Determining the Opportunities and Barriers Behind Establishing Carbon Credits for Okanagan Orchards

FRST 497: Graduating Essay

Reece Allingham

Advising Professor #1: Dr. Gary Bull

Advising Professor #2: Dr. John Nelson

Completed: April 6, 2009

Table of Contents

1.0 Introduction

In November of 2007, the government of British Columbia introduced groundbreaking legislation aimed at reducing the province's greenhouse gas emissions (GHGs). The legislation aims to reduce the provincial carbon footprint by 33 percent of 2007 levels by 2020 and to make the public sector in BC carbon neutral by 2010 (MOE 2007). BC is the first jurisdiction in North America to introduce this type of policy. And while the global recession has put climate change and environmental issues on the back burner, most people would agree that this is an issue that will not leave the public's consciousness anytime soon.

With legislation such as this now law in BC, and with many experts predicting that North America will soon have a comprehensive and regulatory cap-and-trade system in place, carbon will continue to become a valuable commodity. At the same time, the provincial tree fruit industry has been in decline for several years (MOAFF 2004). This has led tree fruit orchardists in the Okanagan Valley to continually look for alternative revenue sources. The carbon credit industry would provide a viable source of income while not negatively affecting the traditional objective of the valley's farms.

This paper will examine how changing management strategies in tree fruit orchards could earn carbon credits. Furthermore, these strategies will be ranked according to the perceived opportunity and practicality in earning credits.

2.0 Fruit Orchards and Carbon

As climate change and the environment have become more important to the general public, a solution tied to market economics is needed to bring about substantial change. The prime financial instrument in this cause has been the carbon credit. In essence, a carbon credit is created when an action is undertaken that helps reduce the release of greenhouse gases into the atmosphere (Bull & Greig 2009). Carbon credits can be produced in either one of two ways. First, an activity is undertaken that reduces greenhouse gas emissions. This must be "in addition to" what would have normally occurred, a concept known as additionality (Bull & Greig 2009). Second, an action is undertaken that sequesters, or absorbs, additional carbon from the atmosphere. These credits can then be sold to a company, organization, or individual who wishes to reduce emissions either voluntarily or as part of a regulated system. In 1992, the United Nations passed a treaty that included the Kyoto Protocol, a legally binding arrangement aimed at reducing global greenhouse gas emissions (Bull & Greig 2009). While the protocol is not yet in effect in Canada, there is still a market for voluntary offsets. Carbon credits are calculated, marketed, and sold in units of tonnes (t) of carbon dioxide equivalents (CO_2e).

The agricultural sector produces approximately 10% of Canada's GHG emissions (CMC 2003). Tree fruit orchards have a role to play in establishing meaningful reductions since they act as both carbon sinks and sources. As a sink, orchards remove carbon from the atmosphere and use it to add woody material, create fruit and increase the amount of carbon in the soil through the process of photosynthesis. Conversely, orchards act as sources by releasing carbon through plant respiration, through the pruning and removal of old trees, through the use of diesel fuel, gasoline, fertilizers and pesticides, and through the consumption of fruit (Kerckhoffs & Reid 2007).

Fruit trees have the highest potential to sequester carbon from the atmosphere during the first ten years of their lives. Young trees grow quickly and are rapidly expanding the amount of woody material and their roots during this time (Kerckhoffs & Reid 2007). However, trees are often extensively pruned once they have reached their second decade. In addition, it is estimated that 50-65% of new carbon is contained within the fruit of mature trees (CMC 2003). The following table shows a comparison of carbon sequestration by fruit type.

Table 1: Comparison of CO_2 equivalent storage for tree fruit crops

Crop	Total Dry Weight (t/ha)	Total CO_2e Stored (t/ha)
Plums, prunes	62	114
Peach & nectarine	40	73
Apple	36	66
Grape Vines	4	8

Source: Kerckhoffs & Reid 2007

Orchards do have an advantage over several other types of agriculture. Annual field crops such as wheat do not create wood where carbon is stored, they contribute less biomass through roots, and they add less carbon to the soil. Furthermore, field crops promote soil disturbing practices such as tillage (Field & Kroodsma 2006). Consequently, there is the possibility that other agricultural industries could become a major market for orchard-based reductions since emitters with a high cost of reducing emissions could pay those with a low cost of reducing net GHG emissions (Marland *et al.* 2001).

