UBC Farm: Impact Assessment of Current Methods for Produce Storage and Transportation

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ABSTRACT

This research report is concerning the assessment of the UBC farm's current method that uses plastic totes and crates for storage and transportation and, compares this process with three other alternatives using a triple bottom line approach. The report provides an overall view of the economic, social and environmental impact of a total of four methods. The UBC farm currently uses reusable plastic and rubber containers but there is a possibility of enhancement outlined by this report that provides a solution in this aspect of its production.

The current method at the UBC Farm uses plastic totes and crates however there are some constraints that had to be taken into account, which could possibly be limiting the storage and transportation of produce. Putting the advantages asides, the current method of reusable plastic containers (RPC) uses water for the purpose of cleaning and also costs more initially than other alternatives. One of the alternatives, display-ready corrugated containers (DRC), removes the need of water usage, and cuts costs of labor significantly. Wooden boxes were another alternative that was researched and assessed. They provided excellent durability and were eco-friendly however; the likelihood of infestation of pests and insects was much higher compared to the other three options. Lastly, plastic liners provided a much easier option of cleaning and disposing as compared to the other possibilities but again, the cost of liners was subject to fluctuation depending on the volume of production of the UBC farm.

After an extensive assessment, this report concludes the use of RPC to be the most sustainable viewing it from an economical, social and environmental standpoint. The benefits outweigh the detriments comparably to the other three options that were assessed.

LIST OF ILLUSTRATIONS

GLOSSARY

LIST OF ABBREVIATIONS

UBC	The University of British Columbia
RPC	Reusable Plastic Container
DRC	Display-ready Corrugated Container

1.0 INTRODUCTION

This report investigates the sustainability of the current method of storage and transportation of produce at the UBC farm and compares them to three alternatives using a comprehensive triple bottom line approach.

This report is split into three distinct sections, reusable plastic containers (RPC) and display-ready corrugated containers (DRC), wooden boxes and plastic liners. Each section provides an outline and compares the current method of storage and transportation to an alternative whilst taking into account the impact of an economical, social and environmental aspect.

The UBC farm grows over 50,000 pounds of produce each year and transports these goods from the field to the harvest hut and market. Currently, the UBC farm is using reusable plastic containers. The containers are washed periodically to get the maximum output of reusability. There is room to explore possibilities that could possibly make this practice more sustainable. Plastic liners, cardboard containers (DRC) and wooden containers were the few options that will be considered. We analyzed the different methods with respect to the triple bottom line analysis, the manufacture and disposal process, all involved costs, and the effect on UBC farm personnel. Evaluating the lifecycle of the current and alternative methods was also researched.

This report continues by discussing the current method of storage and transportation, RPC. Conclusions and recommendations are made in the final section of the report.

2.0 REUSABLE PLASTIC CONTAINERS & DISPLAY-READY CORRUGATED CONTAINERS

2.1 GENERAL OVERVIEW

To retrieve the data about energy, solid waste and greenhouse gas, we use the result from an analysis done in US, which is about RPC and DRC. The UBC farm is currently using RPC, slightly different in size and weight and other details. The data from the analysis will show a general sense of the difference between RPC and DRC, and illustrate how the RPC is compared to DRC in term of environment and society.

The analysis system:
In order to perform the analysis of RPC and DRC, there must be some standards and rules to build up a system in which the data required to perform the analysis can be retrieved.

Figure 1 – Sample Reusable Plastic Container
Source:http://onlinelibrary.wiley.com.ezproxy.library.ubc.ca/doi/10.1002/pts.731/abstract

The whole analysis operates under a closed pooling system. In this system, one company called a pooler lends containers to users. The pooler company operates depots at various locations throughout the country (United States). Users lease their containers from depots and give them back to depots after use. The pooler company will repair and clean the containers after each use. Broken containers will be permanently moved from service.

