however, traditionally occupy areas where no other use of the land can be made (e.g. under electrical lines). In addition, these impacts are generally local while the impacts on climate change are global.

Limits of the study

The current LCA study has limitations. It does not take into account noise, odor, human activities (eating, lodging, etc.), soil erosion that is avoided by the plantations, dioxin emissions from plastic in the artificial tree during use and disposal (if burned), impacts of fillers contained in PVC. Also, the electricity from China was mostly modelled with electricity from Europe. In addition, the CO_2 sequestration as well as fertilizer emissions can vary greatly with environmental conditions (soil content, sun exposure, rainfall, etc.) and add uncertainty to the results. Finally, results are specific to Montreal and may vary depending on geographic location because of differences in processes such as travelled distances and the end of life of the natural tree.

Conclusion

A Life Cycle Assessment was performed to guide the environmentally conscious consumers on their choice of Christmas tree. The natural tree is a better option than the artificial tree, in particular with respect to impacts on climate change and resource depletion. The natural tree, however, is not a perfect solution as it results in important impacts on ecosystem quality. Clients who prefer using the artificial tree can reduce their impacts on all categories by increasing the life span of their tree, ideally over 20 years.

Although the dilemma between the natural and artificial Christmas trees will continue to surface every year before Christmas, it is now clear from this LCA study that, regardless of the chosen type of tree, the impacts on the environment are negligible compared to other activities, such as car use.