When it comes to carbon sequestration, tree fruit orchards and forests have similarities. Accordingly, it is appropriate to use forest carbon accounting as a reference point. Both types of land use involve carbon storage above ground in trees and below ground in roots and within soil organic matter. However, mature forest stands have the potential to sequester a significant more amount of carbon, in the order of 550-900 tonnes of CO_2e/ha (Kerckhoffs & Reid 2007). In addition, forests do not direct a significant portion of their resources to fruit production.

3.0 Management Strategies: Opportunities and Barriers

There are several ways that orchardists can create carbon credits and reduce greenhouse gas emissions. These include eliminating the burning of wood waste; planting fallow acreage and replanting old, low density orchards; planting shelterbelts; practicing conservation tillage and planting improved cover crops; and growing organic crops or reducing the amount of fertilizers and insecticides in use.

In order to evaluate the merit of each of these management strategies, they need to be assessed on the strength of the opportunity as opposed to the barriers behind implementation. The opportunity lies in the amount of carbon that can be sequestered as well as the likelihood of the strategy becoming adopted. Also, the creation of credits could have other unintended positive consequences for orchardists such as increased production levels. The barriers revolve around whether carbon credits would actually be certified and verified by an independent third party organization.

The first barrier is the concept of a *baseline*, or the reference point from which variation is measured (Bull & Grieg 2009). The baseline scenario involves what would normally occur if no management for carbon had taken place. The second obstacle is determining *additionality*. The additionality factor states that reduction credits should only be granted if activities are beyond what would have "happened anyway" (WRIWBC 2005). Therefore, tree fruit growers must be willing to change their accustomed tactics to pursue carbon as an extra revenue source. The next issue is *permanence*, or the length of time in which carbon is stored or GHG emissions are reduced. Subsequently, any new management strategies must not result in *leakage*. Leakage occurs when reductions created from one project result in an increase in emissions outside of the scope of that project. Finally, the last barrier concerns developing a *quantification protocol* that establishes how reductions are measured and verified (Bull & Greig 2009). This step is necessary in creating credits through regulating and purchasing bodies such as Environment Canada or the Pacific Carbon Trust, which is a British Columbia crown corporation established to purchase offsets created within the province.

In order to evaluate these barriers, a reporting standard is required. Since there are no present accounting standards for tree fruit orchards, the California Climate Action Registry's (CCAR) *Urban Forest Project Reporting Protocol* was chosen. This standard is acceptable for fruit orchards since it was created to supervise similar reductions in emissions (as compared to traditional forest accounting standards), it assumes that intensive management is applied, and it accounts for the pruning of trees (CCAR 2008). However, this standard has its deficiencies in providing an all-encompassing comparison since it does not consider some agriculture techniques associated with orchards such as tillage practices and the use of fertilizers and pesticides.

3.1 Eliminating the burning of wood waste

Fruit trees need to be pruned once or twice a year in order to stimulate fruit development and create a successful crop. This practice results in a considerable amount of wood waste that must be discarded annually. More often than not, the prunings are burned (CMC 2003). Another source of wood waste is the removal of old trees, often to replant but sometimes to create fallow fields. Again, this woody material is often burned, especially the stumps and roots.

3.1.1 Opportunities

Fortunately, there are alternatives to dealing with what is a major source of carbon from orchards. One practice already implemented by some growers involves flail mowing prunings into mulch. If the financial incentive was present, the complete implementation of this practice would not be hard to achieve. However, encouraging growers to undertake the expensive and timely process of grinding stumps and roots into mulch will be harder to accomplish. Therefore, the greatest potential for wood waste would be to produce a commodity out of it. Wood waste could be chipped down and used for bioenergy applications such as wood pellets or electricity generation. While the costs to chip and transport the wood fuel to an appropriate facility would be high, there is potential government funding to acquire the necessary infrastructure. There are currently several programs from all levels of government in place to promote renewable energy sources (GOC 2006). Moreover, there are two Tolko co-generation plants within the Okanagan that will pay for wood residue (CMC 2003).