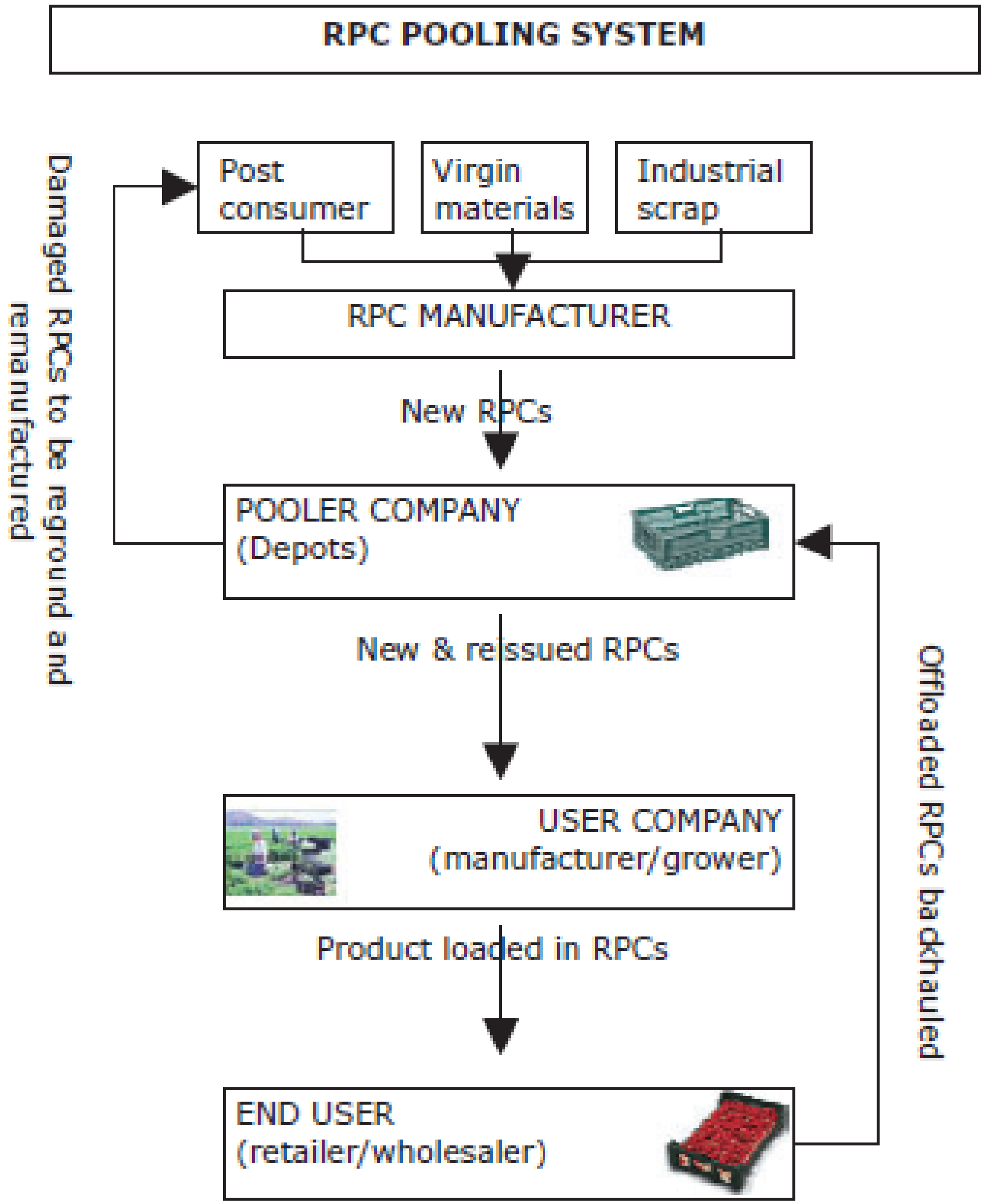

Figure 2 - RPC life cycle flowchart

Source:http://onlinelibrary.wiley.com.ezproxy.library.ubc.ca/doi/10.1002/pts.731/abstract

Figure 3 - Sample DRC

Source:http://onlinelibrary.wiley.com.ezproxy.library.ubc.ca/doi/10.1002/pts.731/abstract

The display-ready corrugated containers used in this analysis are cardboard containers with the similar dimensions as RPCs so that the pallet and truck loading or both are similar, making the analysis more reasonable and convincing.

