A STUDY OF THE CARBON FOOTPRINT OF THE SUMNER COMMUNITY: PROPOSING OPPORTUNITIES FOR EMISSION REDUCTIONS AT A COMMUNITY SCALE

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Executive Summary

- Research to address the two questions:
  i. What is the approximate carbon footprint of the Sumner community?
  ii. What types of mitigation strategies can be put in place to reduce this carbon footprint?

- Research considered within the wider context of:
  i. Climate change as the result of increasing carbon footprints worldwide
  ii. The importance of taking a bottom up community approach to reducing carbon footprints

- Methodologies
  i. Carbon footprints of Sumner households and businesses were measured using a combination of two online calculators
  ii. Surveys were distributed within the community to gain information needed to calculate a ‘community level’ carbon footprint and determine related behaviours

- Key Findings of Research
  i. Households have a much greater impact on the overall community level footprint of Sumner than businesses
  ii. Transportation sectors, followed by the energy sectors were the greater contributors of emissions to the community carbon footprint

- Mitigation Strategies
  i. Transport – offsetting flights, local government and infrastructure changes as well as improved resources to promote cycling and carpooling
  ii. Energy – Increased energy efficiency of buildings, the implementation of renewable energy
  iii. Household behaviour – Waste reduction and more sustainable food choices
  iv. Carbon neutrality – Tree plantations and carbon neutral schemes for businesses

- Limitations of Research
  i. Low response rates for both household and business surveys
  ii. Inconsistencies with carbon calculators
  iii. Viability of mitigation strategies

- Suggestions for future research
  i. More extensive investigation into carbon calculators, in particular for ‘secondary’ data
  ii. An increase in data retrieved in relation to carbon footprint emissions and behaviours
  iii. Further research into the viability of mitigation strategies for the Sumner community
Introduction

There is a wide acceptance that increasing emissions of greenhouse gases (GHGs), due to the social demands for energy from consumer lifestyles is resulting in rising global warming. Measurements taken in 2005 indicate that emissions of dominant GHGs have reached 379 parts per million (ppm); comparable to the pre-industrial value of 280 ppm (IPCC, 2011). Such emissions, resulting from the industrialization and development of modern society, are considered to be having a pronounced effect on the chemical make-up of the life supporting systems of the Earth. Thus, it is necessary to identify sources of emissions for future reduction.

With the greatest share of global GHGs attributed to cities or high development and consumption areas, a focus on emissions reduction in these areas is crucial in expanding sustainability to the global scale. In promoting positive climate action, Hoornweg et al. (2011) note that it is important to utilise the concentration of individuals in small areas for the generation of sustainable economic activity, knowledge, social transformation and new technologies. Furthermore, it is important that responsibility for global warming is engaged on all societal levels, from international to individual (VandeWeghe & Kennedy 2007). It is becoming increasingly accepted that targeting emissions at a community level is an effective way to reduce GHG production, and thus ease the load that individual lifestyles place on global emissions.

All around the world, individuals, retailers, firms and nations are beginning to consider and implement the reduction of carbon emissions (Mathews et al. 2008). The concept around which this reduction is based is known as a carbon footprint; a means by which lifestyles
may be given a quantifiable weighting of CO\textsubscript{2} emissions. Despite the existence of differing definitions, there is general acceptance that a carbon footprint incorporates the amount of GHGs emitted from a specified source/s, over a particular period, and is measured in tonnes of carbon dioxide equivalents (CO\textsubscript{2}-e).

The aim of this study was to produce such a carbon footprint for the Sumner community of Christchurch, New Zealand, and identify the opportunities for emissions reduction at the community level.

**Literature Review**

Carbon footprint studies are widespread, encompassing a variety of nations and lifestyles. Displayed across such studies is a trend for cities in developing countries to have a greater carbon footprint than the national average. In contrast, it has been found that in developed countries average carbon footprints per capita tend to decrease with increased population density (Hoornweg et al. 2011). For example, China’s per capita emissions are 3.9t/CO\textsubscript{2}-e while Beijing’s are 10.1t/CO\textsubscript{2}-e, whereas the USA’s and New York’s are 23.59t/CO\textsubscript{2}-e and 10.5t/CO\textsubscript{2}-e, respectively (Hoornweg et al. 2011).

