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Fresh Food & Food Deserts in Christchurch



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Abstract:

Food desert analysis was conducted in the central city and eastern suburbs of Christchurch city with the task of identifying potential locations for a fresh food market to service communities in low socio-economic locations. Using geo-spatial buffer zone, and service area analysis, the suburbs of Aranui, Bromley and Woolston South were identified as the most suitable locations for a potential fresh food market. Consumer shopping trends were conducted on 5 supermarket and fast food outlets around the city centre. The results of this analysis identified early to mid-afternoons as the busiest period for supermarkets and early mornings as the quietest. Interviews with market vendors at pre-existing markets in Christchurch found that vendors were primarily interested in a market's popularity rather than its location or layout. Vendors were also not immediately interested in a market open in the early afternoon due to free time available after morning markets. A feasibility study into potential market profits, and research into future food transport systems (such as refrigeration) is recommended to identify possible market success rates and how the market can adapt to global issues such as climate change and food miles etc.

1. Introduction:

Food desert analysis investigates how local communities access 'healthy food' groups. Through identifying regions where access to good food is restricted can help ensure local community initiatives such as food markets can best serve the community in the surrounding areas. Understanding how shoppers and vendors use these local community markets can also be used as a means to studying potential success and failure of a new market initiative.

This report aims to identify potential suburbs where a new fresh food market could be located to best service populations with a lack of access to 'healthy food' types. This will be done through conducting a food desert analysis study on Christchurch central city and its eastern suburbs, by investigating shopper's habits between fast food outlets and supermarkets, and through interviews with vendors at pre-existing markets to identify any potential limitations to market implementation and development. Analysis of literature will also be used to identify how populations may respond to a local market development.

2. Methods:

2.1. Food Desert Analysis – Buffer Zone Method:

In order to best analyse the extents of food deserts and understand Christchurch's socio-economic situation within the eastern suburbs buffer zones were used and generated in Quantum GIS (QGIS), and a service area analysis was generated using ArcGIS. The methods involved in generating these outputs are broken into data acquisition and data manipulation.

2.2. Data Acquisition:

The data acquisition part of this step was done using google maps, and a location search engine called Zenbu. The data from each of these sources was then cross referenced to check accuracy, and google searches of the possible food outlets were done in order to check against these search methods and identify any possible missed locations. The categories which were identified as a part of this data acquisition were, supermarkets, green grocers, butcheries and fast food outlets. Data on locations of markets, food co-operatives and food banks was acquired from research done by Marney Ainsworth, Simon Roper and Luo Hao as a part of research on the effects of urban markets on community development.

After initial analysis was run on these categories, community gardens were added to the list from the Canterbury Community Gardens Association website. Shapefile data was acquired from; Koordinates, a website which has a database of shapefiles and other spatial data for use in GIS analysis, and the

University of Canterbury bulk drive. The shapefiles used to complete this analysis were: kx-nz-area-units-2006-census-SHP (Census mesh block data), kx-nz-road-centrelines-topo-150k-SHP (LINZ supplied roadways data), and CHCh_Bus_Routes_Pre_Sept2010_Quake, a shapefile of food supply location points generated from x,y coordinates in csv form, and Christchurch road network data if a service area analysis is being run. For the census area unit data to be useful we needed to have deprivation census data to add to the layer, which was acquired from statistics New Zealand as a part of the 2013 census. We had intended to use bus stop data rather than bus route data, however this data was incorrectly geo-referenced and was therefore not able to be used.

2.3. Data Manipulation:

Once the necessary data sets were acquired the census deprivation data was added to the census area unit shapefile as a separate attribute, this allowed the analysis to compare the levels of deprivation between different census units, then compare that to the availability of food supply in each area unit. In order to compare all of these different food supply types and compare them to the census units using QGIS was used in order to create buffer zones. Decisions regarding the sizes of buffer zones were based on readings on food desert analysis, various distances used based on travel times and access are used such as, 1000 metres based on 15 minute walking time (D'Acosta, 2015), 4000m based on a 5 minute driving time (Luan, Law, & Quick, 2015). Each of these studies, uses different buffer zone values based on differing criteria. Each of these are based on networks and travel time for the communities using the food supply locations. These values show that the standard distances used are between 1000 metres and 3 miles (4828.02 metres) depending on the population density. Analysed urban areas tended to be studied using a 1 mile (1.6km) buffer, which is why 1500 metres was chosen as the buffer zone around food supply locations.