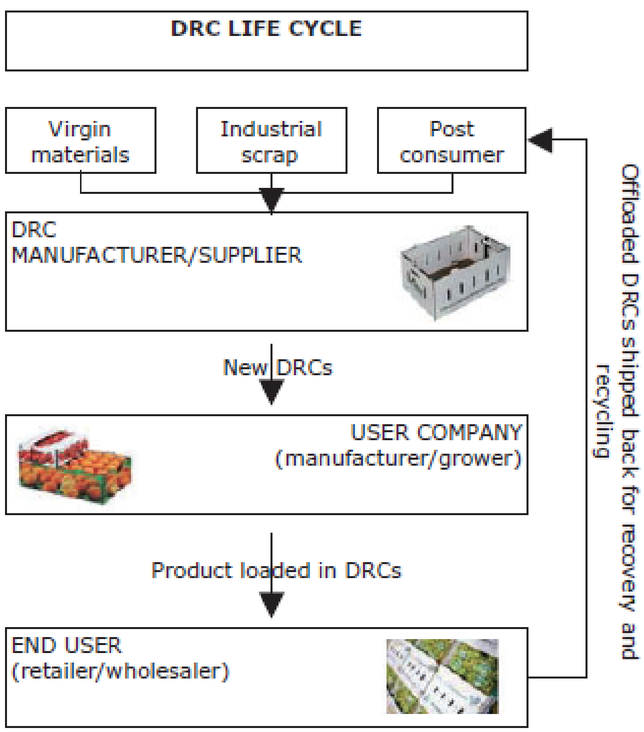

Figure 4 - DRC life cycle flowchart

Source:http://onlinelibrary.wiley.com.ezproxy.library.ubc.ca/doi/10.1002/pts.731/abstract

Life Cycle steps:

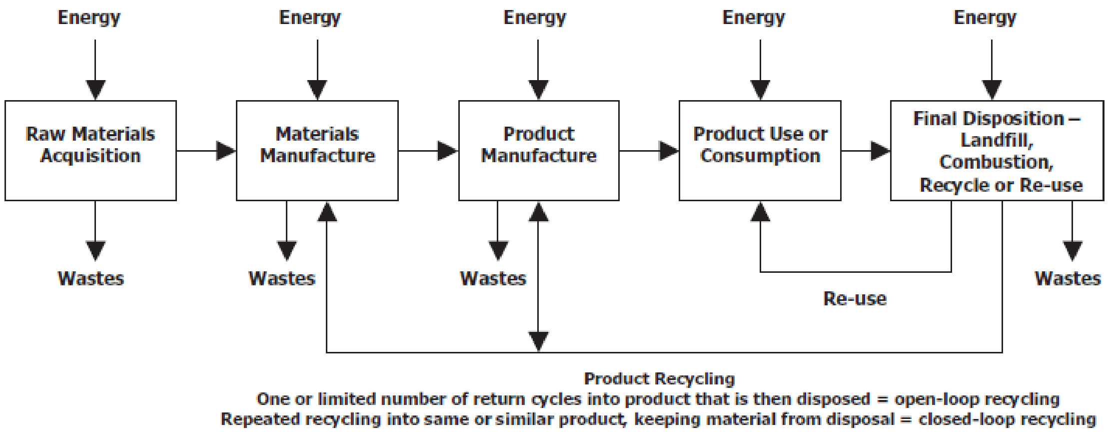

Figure 5 - General materials flow for "cradle-to-grave" analysis
Source:http://onlinelibrary.wiley.com.ezproxy.library.ubc.ca/doi/10.1002/pts.731/abstract

The life cycle steps analyzed in this study include extraction of raw materials from the earth, materials and container manufacture, outgoing transportation of containers, backhauling and washing of empty RPCs, recycling of DRCs and RPCs, and end-of-life disposition.

To be specific:

The produce container system models include the following steps:

- Production of virgin polypropylene resin (beginning with raw material extraction) and RPC manufacture.
- Production of corrugated containers with industry average recycled content (including collection and processing of post-consumer corrugated boxes and industrial scrap, as well as virgin inputs to box manufacture).
- Transportation of containers to growers.
- Transportation of packed containers from growers to retail.
- Backhauling, washing and re-issue of RPCs.
- Recycling and/or disposal of DRCs at end of life.
- Recycling of RPCs retired from service.
- Disposal of RPCs lost during use.

Functional units:
The functional unit is shipment of 1000 tons of each type of produce using RPCs and DRCs. Because the weight of RPC and DRC is different, the number of DRC is actually more than RPC with the same 1000 tons weight.