Definitions of a community are found to be overlapping and contradictory. For example, while Nelson (1948) states that a community is a group of people who inhabit a limited area and have a sense belonging together Green and Mercer (2001) believe that community should be interpreted more broadly as all individuals who will be affected by the research results. Moreover, a study of the Toronto area undertaken by VandeWeghe & Kennedy (2007) used the physical boundary of census area units to classify a neighbourhood for community carbon footprint reduction.
Literature surrounding the concept of carbon footprinting is broad and generally indecisive about whether a carbon footprint consists of only carbon, or all greenhouse gases (Pandey et al. 2011). Following on from this the methods employed to calculate a carbon footprint lack consistency, resulting in differing outcomes, as shown by an investigation into online carbon calculators (Padgett et al, 2008). While such variations may be due to different calculating methodologies or conversion factors most calculators lack the transparency to understand why these differences exist. Therefore, the careful selection of an appropriate carbon calculator is imperative (Mathews et al, 2008).

The concept of carbon footprinting frequently extends beyond calculation and into the field of emissions mitigation. Studies such as those by Barthelmie et al. (2008) and Jones & Kammen (2011) consider the carbon footprints of communities and assess emissions mitigation strategies including changes in energy consumption and production, home efficiency and behaviour. Beyond the household, there is ongoing discussion of possible mitigation strategies at personal, community and policy levels. The development of improved infrastructure, including cycle lanes and public transport systems, is frequently considered an effective means by which to reduce transport based carbon emissions with the involvement of local government (Wegener, 1996; Dill & Carr, 2003). The offsetting of emissions, particularly in relation to air travel, is a common theme in relation to emissions reduction (Dernbach, 2008). Furthermore, offsetting is becoming increasingly considered for other emitting activities. On a local level, community mitigation initiatives are seen as a means by which to change attitudes as well as reducing carbon emissions through strategies such as community gardening and carpooling (Builung et al., 2009; Turner, 2008). Renewable energy initiatives such as solar and wind energy are frequently considered as
alternatives to traditional power generation in the reduction of community and urban emissions (Mithraratne, 2009; Kalogirou, 2004).

Discussion about the implementation of top down versus bottom up approaches in tackling carbon emissions is prevalent. Top down approaches may include policy implementation or large scale initiatives requiring council involvement such as wind farms or law changes. Alternatively, bottom up approaches focus on individual and community based change such as community gardening, cooperatives and behavioural change (Turner, 2008). While top down models have been found to lack intimate detail, bottom up approaches are considered by some to be too specific to implement on a suitable scale (Mendelsohn, 2001). Both approaches are considered in studies with some communities relying on policy and infrastructure change and others focusing on changing behaviour relating to emissions (Barthelmie et al.; Jones & Kammen).

**Methodology**

**Attributing GHG Emission Responsibility**

In the early stages of creating a community carbon footprint it was important to consider the spatiality of emissions and how these were to be incorporated with the overall footprint. VandeWeghe & Kennedy (2007) note that it is possible to either attribute GHG emissions to the spatial location in which they were produced, or place the responsibility on the consumer who essentially produced such emissions. The latter option, used in this study, creates a situation of individual responsibility in which emissions released far from home and out of site do not go unaccounted for, such as offsite electricity generation, production of consumer products and air travel. In addition, in order to simplify the
definition of the Sumner community, the Sumner area unit from census data was used, a similar approach to that used by VandeWeghe & Kennedy (2007).

**Determining calculators for carbon footprint**

To determine the carbon footprint of households and businesses a combination of calculators were utilised. This included the household calculator from Landcare Research’s website ‘CarboNZero,’ [http://www.carbonzero.co.nz](http://www.carbonzero.co.nz), the ‘secondary’ section of the household calculator from Carbon Footprint Ltd’s website, [www.carbonfootprint.com](http://www.carbonfootprint.com) as well as the business calculator from Carbon Footprint Ltd.

‘Carbon Zero’ is an ‘internationally accredited greenhouse gas certification programme’ (Landcare Research n.d.) which uses standard conversion factors to convert consumption values to carbon dioxide equivalent emissions. To ensure conversion factors are kept up to date CarboNZero regularly seeks advice from relevant New Zealand and international government departments and ‘monitors international best practice.’ Carbon Footprint Ltd is one of four carbon offsetting organisations in the UK which meets the government’s ‘Quality Assurance Scheme’ to promote the reduction and offsetting of carbon emissions among individuals and businesses.

Carbon footprints were calculated in tonnes of CO$_2$-equivalent (CO$_2$-e), accounting for the global warming potential of other greenhouse gases in relation to CO$_2$.