In order to display the area which was within an easily accessible range of the location; buffer zones were created around all fast food locations, and around all other food source locations which were then classified as access to healthy food. Another layer was created with centroids for each of the census area units and buffer zones created around each of these in order to calculate the number of 'healthy food' locations each area unit had access to. A comparison between supermarkets and other 'healthy food' options was also identified as; supermarkets are not always used for access to healthy food due of the abundance of high energy foods which are also located in supermarkets, and the lack of knowledge regarding shopping habits/behaviour.

After conducting these two buffer zone analysis to see areas of the highest concentration of various food types, the census data was added in order to display areas of higher or lower concentrations of differing food supply compared to the deprivation index score for each census mesh block. Using an intersection analysis, census area units which intersected with the buffer zones of food supply locations were identified. From this it is possible to compare numbers of healthy food alternatives compared to fast food locations for each census buffer zone. This was used to identify areas in most 'need' of healthy food supply.

As a second comparison, ArcGIS was used in order to create a service area for 'healthy food' options only. A service area is a distance analysis based on road networks. This analysis is more complex than buffer zone analysis however, the analysis does not provide sufficient accuracy to justify the use of a more complicated analysis method. Further analysis was conducted using bus routes and buffer zones around these routes, rather than buffers around bus stops. As the sourced bus stop data was incorrectly geo-referenced, this data was ignored however, this made very little difference to analysis due to the relative close proximity of bus stops in Christchurch. The use of the various outputs from these generated buffer zones allowed for a simplistic comparison of coverage of each food type.

2.4. Shopping Habits and Vendors:

In conducting the analysis on shopper's habits, a comparison of open hours and busy vs. quiet periods for two different types of food outlet was undertaken. Supermarkets and fast food outlets were chosen for study as the results could be used in conjunction with the GIS analysis mentioned in Section 2.1. The data used in the analysis of shopping habits was sourced from Google searches of identified locations. Based on location data supplied to Google through registered user sourced location data, popularity graphs are derived for each day of the week (Google, 2016). These graphs are available on the primary result page for a business or location of interest (Figure XXXX) that has sufficient data available (Google, 2016).

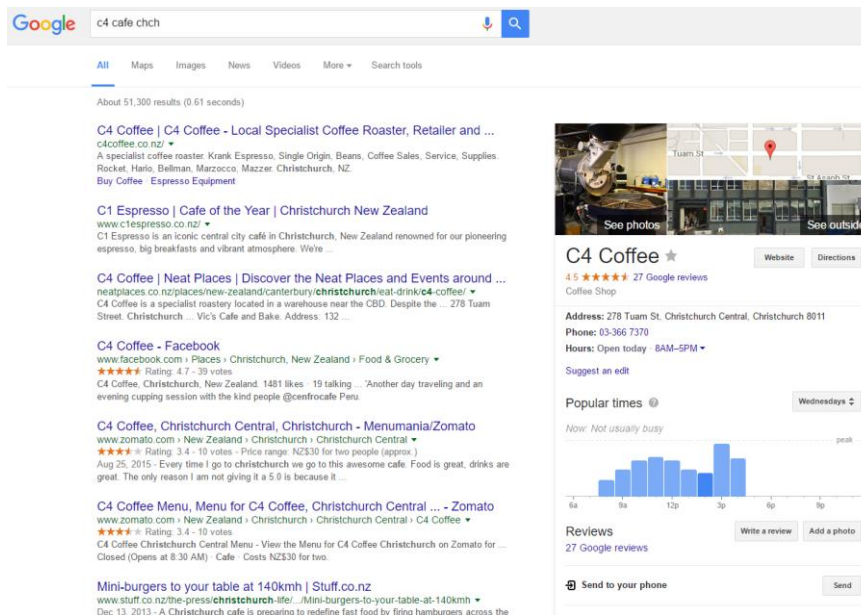


Figure 1: Google search results for C4 Coffee House, Christchurch illustrating popularity (graph supplied by Google).

Based on the relatively low coverage of popularity graphs available for fast food outlets across the eastern portions of the research area, the supermarkets and fast food outlets surrounding the centre city were chosen. The following localities were identified and used for analysis:

Supermarkets:

- New World South City
- Countdown Moorhouse Avenue
- Pak n Save Moorhouse Avenue
- Supervalve Stanmore Road
- New World Stanmore Road

Fast Food Outlets:

- Mc Donalds Moorhouse Avenue
- Burger King Moorhouse Avenue
- Burger King Bealey Avenue
- Burger King Linwood
- KFC Shirley

Population graphs for each site were then interpreted to identify the busiest 4hr period (on average) and quietest 4hr periods for each day of the week at each site. These datasets were then compiled per group to constrain the average 'busiest' and 'quietest' periods during the weekdays (Monday – Friday) and weekends (Saturday and Sunday).