	Average weight per empty container [kg (lb)]		Produce per container [kg (lb)]	
Fresh produce	RPC	DRC	RPC	DRC
Apples	2.45 (5.4)	0.82 (1.8)	18.6 (41)	18.1 (40)
Bell peppers	2.18 (4.8)	0.91 (2.0)	11.3 (25)	11.8 (26)
Carrots	2.31 (5.1)	0.91 (2.0)	21.8 (48)	21.8 (48)
Grapes	1.5 (3.3)	0.77 (1.7)	8.62 (19)	9.53 (21)
Lettuce (head)	2.4 (5.3)	1.13 (2.5)	15.9 (35)	18.1 (40)
Oranges	2.18 (4.8)	1.0 (2.2)	18.1 (40)	18.1 (40)
Peaches/nectarines	1.59 (3.5)	0.86 (1.9)	15.4 (34)	15.9 (35)
Onions	1.77 (3.9)	0.82 (1.8)	18.1 (40)	18.1 (40)
Tomatoes	1.77 (3.9)	0.68 (1.5)	12.7 (28)	12.7 (28)
Strawberries	1.13 (2.5)	0.41 (0.9)	4.08 (9)	4.08 (9)

Figure 6 - Average container weight comparison

Source:http://onlinelibrary.wiley.com.ezproxy.library.ubc.ca/doi/10.1002/pts.731/abstract

Other important information:

- The RPCs in this study are modeled at the average weight, lifetime use rate and loss rate reported by the four prominent poolers in the USA. DRCs are modeled at the reported container weight for one-piece folded boxes reported by a major corrugated manufacturer.
- The difference of labor associated with the difference of containers is ignored in this analysis.
- The total number of lifetime trips for an RPC is equal to the number of trips(‘turns’)/year × the number of years the container remains in service.
- The pooling system operates nationwide, enabling growers to obtain RPCs from the nearest pooling location, regardless of where the RPCs were used prior to arrival at that pooling location.
- Lower re-use rates and higher loss rates for RPCs mean that more containers must be manufactured to transport the same quantity of produce, more lost containers end up in solid waste, and there is more material to be recycled from retired containers.

Scenario explanation for the result table:

- Average RPC (average re-use and loss rate) at maximum backhaul distance compared to average DRC (reported weight for folded box).
- Average RPC (average re-use and loss rate) at 20% reduced backhaul distance (‘80% backhaul’ in table) compared to average DRC.
- Conservative scenario: RPC at 75% of average re-use rate, twice the average loss rate, maximum backhaul distance compared to DRC with 10% light weighting.

Table 2. Summary of LCI results for all produce container scenarios (all results reported on basis of 1000 tons of produce shipped)

	RPCs			DRCs		Percentage difference*		
Fresh produce	Avg	Avg with 80% BH	Conserv	Avg	Conserv	Avg DRC, avg RPC	Avg DRC, avg RPC w/80% BH	Conserv
Total energy (million BTU)								
Apples	853	789	900	1073	966	23	31	7
Bell peppers	1121	1040	1188	1818	1637	47	54	32
Carrots	531	504	567	981	883	60	64	44
Grapes	1080	1010	1141	1920	1729	56	62	41
Lettuce (head)	905	839	958	1485	1338	49	56	33
Oranges	650	601	692	1241	1117	63	70	47
Peaches/nectarines	671	621	707	1284	1156	63	70	48
Onions	533	501	566	1075	968	67	73	52
Tomatoes	797	736	864	1241	1117	44	51	28
Strawberries	1975	1858	2071	2455	2212	22	28	7
Total solid waste (tons)								
Apples	1.35	1.32	1.60	25.3	22.8	18.8	19.2	14.2
Bell peppers	1.99	1.96	2.37	43.2	38.9	21.7	22.1	16.4
Carrots	1.04	1.03	1.25	23.4	21.1	22.4	22.7	16.8
Grapes	2.15	2.12	2.50	45.5	41.0	21.2	21.4	16.4
Lettuce (head)	1.53	1.50	1.82	35.1	31.6	23.0	23.5	17.3
Oranges	1.23	1.21	1.47	30.2	27.2	24.5	24.9	18.5
Peaches/nectarines	1.25	1.23	1.45	30.5	27.5	24.4	24.8	18.9
Onions	1.09	1.07	1.28	25.7	23.1	23.7	24.0	18.2
Tomatoes	1.57	1.54	1.84	30.1	27.1	19.2	19.6	14.7
Strawberries	4.03	3.98	4.57	55.6	50.1	13.8	14.0	11.0
Total greenhouse gas (tons CO_2 equivalents)								
Apples	62.7	57.5	64.3	67.1	60.5	7	15	−6
Bell peppers	81.3	74.7	83.6	113.0	102.0	33	41	20
Carrots	37.8	35.6	39.0	61.1	55.1	47	53	34
Grapes	78.3	72.6	80.4	120.0	108.0	42	49	29
Lettuce (head)	65.9	60.5	67.7	92.8	83.6	34	42	21
Oranges	46.6	42.7	48.1	76.9	69.2	49	57	36
Peaches/nectarines	49.0	44.9	50.2	80.1	72.2	48	56	36
Onions	38.2	35.7	39.4	67.0	60.3	55	61	42
Tomatoes	57.5	52.5	59.3	77.0	69.3	29	38	16
Strawberries	145.0	135.0	148.0	155.0	140.0	7	14	−6