**Determining survey process**

Using variables from the appropriate calculators surveys were developed to obtain information from Sumner residents. The first section of the household survey (Appendix A)
assessed carbon emissions incorporating energy (electricity and gas), transport (car, bus and air travel, domestic and international), waste (rubbish, recycling and organics), food (animal products, organic food and imported food) and goods and services (fashion, packaging, furniture and electrical and recreation). The second section considered other factors related to carbon footprints, investigating household energy efficiency (energy saving appliances, heating sources and household structure), transport (carpooling, biking and offsetting travel emissions), waste and gardening. The business survey was similar in structure to the household survey but less extensive (Appendix B).

An online blog was created to provide a link to a version of the household survey. In order to promote this blog one thousand flyers were deposited into mailboxes of Sumner households (Appendix C). Copies of the business survey were distributed to businesses within the community and retrieved shortly after.

**Data analysis**

Carbon footprints were calculated for a one year period and a number of values had to be re-converted into units used by the calculators where appropriate.

To calculate the yearly electricity consumption for each household and business an average cost of $0.2285 per kWh for Christchurch during September 2011 was utilised, taken from the Consumer NZ organisation (Consumer NZ, n.d.). For domestic air travel a value of 700km per one-way flight was used; derived from the average cost of travel from 2006 census data, which was approximated for a length of flight. Similarly, if destinations for international flights were not specified a distance of 5000km was used. In determining waste production, a value of 25kg for a full red waste bin per fortnight was used.
From the average carbon footprints calculated, a community carbon footprint could be obtained by multiplying this by the number of households and businesses in Sumner, 1559 and 60 respectively; retrieved from census data and visual observation estimation. Finally census data was used to determine the representativeness of this study to the Sumner area, and calculate a comparative carbon footprint for the average New Zealand resident. Analysis of data occurred through the use of Microsoft Excel and SPSS Statistics.

Results and Discussion

A total of 78 household surveys and 7 business surveys were retrieved from the community. A comparison between 2006 census data and survey results found that the average number of household members in Sumner is 2.5 and 2.8 respectively. Similarly, from census data the average household owns 2 cars, compared to 1.9 for survey data. Thus, we see that our sample may be somewhat representative of the actual Sumner area in question.

Carbon Footprints

In comparison to businesses, the carbon footprints of households have a greater average value and span a larger range, consisting of a number of high outliers (Figure 1).
Figure 1: The spread of the carbon footprints for Sumner households and businesses surveyed (a total of 78 and 7 respectively), including the minimum, maximum, median, lower quartile and upper quartile values.

As Figure 2 demonstrates, the make up of the household and business carbon footprints differ considerably. The major source of emissions from households is transport, in particular international air travel and petrol consumption. Domestic flights, diesel, electricity and recreation also contribute a significant amount to the overall household carbon footprint. In contrast, the greatest areas of emissions from businesses is energy use through
electricity and bottled gas consumption. The summation of all emissions sources reveals an average carbon footprint of 19.16 tonnes CO$_2$-e per household and 7.09 tonnes CO$_2$-e per business. Through the same calculation of New Zealand census data it was found that the average household carbon footprint was 8.059 tonnes CO$_2$-e. Thus, Sumner households have a considerably higher carbon footprint than the national average.

![Figure 2: Average emissions from carbon dioxide sources per household and business in Sumner.](image)

The community carbon footprint for Sumner was found to equal a total of 30774.36 tonnes CO$_2$-e with the majority of emissions seen to be stemming from air travel (42.09%), fuel consumption (34.61%) and energy use (12.5%) (Figure 3). Recreation and bus travel contributed small quantities. For more household related emissions food preferences was
the greatest emitter (2.64%) followed by rubbish (1.65%). Finally, packaging, imported food and goods, organics, furniture and electricals and fashion all contributed minimal amounts to the total community carbon footprint.
Figure 3: Composition of the community carbon footprint (total of 30774.36 tonnes) with the contribution of carbon dioxide sources shown in percentages and measured in tonnes (T).
Mitigation of carbon emissions

Air Travel

The largest proportion of Sumner’s carbon footprint was from air travel, both international and domestic. While the most obvious way to reduce air travel related emissions is to cease flying, carbon offsetting provides another alternative. Carbon offsetting is based on the concept of the consumer paying a cost in order to fund projects that compensate for or offset the emissions produced, for example through the development of renewable energy or sequestration of CO$_2$ (Taiyab, 2006). By assigning a monetary value to the impact of activities on global carbon emissions, offsetting is becoming an increasingly popular method of carbon footprint reduction. Most air travel companies now provide the option to offset flights relatively cheaply. For example, to offset a one way flight on Air New Zealand from Christchurch to Auckland or Christchurch to Sydney would cost $3.60 and $13.60, respectively (Air New Zealand, n.d.). Brouwer et al (2007) notes that three quarters of the travelling community have suggested that they would be willing to pay a carbon tax to offset emissions; however only 7.7% of Sumner residents surveyed offset their travel emissions. Thus, there is considerable potential for the community to embrace such an initiative.