3.1.2 Barriers

Not only do the aforementioned management techniques have to be operationally and fiscally practical, but they must be able to overcome the following barriers:

(a) Baseline and Additionality

There is some debate on whether or not flail mowing is already common practice among orchardists. According to the CCAR, projects must be "better than business as usual" and above an annual average (CCAR 2008). Therefore, it should be expected that in order for this management practice to be accepted there must be fewer than 50% valley growers who practice flail mowing. This data would have to be acquired through an approved statistical method. In addition, the creation of bioenergy from fruit tree wood waste would certainly be labeled as a new management practice.

The potential to sequester GHGs through the elimination of burning wood waste is substantial. In fact, current estimates are that over 37,000 t of CO_2e per year would not be released into the atmosphere if this practice was eliminated (CMC 2003).

(b) Permanence and Leakage

According to the *Urban Forest Project Reporting Protocol* and in accordance with United Nations' guidelines, the biological carbon should be stored for a minimum of 100 years (CCAR 2008). It is questionable whether the carbon stored from flail mowing would meet these standards as some of the carbon from the prunings would not remain permanently sequestered in the soil. In addition, the participating orchardists would need to guarantee that this practice would be maintained over the length of the carbon contract, although this is obstacle is more easily overcome. However, the conversion of prunings and uprooted trees to bioenergy would eliminate these concerns. There are no predicted major leakage concerns from adapting these new activities.

(c) Quantification Protocol

In order to measure the amount of wood waste created from pruning or removing older trees, an accurate model would need to be developed based upon sample studies (CMC 2003). The carbon sequestered would need to factor in emissions created by flail mowing, although they would likely be in the same vicinity as those created from preparing prunings to be burned by using a brush rake attached to a tractor. With regards to verification, the CCAR states that reporting must occur on 5 year cycles. For that reason, it is predicted that reduced emissions from eliminating the burning of wood waste would have to be recalculated every 5 years.

3.2 Planting fallow acreage and replanting old, low density orchards

Over the last several years, the amount of acreage being replanted for apples and pears has been in decline (MOAFF 2004). However, the amount of soft fruits (cherries, peaches, etc.) replanted in the valley has risen considerably since 1992, leading to a slight increase in total acreage replanted (see

Appendix I). Nonetheless, there are sizeable areas that have been left fallow as the profit margins from farming have become smaller and smaller.

3.2.1 Opportunities

The planting of empty land and the replanting of old trees provides another significant opportunity to reduce GHG emissions. If 50 acres was planted per year, the total CO_2e sequestered would be 579 t. The amount of carbon stored from replanting is projected to be over 7000 t (CMC 2003). Not only could carbon credits be earned, but this would also create an incentive to replant land that was deemed marginally productive or operationally difficult over the last several years, thereby increasing the valley's total production levels.

3.2.2 Barriers

(a) Baseline and Additionality

In order to determine which land is considered fallow, a baseline year would need to be established. The CCAR has ascertained 2001 as their baseline year, but this would ultimately depend upon what year was chosen by a North American carbon regulatory body or the purchasing agent.

Planting vacant land would meet additionality requirements. On the other hand, replanting is usually considered a normal practice. Again, potential reductions could vary greatly depending on what year is determined as a baseline.

(b) Permanence and Leakage

If regulations stated that the carbon must be stored for over 100 years, as declared in the California Climate Action Registry's *Urban Forest Protocol*, then the issue of permanence is clearly an impediment. Even the planting of empty land would need to be backed by a guarantee that the acreage would be kept under production for the next century. Conversely, a shorter timetable and less strict standards would be beneficial for orchardists seeking value from the creation of emissions reduction credits.

Leakage could occur related to this management activity if funds allocated to planting and replanting led to a decline in the overall health of the existing orchard. This would lead to an unexpected release of emissions as the original orchard sequestered less carbon than before the new management activity was undertaken.

(c) Quantification Protocol

Planting and replanting would both result in real, measurable reductions in carbon emissions. Taking into account verification, the CCAR's *Urban Forest Project Reporting Protocol* requires that average tree spacing is no less than 5 metres between trees. This is done in order to accommodate biomass equations for open growing trees. However, tree spacing for fruit trees is much less, especially in newer high-density orchards. In order to meet the protocol's standards, a new equation would have to be developed. Another requisite of this standard is that all newly planted trees must be mapped accurately.