2.5. Vendor Interest in Market Locality:

Analysis was also undertaken to try and constrain how vendors viewed market places and what factors may influence their decisions with regard to market location and to operation hours. Informal interviews were held at the Riccarton Bush Market held every Saturday morning, and the Opawa Food Market held every Sunday morning. The discussions with vendors was primarily around their respective business and how they viewed their transport options to get to and from the market they were at. The discussion was continued a few weeks later looking at how the vendor would feel about markets which may have been open at a different time of day than the market they were currently at.

3. Using the NZ Deprivation index:

The New Zealand Deprivation index is calculated from census data using the average individual response within each mesh block. A mesh block contains approximately 60 persons, providing individual response anonymity. Deprivation is based on responses to nine questions, designed to show personal vulnerability through finance and interconnectivity (Figure 10). Although several parameters can be choice-based, ie. Choosing not to own a car or use the internet, these choices do make individuals less self-reliant, and therefore more vulnerable. The census data used in modelling is based on census Area Units, which are based on geographic areas and are made up of mesh blocks. Because the data is averaged, mesh block heterogeneity is often under-represented, with the danger of ignoring severely deprived clusters (Figure 2). This should be kept in mind when examining any population average result.

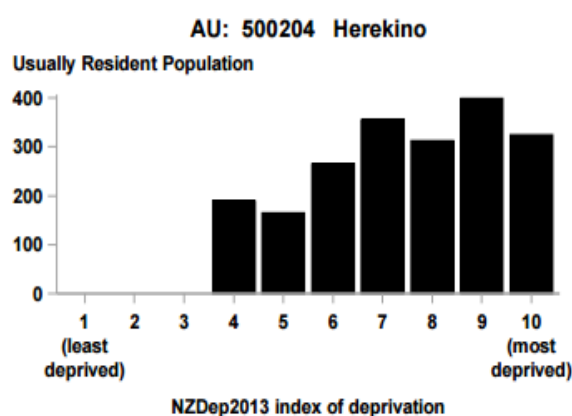


Figure 2: Mesh Block representation in an Area unit. The average deprivation value is 8.

4. Literature Review:

The types of food we consume has a huge impact on health. One of the major issues facing Western culture is that of obesity. Fast food is becoming more incorporated into daily routines, with a recent study showing Americans on average spend half of their food budget on eating outside of the home environment. In addition to this, a lower proportion of income is spent on food. The sad fact is that unhealthy food is more affordable (price per portion size) than healthy alternatives. Unhealthy food is best identified as a source of high, dense energy, with a low water percentage. These foods are high in sugars and fats. The link between poverty and obesity initially seems counterintuitive, however individuals will sacrifice quality of food before going without (Drewnowski & Specter, 2004).

Food deserts are areas where there is little to no reasonable access to healthy food options, such as fresh fruit and vegetables. The concept of food deserts became more mainstream after their use in the 2009 US Department of Agriculture study, which found 23.5 million Americans do not have a supermarket within a mile of their home. Supermarket and specialty food suppliers were much more densely distributed in affluent areas, often tightly clustered. Low income areas were mainly serviced by convenience stores. Food desert studies have identified patterns of clustering with ethnic groups and low-income households. An Auckland study found a correlation between the NZ Deprivation Index and the ratio of supermarkets (considered a supplier of all food types) to fast food outlets, where high deprivation areas had less access to healthy food, and increased access to fast food sources. The proliferation of unhealthy food supply in an area was coined as 'Food Swamps' (Woodham, 2009). Many dispute the efficacy of food desert analysis, where evidence exists to support a lack of correlation between proximity to food types and consumption (Franco, 2015). When a supermarket was added to an area identified as a food desert, surveys indicated a very minor positive change to dietary behaviour. However, evidence supports the addition of zoning restrictions for fast food outlets around low-income areas (Janne Boone-Heinonen, et al., 2011). This indicates that while access and distance are factors of diet, for positive dietary change to occur, complementary or alternative solutions need to be used.

Poor dietary habits can be linked to education levels, one of the deprivation index classifiers. Those with low education levels are also likely to be low wage earners. Obesity can be related to eating behaviours such as sporadic eating, where meals change in quality and quantity in cycles (famine/feast). This behaviour is prevalent in low-income earners and those reliant on government support systems such as food stamps (Burns, 2004). Education also plays a role in understanding a healthy diet. Prioritisation of diet according to taste preference and perceived value is a common symptom of poor dietary skill. Traditional skills in both food preparation and agriculture are being lost through urbanisation, to the point where many are unfamiliar with vegetables.