*Percentage difference = (difference between system results)/(average of system results).
Percentage difference is considered inconclusive if <10% for total energy or <25% for GHG.
Inconclusive results comparison in the table are shaded grey.
Average scenario defined as RPC with average use/loss rates (separate results for maximum and 80% backhaul) and reported weight DRC.
Conservative scenario for RPC is use rate at 75% of average and loss rate 2 × the average loss rate. Conservative scenario for DRC is 10% lightweighting.

Figure 7 - Summary comparison of RPC & DRC scenarios

Source:http://onlinelibrary.wiley.com.ezproxy.library.ubc.ca/doi/10.1002/pts.731/abstract

About the data:
This analysis focuses on the life cycle of the containers and uses three final data types as an indicator of conclusion. Each of them is the combined result associated with the many steps in the life cycle.

2.2 ENVIRONMENTAL ASSESSMENT

Energy: Total energy mainly consists of process energy and transportation energy. For RPCs, fuel resources used as material for the production of plastic resin are also considered.

Energy used for:	**RPC**	**DRC**
Cradle-to-production manufacture	less	more
Transportation of new containers to growers	less	more
End-of-life management	less	more
Backhauling and washing	yes	none

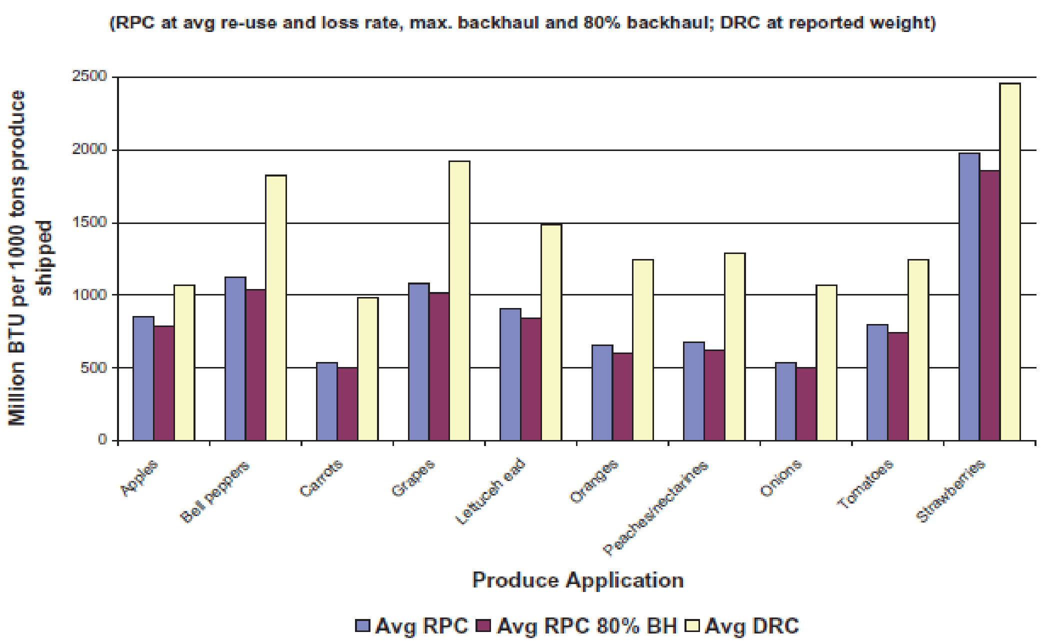

Figure 8- Average scenario GHG comparison
Source:http://onlinelibrary.wiley.com.ezproxy.library.ubc.ca/doi/10.1002/pts.731/abstract