3.3 Shelterbelt plantings

Shelterbelt plantings along property lines can be used to sequester carbon through the growth of non-crop trees. Furthermore, shelterbelts around building such as shops, packinghouses, and homes can result in energy savings that are substantial enough to create reduction credits.

3.3.1 Opportunities

While tree fruit orchards are usually planted to a high density and much of the land is occupied, there is often a gap between neighbouring properties that would allow for shelterbelt planting. Fast growing trees that sequester carbon quickly could be planted, such as poplar. Shelterbelts can be expected to achieve as much as 41 t of C per hectare (or approximately 150 t of CO_2e) over their life spans (Kerckhoffs & Reid 2007). This equals 1 t CO_2e/ha per year based on a 150 year lifetime for each tree. Therefore, the maximum annual sequestration from shelterbelts is approximately 4990 t for the Okanagan. Not only could carbon credits be created, but tension between orchards and non-farming adjacent land could be reduced as a buffer is created. These ill feelings are sometimes created when commercial agriculture borders residential communities.

3.3.2 Barriers

(a) Baseline and Additionality

This practice is external to present management practices or governmental regulations. As a result, any carbon storage created by shelterbelt plantings will pass the additionality test. However, any existing shelterbelt plantings would not be included in reductions calculations.

(b) Permanence and Leakage

Shelterbelt plantings would be long term and therefore permanence would not be a problem. However, leakage could arise if excessive shading caused by the shelterbelt trees hindered the growth of the main crop trees. In addition, increased water consumption could result in marginal increases in emissions related to irrigation.

(c) Quantification Protocol

Shelterbelts provide a real and measurable form of carbon sequestration. Accounting for reductions from shelterbelt plantings would be relatively simple. Calculations such as those used by the *Urban Forest Project Reporting Protocol* would be appropriate.

3.4 Conservation tillage

High intensity tilling practices lead to greenhouse gas emissions as the soil is disturbed, respiration is increased, and fossil fuels are burned in the process. Conservation tillage aims to reduce the emissions associated with soil disturbance.

3.4.1 Opportunities

Since orchards are a perennial crop, most are not tilled annually. However, it is a common practice to till orchards that are being replanted. In order to reduce soil disturbance and consequently reduce greenhouse gas emissions, new plantings could be left untilled and augers/post-hole diggers could be used to disturb only the minimal amount of soil. However, even zero tillage of annual crops results in minimal carbon sequestration when compared to the previously mentioned management strategies. For instance, the estimated carbon storage created in Okanagan orchards from this practice was only 5% of the value associated with replanting (CMC 2003). In addition to conservation tillage, new cover crops could be explored that increased the carbon storage capacity of soils.

3.4.2 Barriers

(a) Baseline and Additionality

Conservation tillage is not currently practiced frequently in the Okanagan since there is a limited risk of erosion associated with orchards. For that reason, this practice would be considered above and beyond current strategies and would qualify for carbon credits according to the additionality principle.

(b) Permanence and Leakage

The reductions associated with conservation tillage are not permanent. Soil carbon is accumulated and stored until a new equilibrium is reached after saturation. Additionally, the increased carbon composition of the soil is very susceptible to being released back into the atmosphere if the new management strategies are ended (Marland *et al.* 2002). Nevertheless, new and improved cover crops could help to solidify the carbon storage potential of the soil as well as protect against any unexpected releases.

(c) Quantification Protocol

In order to accurately model carbon sequestration associated with conservation tillage, models would need to be borrowed from other agricultural sectors such as grain farming. According to the Kyoto Protocol, emissions reductions related to agricultural soils are only listed as an item for future inclusion (Marland *et al.* 2002). This casts doubt upon whether or not credits earned from soil sequestration will have considerable value in the near future.

3.5 Organics and the reduced use of fertilizers and insecticides

Orchards are a source of GHG emissions not only from biological processes such as decay and respiration, but also from the use of petroleum-based fertilizers and pesticides.

3.5.1 Opportunities

The conversion to organic farming is another management activity that could create carbon credits. A reduced use of fertilizers would result in measurable GHG emissions (Marland & West 2002). Fertilizers are derived from fossil fuels and often have to be transported long distances to farms. In their place, animal manure from local sources could be used. The same implications are associated with insecticides and other pesticides, since they are also manufactured from crude oil or natural gas products. The possible use of biodiesel for tractors and trucks would provide another source of reductions.