Transport

Individual transport through the use of petrol and diesel vehicles contributed 34.61% of the emissions of the residents surveyed, representing a trend of high private transport use which is reflected on a larger scale worldwide. Reducing such emissions essentially means reducing reliance on private vehicles as a form of transportation and creating a need for
effective alternatives. In a relevant case study, an investigation into private transport in the German city of Dortmund projected that by implementing policies which made public transport faster than private transportation and increased petrol prices and parking costs, private transport use could be reduced from 7748 to 2578 million km a year (Wegener, 1996). While the Sumner community has no control over petrol prices, there may be potential to establish public transportation options which are faster methods of commuting to and from the suburb than private transport. The implementation of parking costs and fines in the suburb of Sumner is also an option which may encourage more sustainable travel options, such as cycling, which is seen to be a minimal mode of transport within the community (Figure 4).
Figure 3: How frequently Sumner individuals carpool or bike as a means of transport, measured in percentage of survey respondents.

In addition, the availability of suitable infrastructure is considered to determine the likelihood of the uptake of cycling as a method of transport (Dill & Carr, 2003). The construction of safe and extensive cycle lanes, particularly between Sumner and Christchurch city, is likely to encourage such sustainable transport.

Implementing strategies encouraging carpooling within the community, which is currently minimal (Figure 4), is also an effective, bottom up approach to reducing carbon footprints. In 2005 the Toronto area implemented a scheme to encourage carpooling with the creation of an online carpooling database to connect residents interested in participating (Builing et al., 2009). The creation of a carpooling database for the Sumner community is a means by
which increased sustainable transport could result at little cost to the community and ultimately leading to reduced carbon footprints.

**Energy efficiency**

Energy use was the third greatest contributor to the community carbon footprint. It has been noted that over half of household energy use can be attributed to heating and cooling, thus by increasing the energy efficiency of buildings energy and related emissions can be significantly reduced (Energy Star, n.d.). Building orientation, wall colour and window size are all factors that contribute to thermal performance of a building, however the most effective and least intrusive alteration that can be made is increased insulation (Matthews et al. 1999). The majority of Sumner households and businesses surveyed were found to have either batts or no insulation, leaving a large proportion of the population exposed to thermally insecure homes and workplaces (Table 1).

**Table 1: The percentage of households and businesses surveyed with specified building insulation.**

<table>
<thead>
<tr>
<th>Insulation Type</th>
<th>Households (%)</th>
<th>Businesses (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batts</td>
<td>68.13</td>
<td>42.86</td>
</tr>
<tr>
<td>Foam Insulation</td>
<td>1.1</td>
<td>0</td>
</tr>
<tr>
<td>Foil Insulation</td>
<td>8.79</td>
<td>0</td>
</tr>
<tr>
<td>Thermal Block</td>
<td>1.1</td>
<td>0</td>
</tr>
<tr>
<td>Thermal Curtains</td>
<td>1.1</td>
<td>0</td>
</tr>
<tr>
<td>Underfloor Insulation</td>
<td>15.38</td>
<td>0</td>
</tr>
<tr>
<td>Wool Ceiling Insulation</td>
<td>4.4</td>
<td>0</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>57.14</td>
</tr>
</tbody>
</table>

A projected 10 year model of households in Ireland found that through increased insulation measures, including installation of wall and ceiling insulation, insulating hot water tanks and
heating control found that households stood to significantly benefit financially and in terms of health as well as reducing emissions (Clinch & Healy, 2001). Multiple window glazing has also been proven to reduce thermal losses and significantly reduce the energy required to heat or cool the building (Stegou-Sagia et al. 2007) however only only 41% of households and 14.3% of businesses surveyed were found to already have this (Figure 5).

**Figure 4: Percentage of households and businesses surveyed that use energy saving light bulbs, own energy efficient appliances and have double or triple glazing in their buildings.**

A further method of reducing business and household emissions is through the use of energy efficient appliances and installation of incandescent light bulbs; the latter can reduce lighting CO$_2$ emissions by up to 75% (Vandenbergh, 2008). Over 80% of households surveyed already used these methods (Figure 5), making Sumner businesses the primary target for the implementation of such strategies.
Renewable Energy

Renewable energy also provides an effective option to reduce emissions related to traditional power generation and although this is generally more costly than increasing building energy efficiency, it is the most inclusive way to reduce emissions. With the majority of households and businesses using electrical heating sources, renewable energy is an excellent option in targeting emissions from heating (Table 2).