Greenhouse gas: CO_2

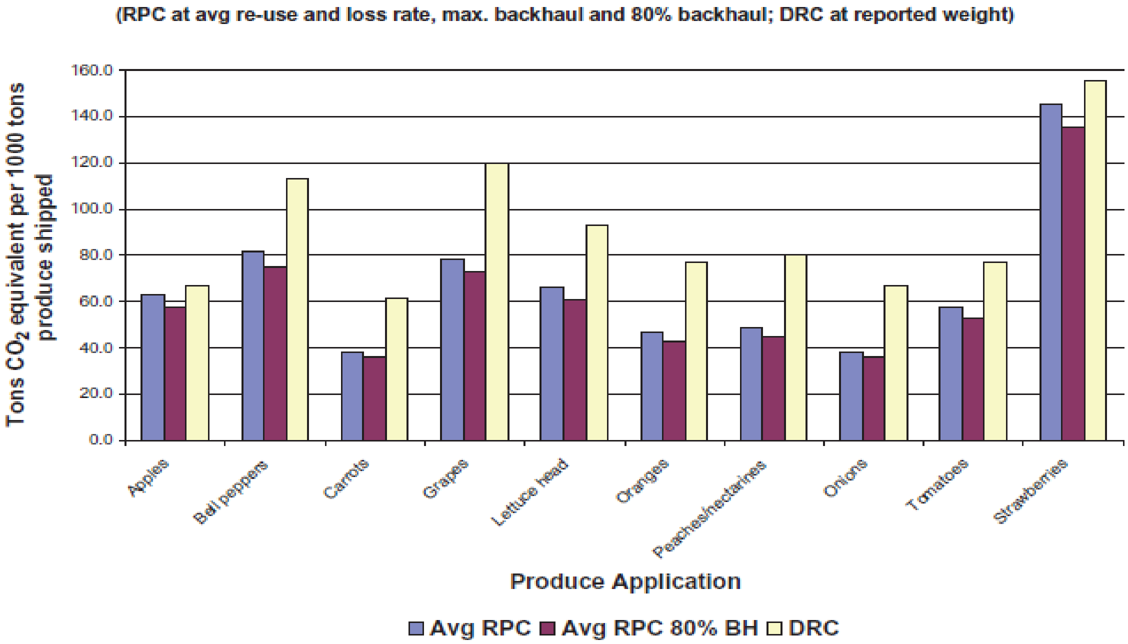

Figure 9 - Average CO_2 production

Source:http://onlinelibrary.wiley.com.ezproxy.library.ubc.ca/doi/10.1002/pts.731/abstract

The emission of CO_2 is a straightforward environmental problem.

Solid waste: Total solid wastes are the combination result of the following four types of waste.

Waste type	**Description**
Process wastes	Directly result from a process
Fuel-related wastes	Associated with the production and combustion of fuels used for process energy or for transportation fuel
Post-consumer wastes	Land-filled containers and ash from containers that are burned

For the produce shipping scenarios analyzed within the defined scope of this study, findings indicate that, on average across all 10 produce applications, RPCs require 39%

less total energy, produce 95% less total solid waste and generate 29% less total greenhouse gas emissions than do DRCs.