Unfortunately, the reductions from the aforementioned changes in management would be small on a farm-by-farm basis. As a result, incremental reductions such as these must be pooled across the whole industry in order to see reasonable benefits.

3.5.2 Barriers

(a) Baseline & Additionality

While the recent popularity of organic produce has resulted in more organic orchards in the Okanagan, they cannot be considered the current norm. Also, a switch to organic agriculture from conventional methods leads to an increase in soil organic carbon. During the first 50 years after conversion, the increase in carbon sequestration is rapid (estimated at 10-40 g C/m2/year). The rate then declines until stabilizing after 100 years (Foereid & Hogh-Jensen 2004). Although this study was conducted for annual crops, it can be assumed that similar results could be expected for organic orchards because of shared management strategies.

(b) Permanence and Leakage

The reductions associated with organic farming are long-lasting on the condition that the orchardist does not revert back to conventional techniques. In order to guarantee the continuation of reductions, the land owner would need to sign a contract stating their obligation to organic farming. In spite of the benefits associated with this strategy, there are some leakage concerns. Organic orchards may produce lower yields than traditional farming due to nutrient limitations, resulting in a higher land requirement to reach the same outputs (Foereid & Hogh-Jensen 2004).

(c) Quantification Protocol

While the reductions in emissions associated with organic farming and a lessened dependence on petroleum-based products are real, the extent to which they are measurable is limited. The calculations to determine the benefits from organic farming are complex due to the length of time needed to accurately evaluate all changes (Foereid & Hogh-Jensen 2004).

3.6 Ranking the Management Strategies

The following table provides a relative analysis of each management activity's ability to earn carbon credits with respect to the main barriers. A score of 1 indicates both a low potential that the activity could be certified as well as only a limited amount of tonnes that could be sequestered. A score of 5 signifies that the management activity could be easily implemented as well as resulting in a substantial reduction in emissions.

Table 2: Comparison of barriers related to improved management strategies

Management Strategy	Baseline & Additionality	Permanence & Leakage	Quantification Protocol	Total
Eliminate burning of wood waste	4	3	4	**11**
Planting & replanting	3	2	4	**9**
Shelterbelt trees planted	2	3	3	**8**
Conservation tillage	1	1	2	**4**
Organic farming techniques	2	2	2	**6**

Note: Each management strategy has been ranked on a scale of 1-5 for each barrier

The highest potential for carbon credits to be earned within the provincial tree fruit industry comes from changes in practices surrounding the disposal of wood waste. This practice is financially and operationally feasible, will likely meet the requirements of carbon regulatory bodies, and will result in a significant reduction in GHG emissions. The activity of planting vacant land and replanting older orchards also has potential. Creating shelterbelts along property lines and switching to organic farming could also lead to marketable reductions. On the other hand, the practice with the least potential is conservation tillage. The incremental carbon stored would be miniscule, and the practice is both hard to guarantee over an extended period of time as well as hard to quantify.

4.0 Discussion

Since the management actions have been identified and evaluated, the next step is to consider the practicality of establishing a carbon project through Okanagan orchardists. This includes a brief discussion regarding the steps in implementing the program and a rough financial estimate of the benefits to the individual grower.

4.1 Practicality and Implementation

In order for tree fruit orchardists to create revenue from carbon credits, a type of carbon cooperative should be established. The costs of implementing a monitoring, verification and reporting protocol are between $30,000 and $120,000. A cooperative would distribute the costs between each individual farmer, thereby making the process economical. In addition, the industry is already organized into groups of growers such as the Okanagan Tree Fruit Cooperative and the BC Fruit Growers Association, making the establishment of a valley-wide collective relatively easy.

In order to examine the potential economic impact of carbon credits, the three most realistic management strategies were chosen: the elimination of burning wood waste, planting and replanting, and shelterbelts. These actions would not impose too much of a financial burden on growers and much of the infrastructure and equipment to accommodate them is already in place. As a matter of fact, some of these management strategies are already in place in other jurisdictions. For example, there are companies in California that buy wood, stumps and roots from old orchards in order to power biomass plants (Field & Kroodsma 2006).