Table 2: The percentage of households and businesses surveyed with specified heating sources.

<table>
<thead>
<tr>
<th>Heating Type</th>
<th>Households (%)</th>
<th>Businesses (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal Burner</td>
<td>1.05</td>
<td>0</td>
</tr>
<tr>
<td>Diesel Boiler</td>
<td>1.05</td>
<td>0</td>
</tr>
<tr>
<td>Electric Heating</td>
<td>17.89</td>
<td>57.14</td>
</tr>
<tr>
<td>Gas</td>
<td>5.26</td>
<td>0</td>
</tr>
<tr>
<td>Heat Pump</td>
<td>38.95</td>
<td>14.29</td>
</tr>
<tr>
<td>Night Store Heater</td>
<td>1.05</td>
<td>0</td>
</tr>
<tr>
<td>Oil Heater</td>
<td>2.1</td>
<td>28.57</td>
</tr>
<tr>
<td>Pellet Burner</td>
<td>5.26</td>
<td>0</td>
</tr>
<tr>
<td>Solar</td>
<td>3.16</td>
<td>0</td>
</tr>
<tr>
<td>Underfloor Heating</td>
<td>2.1</td>
<td>0</td>
</tr>
<tr>
<td>Wood Burner</td>
<td>22.1</td>
<td>0</td>
</tr>
</tbody>
</table>

From the survey only 17.9% of households and 0% of businesses surveyed reported the use of renewable energy meaning there is considerable potential for the uptake of renewable energies within the Sumner community including solar panels, and micro or normal wind turbines.

With a high daily uptake of sunshine hours within the Sumner community solar panels could be a viable option for reducing carbon footprints. Photovoltaic solar electricity is “the most elegant method to produce electricity without moving parts, emissions or noise” and is one
of the easiest and cheapest renewable energy options available to implement (Hoffmann 2006, pp. 3286). The EECA states a well-located 1kW PV panel, which requires the space of eight square metres, can produce between 880kWh to 1750kWh per year (EECA n.d.). If all households and businesses in Sumner installed one PV panel, each producing an average of 1315kWh per year, an annual reduction of 29.8057 tonnes CO₂-e would be possible. Furthermore, options also exist to sell excess energy produced back to the electricity grid.

Wind turbines provide increasingly popular options for sustainable energy production and carbon footprint reduction. While micro wind turbines, installed on buildings, are more commonly found in rural environments, they still remain suitable for any areas exposed to strong, consistent wind. Furthermore, it has been noted that they can pay back their cost over their lifetime and have the potential to reduce carbon intensity of electricity in New Zealand by 26% (Mithraratne, 2009; Bahaj et al. 2007). Despite this, Mithraratne (2009) found that the electricity-generating potential of large wind turbines in New Zealand is 11.3-7 times greater than such roof top turbines. Wind Turbine manufacturer ‘Windflow’ of Christchurch suggests one of their turbines can ‘power the equivalent of approximately 200 households’ on a site with an annual mean wind speed of 30km/h (Windflow, 2007). In this case, at least 8 turbines would be required to provide the energy consumption of Sumner, and a considerable number more to offset the community carbon footprint. This conclusion is similar to a study on carbon neutrality of Biggar, UK which investigated the carbon footprint reduction of wind turbines (Barthelmie et al. 2008). While there is little viability for a wind farm in the Sumner town ship, there may be potential for one, or many wind turbines on the windier surrounding hills, in particular Godley Head.

**Waste**
On the whole the Sumner community was relatively good at recycling with 79.5% and 80.5% of those surveyed saying that they recycled all of their recyclables and food and garden waste respectively and the majority of households displaying sustainable waste behaviour (Table 3).

### Table 2: Percentage of households surveyed that take part in specified waste behaviour.

<table>
<thead>
<tr>
<th>Households that do the following activities:</th>
<th>Yes (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use reusable shopping bags at the supermarket</td>
<td>76.9</td>
<td>23.1</td>
</tr>
<tr>
<td>Regularly consume beverages from disposable containers</td>
<td>26.9</td>
<td>73.1</td>
</tr>
<tr>
<td>Regularly use a waste disposal unit</td>
<td>12.8</td>
<td>87.2</td>
</tr>
<tr>
<td>Compost or have a worm farm</td>
<td>62.8</td>
<td>37.2</td>
</tr>
<tr>
<td>Have a vegetable garden or participate in a community garden</td>
<td>78.2</td>
<td>21.8</td>
</tr>
</tbody>
</table>

While red bin waste contributed only 1.65% of the total carbon footprint, the fact that the average household accumulated enough waste fortnightly to fill three quarters of a red bin means much waste can still be reduced. Such opportunities exist with the 3 R’s of waste management: reduce, re-use and recycle. These include buying and using less, not throwing things away if they could be used by another person or for another purpose, and purchasing items that can be recycled. Developing deposition stations within the community for recyclables not included in the council’s yellow recycle bins, such as batteries or e-waste, is an effective way to reduce waste and safely dispose of toxic landfill items.