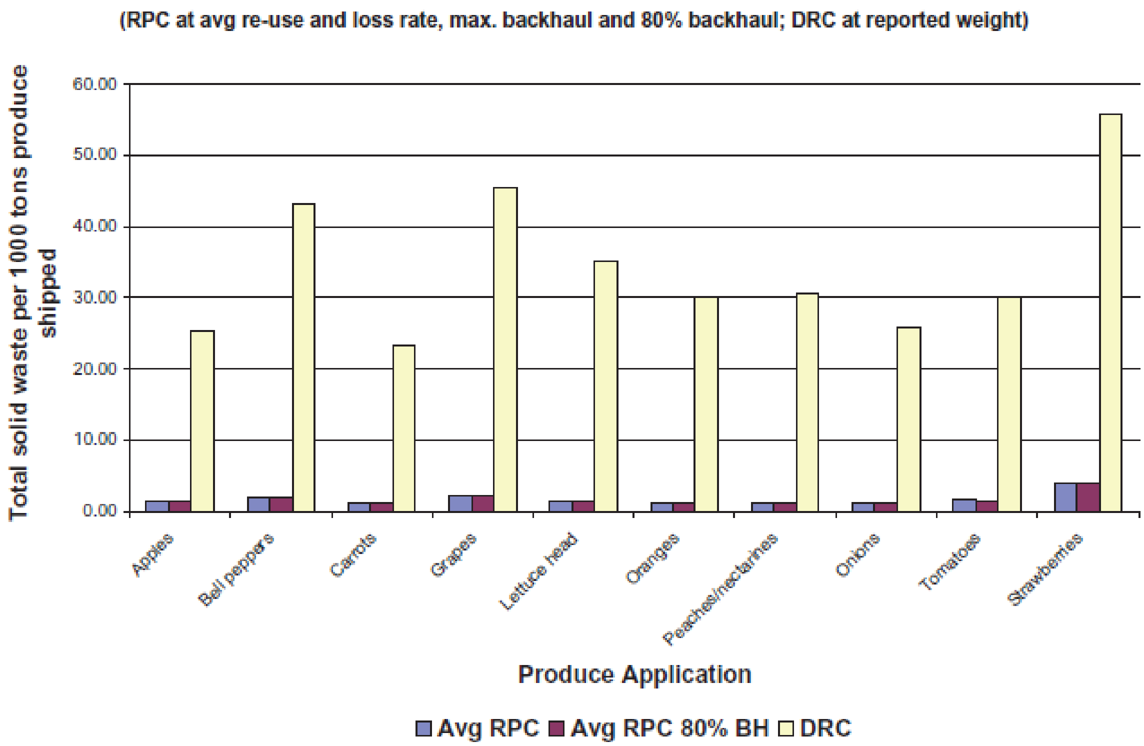

Figure 10 - Average scenario solid waste comparison

Source:http://onlinelibrary.wiley.com.ezproxy.library.ubc.ca/doi/10.1002/pts.731/abstract

Comparably, DRC produces more solid waste than RPC. About 30 tons of solid waste is produced for 1000 tons of DRC. Solid waste is not only a factor of environmental pollution but also a burden for the entire society.

Water:

Cardboard containers are for the most part disposable, and so don't require washing. Although the current Rubbermaid bins, and plastic crates contribute less solid waste than cardboard, the amount of water used in washing these bins is a large environmental detriment. Approximately 1465L of water may be used every two weeks to wash about half of the bins and crates present at the farm. To put this into perspective, the average Canadian uses over 350L of water each day. Although wastewater is an issue, it is fortunate that the water supply for UBC and Metro Vancouver comes from a large supply of lakes collecting snowmelt and stream water. The amount of water used in comparison to the other benefits of using these RPC's is actually very miniscule. Another concern is the use of cleaning products that end up in the drain. Some dish-soaps and cleaning products contain many chemicals, which may harm aquatic plants and wildlife. However, as long as environmentally friendly soaps are used this concern can be easily avoided.

2.3 ECONOMIC ASSESSMENT

Comparing the costs of these two options, a typical Rubbermaid bin amounts to approximately $13.00 each. Considering the lifespan and strength, these are significantly more favorable than cardboard counterparts, which range from $2.00 - $6.00. However finding boxes that other businesses are not using are also an option, but finding enough may not be possible. The cost per use of a rubber or plastic bin or crate is significantly better than that of a cardboard container.

2.4 SOCIAL ASSESSMENT

Currently, the amount of time to wash about half of the total crates and bins is 7.6 hours, or 456 minutes, which is roughly a whole work day. The amount of labour and time going into washing these is their biggest fault, however options such as outsourcing to a washing service is available, as well as using a bin washer. Outsourcing can be quite pricy, as much as $6.00 per bin, and involves moving the bins offsite. Purchasing a new bin washer would cost roughly $250,000.00, and an additional $2,000.00 a year to maintenance. A possible option may be to coordinate with the washer that services the recycling and trash bins.

On a physical note, the current containers have built in handles, have lids, and are stackable. Many cardboards do not have these features, and make handling them more difficult for individuals.

3.0 BIN LINERS

3.1 GENERAL OVERVIEW

Another option we explored was the use of bin liners, in addition to a container. Liners are commonly used in services such as garbage, to keep the trash containers clean. Lining the inside of these bins means less water, and time, is spent to clean the bins so periodically. Bin liners are essentially sheets, and so can be placed to fit into any shaped container if needed. However the trade-off is of course purchasing said liners, and the resources used to manufacture them.