According to the Okanagan Valley Tree Fruit Authority, there are approximately 12,676 acres of tree fruits in the Okanagan and Similkameen valleys (CMC 2003). This includes approximately 500 medium to large size commercial growers (MOAL 2007). As a result, the average size of participating orchards is estimated at 25 acres. However, it is possible that small growers (those with less than 5 acres) would not g in a GHG reduction project due to the limited financial gains available to them. As far as the price of credits is concerned, the current voluntary market (i.e. the Chicago Climate Exchange) at $2 per tonne of CO_2e makes a tree fruit project unfeasible. However, it is more likely that a price of $10 could be presently earned through the Pacific Carbon Trust. Prices are also likely to rise considerably; the BC Climate Action Secretariat predicts prices will be as high as $25 per tonne by 2012 (MKJA 2008).

Table 3: Potential Revenue per Orchard with $10 and $25 CO_2e Price

			Potential Revenue per Orchard	
	t CO_2e total	*t CO_2e/orchard*	*$10 per t CO_2e*	*$25 per t CO_2e*
Eliminate burning	37,737.1	75.5	$754.74	$1,886.85
Planting/replanting	7,850.0	15.7	$157.00	$392.50
Shelterbelt	4,990.6	10.0	$99.81	$249.53
Total	**50,577.6**	**101.2**	**$1,011.55**	**$2,528.88**

Note: Data calculated with an estimated 500 growers; average orchard size assumed to be 25 acres

The above estimates assume revenue of $1,011.55 and $2,528.88 per orchard at CO_2e prices of $10 and $25, respectively. The total maximum value of Okanagan orchard credits is approximately $505,000 to $1,250,000. However, these numbers are high as it would be difficult for each individual orchardist to implement all of the possible strategies to their maximum potential. Moreover, carbon prices are anything but stable and volatility should be expected.

4.2 Competitive Advantages

Orchards have a couple of distinct benefits over other carbon projects. Firstly, secure land ownership gives them a competitive advantage. Whoever agrees to buy the credits from orchardists knows that there is security in the transaction and that the seller has the means to sequester the amount of carbon agreed upon. On the other hand, projects related to forestry often have contentious ownership issues, such as who actually owns the carbon sequestered on crown land.

There is also potential for the tree fruit industry to offset emissions from the big polluters within Canada's agricultural industry. Moreover, the smaller scale of a project based upon tree fruit orchards would help supply a small, niche market. As an example, orchardists could partner with municipalities who have pledged carbon neutrality. If carbon markets continue to grow, there will be a demand for incremental reductions. The Pacific Carbon Trust is expected to purchase as much as 1,000,000 t of carbon-dioxide equivalent offsets by 2011 (PCT 2009).

Lastly, there is no conversion of land to a different type of use involved with orchard-related carbon sequestration. The land base will still be used for its original purpose and there is no associated leakage in this respect. As a comparison, carbon sequestration projects involving forest plantations often involve the transfer of land from agriculture to forestry. In turn, other forested land is often cleared to replace the loss of farmland, thereby counteracting the original carbon offsets (Marland *et al.* 2001).

5.0 Conclusion

Tree fruit orchards have the potential to sequester significant amounts of greenhouse gases. The management practices with the most potential include eliminating the burning of wood waste (and converting it to bioenergy), planting vacant land and replanting old orchards, and establishing shelterbelts along property boundaries. Other actions that have the capability of creating carbon credits are practicing conservation tillage and switching to more organic farming techniques. These new management practices can be more time consuming and could even be slightly detrimental to the production of the fruit crop. However, the opportunity to earn additional revenue is enticing for the valley's growers. Moreover, the provincial government's recent commitment to reducing GHG emissions will result in a favourable environment for offset projects. And the viability of any project increases when the price of carbon rises. Additionally, the tree fruit industry's structure that relies on cooperative organizations will provide an advantage in establishing a valley-wide initiative. Finally, any activities taken by the Okanagan's tree fruit industry to reduce GHG emissions could be used as a marketing tool in the domestic and international marketplace.

6.0 References

Bull, Gary & Greig, Mike. "Carbon Management in British Columbia's Forests: Opportunities and Challenges." 2009. Forrex Series 24.

California Climate Action Registry (CCAR). "Urban Forest Project Reporting Protocol." 2008. http://www.climateregistry.org/resources/docs/protocols/progress/urban-forest/urban-forest-protocol-final-082008.pdf. Accessed on March 15 2009.