### Food choices

Sumner residents have the possibility to reduce food based emissions through altering food choices. Survey respondents had positive responses in relation to gardening and organic waste behaviour, with a large percentage of respondents recycling organic waste, composting and being involved in home or community gardens (Table 3). Nevertheless,
85.9% of those surveyed regularly ate both red and white meat; food which contributes a small but somewhat significant portion to the total community carbon footprint due to transportation from farm to fork. Particular foods are also heavy carbon emitters in the production phase with red meat production found to be 150% more GHG intensive than chicken or fish, and vegetarian choices even less carbon intensive (Weber & Matthews, 2008). The Sumner community, therefore, has the potential to reduce carbon emissions through consuming less intensive food types, and reducing food miles through local production in the form of community garden initiatives. Local food initiatives may also help to bridge the nature-culture divide and hold potential for promoting “long term commitment to sustainable practices than broader urban agriculture initiatives which position people solely as end-product consumers of food” (Turner, 2008, pp. 510).

**Plantations**

The popularity of tree plantations for carbon sequestration has increased dramatically in recent years. The amount of possible carbon sequestration changes every year and is dependent on factors including tree species, age and the region of planting. Offsetting of Sumner’s community carbon footprint of 30774.26 tonnes CO₂-e would require approximately 1500 hectares of 9 year old pinus radiata plantations, sequestering at a rate of 20 tonnes CO₂ per year (MAF, 2011). The development of New Zealand native forest may be more desirable than pinus radiata, however these species are much slower growing and have considerably lower carbon sequestration values, thus more land would be required for offsetting (Hall, 2001). While there are time limits to the benefits of carbon sequestration through plantations, the planting of Sumner’s surrounding hills could be an option which has the potential to provide at least some reduction of the community carbon footprint.
Carbon neutrality for businesses

Survey results found that emissions from businesses resulted primarily from day to day running activities, in particular the use of electricity and bottled gas. There are a number of organisations that provide businesses with the opportunity to assess their carbon footprints, and offer solutions to become carbon neutral. One such organisation, CarboNZero, offers a certified carbon neutral programme through which energy efficiency, offsetting and emission reduction strategies are recommended (Landcare Research, n.d.). It has been found that carbon neutral schemes for businesses in New Zealand also have strong economic benefits, as experienced by companies such as New Zealand Wines; the first winery to complete the CarboNZero scheme for businesses and gain increased investment as a result (Fordyce, 2009). Entering into such a scheme is possible for all businesses in Sumner and has the potential to lead to both economic benefits and carbon footprint reduction.

Conclusions

The calculation of a carbon footprint for the community of Sumner revealed a total of 30,774.36 tonnes CO$_2$-e and found that the majority of emissions can be attributed to air travel, vehicle fuel consumption and energy use. Furthermore, while many of the residents surveyed revealed that they were engaging in some sustainable behaviour, such as high levels of recycling and an understanding of energy efficiency, there is still considerable room for improvement with strategies able to be implemented for carbon footprint reduction.Offsetting is a viable way to reduce emissions from air travel while harsher penalties and improved infrastructure and resources may promote the uptake of cycling and carpooling.
For increased building energy efficiency improved insulation and the use of energy efficient appliances, as well as a focus on renewable energy such as solar and wind power, is likely to significantly reduce carbon footprints. While waste and food choices contributed minimally to the overall carbon footprint opportunities still exist for the increased reduction of waste and a shift towards more vegetarian meals and local food initiatives. The planting of exotic and native tree species on Sumner’s surrounding hills would provide some sequestration of the community footprint, however this would need to increase to a much larger scale should the entire community footprint wish to be sequestered. Finally, for businesses with high energy use, opting into a carbon neutral scheme through associated organisations will not only reduce their carbon footprint but could also result in significant economic benefits. The opportunities for carbon footprint reduction within Sumner community are endless. It is clear that at a community level Sumner stands to reduce their carbon footprint if time and resources are made available for such suggested strategies.