Figure 11 - Example of food waste bin liner
Source: http://www.thebincompany.com/catalog/full_images/BC0451_lge.jpg

3.2 ENVIRONMENTAL ASSESSMENT

We will consider biodegradable bin liners. These sort of liners are composed of a breathable corn starch material, and are supposedly “100 percent biodegradable”. Using liners for food transport is comparable to many case studies done in Australia concerning garbage bin liners. Environmental benefits of using liners include less water used to clean bins, since the brunt of the mess is imposed onto the liner. With bin liners, one could reduce washing a container to at most once a month, significantly reducing amount of water used for washing uncovered bins. However liners have a very limited use, as low as only once before it’s strength wanes, and must be replaced. Since under certain conditions (sunlight, warmth) these liners biodegrade, their solid waste is very low. In terms of carbon footprint however, most biodegradable liners are considered greenhouse neutral since they are made up of renewable sources, but when degrading they release small amounts of methane contributing small amounts of greenhouse gasses. Liners reduce the need for cleaning their containers, however they do add small amounts of greenhouse gasses.

3.3 ECONOMIC ASSESSMENT

Biodegradable bin liners and bags cost approximately 60 cents each, and can be purchased locally at many retailers, an example is Canadian Tire. Supposing roughly 400 crates and bins are collectively used every month during harvest, we can estimate 100-240 dollars for the month.

3.4 SOCIAL ASSESSMENT

Due to less mess on the physical bins, less work is needed in terms of washing. The bins will most likely still need to be washed as liners will not protect bins completely. Liners are quite light and don’t add a significant amount of weight to bins, so moving bins around is just as easy. However someone must often replace each liner, and dispose of the old liners.

4.0 WOODEN CRATES

4.1 GENERAL OVERVIEW

In this case we examined the possibility of using the wooden crates and analyze the same using the Triple Bottom Line approach. Wooden crates are made using planks or plywood that are nailed together. They are stackable, can endure high material stress and have a long life span.

4.2 ENVIRONMENTAL ASSESSMENT

Since they are comprised of wood, wooden crates are eco-friendly. They are biodegradable, and do not cause pollution. They can be used and disposed of, as washing with water can invite pests and termites. If washing, they must be dried completely before using. Coastal BC consists of about 10 million hectares of forestland, which is about 25% of the world's tropical rainforests. However, continuous exploitation will result in deforestation; hence care should be taken to grow the trees in the same amount of cutting them. The crates can be coated with resin, another natural product, which will improve their resistance from predators. No greenhouse gases are emitted in the process of making the crates, and hence it does not result in air pollution.

4.3 ECONOMIC ASSESSMENT

Although crates are do not require a large amount of expenditure to be set aside for them, labor is required to make, dry and chop wood for the crates. This in turn encourages local industry and opens up jobs for the unskilled workers. Depending upon the number of persons hired, overall cost can be a bit a higher or lower.

4.4 SOCIAL ASSESSMENT

Wooden crates can be cleaned using water. However, they must be dried thoroughly before using as that would result in pests and termites hiding in the crates. This in turn requires labor. Also, making the crates will also require additional people. Wood materials will typically weigh more, requiring more physical strength to move around.

6.0 CONCLUSION AND RECOMMENDATION

Using a triple bottom line analysis of various options for transporting produce on the UBC Farm, we were able to give more insight into how sustainable they were respectively.

RPC's, such as the totes and crates used now, are far more sustainable in terms of solid waste, and price. The main concerns are water consumption, which is actually quite fair. An suggestion could be taken to try to recycle this water in other farm activities. Although the cleaning of these totes and crates takes quite an amount of time, the benefits are quite heavy, both economically, and even environmentally.

Cardboard containers are weak in strength, and won't get many uses. The risk of the container breaking during transport or stacking is significantly higher. Although they don't require washing one must still dispose of the waste. Cardboard containers may also use up more environmental resources, and are not nearly as cost efficient. The physical waste that accumulates is much higher. Recycling is an option; however cardboard recycling itself is not that efficient yet.

Bin liners contribute small amounts of solid waste and greenhouse emissions, but can reduce amount of times a bin needs to be washed, saving water and cleaning products. Replacing and disposing of liners may be offset by the significant reduction of washing time needed. With this comes an additional cost of about $0.60 per liner, which is limited in its reusability.

Our recommendations are to stay the course. Although there is a large social impact since the containers need a large amount of time to be cleaned, this seems to be the price to pay for excelling in environmental and economic sustainability.

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APPENDIX A