Crane Management Consultants (CMC). "Feasibility and Value of Earning Carbon Credits from Okanagan Tree Fruit Orchards." 2003. Prepared for: BC Fruit Growers Association, Kelowna, BC.

Field, Christoper B. & Kroodsma, David A. "Carbon Sequestration in California Agriculture, 1980-2000." 2006. Ecological Applications. Volume 16, Issue 5: pp 1975-1985.

Foereid, Bente & Hogh-Jensen, Henning. "Carbon Sequestration Potential of Organic Agriculture in Northern Europe – a Modelling Approach," 2004. Nutrient Cycling in Agroecosystems. Volume 68, Number 1: pp 13-24.

Government of Canada (GOC). “Bioenergy: About the Canadian Bioenergy Industry.” 2006. http://www.ic.gc.ca/eic/site/rei-ier.nsf/vwapj/Bioenergy-bioenergie_eng.pdf/$file/Bioenergy-bioenergie_eng.pdf. Accessed on March 31 2009.

Kerckhoffs, L.H.J. & Reid, J.B. “Carbon Sequestration in the Standing Biomass of Orchard Crops in New Zealand.” 2007. http://www.hortnz.co.nz/communications/pdfs/Three_Submission_000.pdf. Accessed on February 26 2009.

Marland, Gregg & West, Tristram O. “A Synthesis of Carbon Sequestration, Carbon Emissions, and Net Carbon Flux in Agriculture: Comparing Tillage Practices in the United States.” 2002. Agriculture, Ecosystems, and Environment. Volume 91, Issues 1-3: pp 217-232.

Marland, Gregg, McCarl, Bruce A. & Schneider, Uwe. “Soil Carbon: Policy and Economics,” 2001. Climatic Change. Volume 51: pp 101-117.

Ministry of Agriculture, Food and Fisheries (MOAFF). “Industry Overview: Apples and Pears in British Columbia.” 2004. http://www.agf.gov.bc.ca/treefrt/profile/pome.pdf. Accessed on March 31 2009.

Ministry of Agriculture and Lands (MOAL). “Profile of the BC Tree Fruit Industry.” 2007. http://www.agf.gov.bc.ca/treefrt/profile/ind_profile.htm. Accessed on March 18 2009.

Ministry of Environment (MOE). “Emission Offsets Regulation.” 2008. http://www.env.gov.bc.ca/epd/codes/ggrta/pdf/offsets-reg.pdf. Accessed on March 17 2009.

Ministry of Environment (MOE). “Greenhouse Gas Reductions Target Act.” 2007. http://www.env.gov.bc.ca/epd/codes/ggrta/index.htm. Accessed on March 17 2009.

MK Jaccard and Associates Inc. (MKJA). “Sensitivity and Uncertainty Analyses to Inform British Columbia’s Interim Greenhouse Gas Targets.” 2008. Prepared for British Columbia Climate Action Secretariat. http://www.livesmartbc.ca/attachments/MKJA_Sensitivity_Report.pdf. Accessed on April 1 2009.

Pacific Carbon Trust (PCT). “Current Opportunities.” 2009. http://www.pacificcarbontrust.ca/Home/BusinessOpportunitiesCurrentOpportunities/tabid/97/Default.aspx. Accessed April 4 2009.

Statistics Canada (StatsCan). “Farms Classified by Industry Group.” 2007. http://www.statcan.gc.ca/pub/95-629-x/3/4123869-eng.htm. Accessed on March 4 2009.

World Resources Institute and the World Business Council for Sustainable Development (WRIWBC). “The Greenhouse Gas Protocol: The GHG Protocol for Project Accounting.” 2005. http://pdf.wri.org/ghg_project_accounting.pdf. Accessed on April 1 2009.

7.0 Appendices

7.1 Appendix I

Table 4: Replant program acreages summary (1992-2002)

	Area Replanted (acres)											
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**20001**	**2002**	**Total**
Apples	431	337	356	322	410	537	391	312	375	250	277	**3998**
Soft Fruits	98	88	138	132	184	292	215	260	259	323	481	**3271**
Total	528	425	494	454	594	829	605	572	634	574	758	**7269**

Source: CMC 2003