Limitations

The main limitation to this study was the low response rate of both the household and business surveys, less than 10%. Thus, results cannot be assumed to be truly representative of the whole community, in particular the accuracy of the community carbon footprint calculated. Furthermore, as participation in the survey was voluntary, individuals with an awareness and interest in sustainable practices may have been more likely to take part. Also, due to the February 22nd earthquake, a number of houses in Sumner were unoccupied meaning fewer responses could be received than may have been otherwise possible.
Discrepancy between the average carbon footprint determined by a) averaging the total carbon footprints calculated, and b) totalling the average of each carbon emissions factor, resulted for household data. This was found to be due to inconsistency with the ‘secondary’ section of the Carbon Footprint Ltd household calculator through which the cumulative total of factors did not equal the individual total of factors when added separately. Despite this, the inconsistency is relatively small with a 2.59% difference between the two calculated values.

Finally, the viability of a number of the mitigation strategies suggested in this report are subject to particular conditions and further research would be needed in determining the extent to which these could be implemented by the community. For example, the feasibility of solar and wind power generation in accordance with sunshine hours and wind strength and consistency.
Acknowledgements

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Appendices

Appendix A: The household survey

Hello,

We are a group of Geography students from the University of Canterbury carrying out a study to assess the carbon footprint of Sumner. A carbon footprint is the total amount of carbon emissions produced by an individual, household or community, measured in tonnes of carbon dioxide (CO₂). In this case, we are working together with the Sumner Community Group to determine a community level carbon footprint for the Sumner lifestyle and identify areas for potential carbon reductions within the community. Case studies have shown that a ‘bottom up’ approach to tackling community issues such as carbon reduction generally leads to increased community participation for effective project implementation; and leads to a range of environmental, economic and social benefits within the community.

If you would like to help with our project and assist in improving Sumner lifestyles please take 10 minutes to fill out this survey. The survey is split into two parts: Part one measures the household carbon footprint from which a community level footprint will be estimated; part two looks at existing behaviours related to this carbon footprint. (n.b. all data collated from this survey is confidential).

PART ONE

HOUSEHOLD

How many people live in your household? ________________________________

*Fill in the column for which data is most available/applicable*

<table>
<thead>
<tr>
<th>Home Energy</th>
<th>Average weekly consumption ($)</th>
<th>OR average yearly consumption ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Usage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If your household uses bottled gas, what size bottles do you use? (*circle one*)

9kg

45kg

How often do you switch to another bottle? ______________

TRANSPORT

Private Transport
How many cars (including motorbikes) does your household have? __________

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>Average amount of household spending on fuel per week ($)</th>
<th>OR average number of litres consumed per week (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Public Transport*

Average number of hours spent travelling on a bus per week. ________________

*Air Travel*

On average, how many one-way domestic flights does your household take per year? (For example, a family of four travelling from Christchurch to Auckland is equivalent to four one-way flights). __________________________

On average, how many one-way international flights does your household take per year? __________

Please list the places that these flights travelled from/to. __________________________

*WASTE*

On average, how full is your red waste bin per 2 weeks?

<table>
<thead>
<tr>
<th>Empty</th>
<th>Quarter full</th>
<th>Half full</th>
<th>Three quarters full</th>
<th>Full</th>
</tr>
</thead>
</table>

*Please tick the box which is most applicable to your household*

<table>
<thead>
<tr>
<th>How much do you recycle?</th>
<th>All</th>
<th>Most</th>
<th>Some</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recyclables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*GOODS AND SERVICES*

*Please circle the one which MOST applies to you:*

**Food Preferences**

- I am a vegan
- I am a vegetarian
- I eat only fish
• I eat mainly white meat
• I eat both white and red meat
• I eat red meat every day

Organic

• I only ever buy or grow our own organic food
• Some of the food I buy or grow is organic
• I never buy or grow organic food, or don’t know what we buy.

Imported Food and Goods

• I grow all my own food and don’t buy any produce
• I only buy locally produced food and goods
• I mostly buy local produce
• I prefer to buy goods produced closer to home
• I don’t notice where goods come from

Fashion

• I regularly shop to have the latest fashions
• I buy new clothes when I need them
• I only buy second hand clothes

Packaging

• I don’t buy anything which has packaging around it
• I only buy things with very little packaging
• I try and buy things with very little packaging
• I only buy things which are nicely packaged.

Furniture and Electricals

• I like to have the latest technology and the latest home fashion
• I mostly buy new but keep things for more than 5 years
• I only buy essential equipment and use it until it wears out
• I only buy second hand furniture and appliances

Recreation

• I only do zero carbon activities e.g. walk and cycle
• I occasionally go out to places like the movies, bars or restaurants
• I often go out to places like the movies, bars or restaurants
• I enjoy carbon intensive activities e.g. quad biking, sky diving and flying.
PART TWO

Please tick the correct box (Yes/No) depending on which is most applicable to your household OR fill in the blanks where provided.

<table>
<thead>
<tr>
<th>Household</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you use energy saving light-bulbs?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you own appliances (washing machine, dishwasher) with energy efficiency ratings (stickers on appliances).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you use any form of renewable energy? (e.g. solar panels; with a renewable energy provider).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does your house have double or triple window glazing?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What are your main sources of heating in your home? ____________________________

What type of insulation do you have in your home? ____________________________

<table>
<thead>
<tr>
<th>Transport</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you carpool?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you answered YES to the above questions, how often do you carpool?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you bike as a means of transport?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you answered YES to the above questions, how often</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>Do you bike as a means of transport?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you ever offset your air travel emissions?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste</td>
<td>Do you use reusable shopping bags when at the supermarket?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Do you regularly drink hot beverages/cold drinks from disposable cups/bottles?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Do you compost or have a worm farm?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Do you have a waste disposal (e.g. InSinkErator) that you use regularly?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goods and Services</td>
<td>Do you have a vegetable garden, or do you participate in the community gardens?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thank you for taking your time to complete this survey! The final results will be compiled into a report and able to be viewed through the Sumner Community Group website by the end of the year.
Appendix B: The business survey

Hello,

We are a group of Geography students from the University of Canterbury carrying out a study to assess the carbon footprint of Sumner. A carbon footprint is the total amount of carbon emissions produced by an individual, household or community, measures in tonnes of carbon dioxide (CO₂). In this case, we are working together with the Sumner Community Group to determine a community level carbon footprint for the Sumner lifestyle and identify areas for potential carbon reductions within the community. Case studies have shown that a ‘bottom up’ approach to tackling community issues such as carbon reduction generally leads to increased community participation for effective project implementation; and leads to a range of environmental, economic and social benefits within the community.

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PART ONE

BUILDING

How many people work in your business? ________________________________

<table>
<thead>
<tr>
<th>Home Energy</th>
<th>Average money spent on energy per week ($)</th>
<th>Average money spent on energy per year ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If your household uses bottled gas, what size bottles do you use? (circle one)

9kg        45kg

How often do you switch from another bottle? _________

TRANSPORT

How many vehicles does your business own (including cars, vans etc)? ________________
### Fuel Type

<table>
<thead>
<tr>
<th></th>
<th>Total average amount of business spending on fuel per week ($)</th>
<th>OR total average number of litres of fuel consumed per week (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On average, how many one-way **domestic** flights does your business take per year? (For example, a group of two employees travelling from Christchurch to Auckland is equivalent to two one-way flights).

On average, how many one-way **international** flights does your business take per year?

Please list the places that these flights travelled to/from.

### WASTE

*Please tick the box most applicable to your business*

<table>
<thead>
<tr>
<th>How much does your business recycle?</th>
<th>All</th>
<th>Most</th>
<th>Some</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recyclables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food and garden waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### GOODS AND SERVICES *(please circle one)*

- Our business frequently updates technology and furnishings
- Our business buys mostly new technology and furnishings but keeps these for more than 5 years
- Our business only buys essential equipment and uses it until it wears out
- Our business only buys second hand furniture and appliances

### PART TWO

*Please tick the correct boxes (Yes/No) depending on which is most applicable to your business OR fill in the blanks where provided.*
### Business

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your business use energy saving light bulbs?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does your business own appliances with energy efficiency ratings (stickers on appliances)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does your business use any form of renewable energy? (e.g. solar panels; with a renewable energy provider).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does your business have double or triple window glazing?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What are the main sources of heating in your business? ________________

What type of insulation does your business have? ________________

### Transport

Has your business ever offset air travel emissions? ________________

Thank you for taking your time to complete this survey! The final results will be compiled into a report and able to be viewed through the Sumner Community Group website by the end of the year.
HELP US MAKE SUMNER MORE SUSTAINABLE!

We are a group of Geography students at the University of Canterbury conducting a project to calculate the carbon footprint of the Sumner Community. To make this calculation we need to know about the behaviour of Sumner residents, so have compiled a SURVEY which we need Sumner residents to complete! The survey can be found online at:

http://sumnerfootprint.blogspot.com/

If you don’t have internet access you can call us on 027 339 3622 and we can get you a hard copy of the survey instead.