Food marketing is a form of information source. A pilot study found that for a 1km radius around several NZ secondary schools, 60% of advertising was for food products, of which over 70% were classified as being unhealthy (Maher, Wilson, & Signal, 2005). Food advertising in the face of an over-consuming society promotes an obesogenic environment. Advertising unhealthy food has been compared to tobacco marketing in terms of the social harm the products may be causing. While health advertising is beneficial, the impact is minimal compared to the combined advertising budgets of multinational corporations.

The role of the government in promoting healthy living has mainly focused on informed individual choice, through health marketing. Each person is assumed to be able to choose to eat healthily. Studies have shown that obesogenic environments such as food deserts create a situation where people unable to remove themselves from their environment are unable to change. The onus is therefore on society to modify the environment through health reform policies (Hoek & McLean, 2016). There exists a paradox in government where the government aims to reduce dietary consumption and promote healthy eating, but government producer policies endorse food over-production. This in turn leads to very cheap, unhealthy foods being available at high volumes. New Zealand is known globally as a free business market, which does promote economic growth, but in the case of diet is increasing national health costs. In vehicle-dominant societies, much of the disadvantage exists around access to public transport. Welfare and social networks in NZ and Australia provide transport support for the disabled and infirm, but not for the unemployed and working poor (J Coveney, 2009)

Markets have positive benefits for the community other than towards health. Suppliers are able to have higher margins, while consumers are often able to buy goods at lower prices than retail value. The addition of more fruit and vegetable suppliers to an area promotes competition, creating a 'halo effect' of lower prices in supermarkets (Pearson 2014). Figure 3 however shows that specialty farmers markets on average do not provide cheaper fruit and vegetables than area supermarkets. Niche markets therefore are not likely to be beneficial to low-income communities where price is the main barrier to obtaining fresh produce.

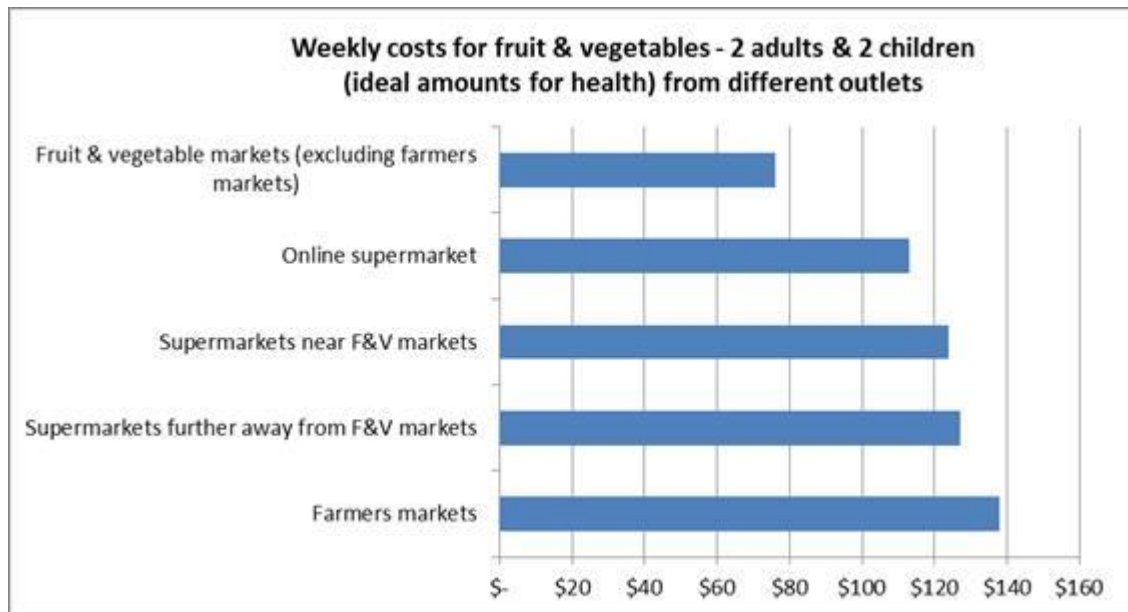


Figure 3: Comparison of average fruit and vegetable prices in Christchurch and Wellington (Sloane, 2014)

5. Market Habit Analysis:

5.1. Shoppers Habits:

Table 1: Shopping habits of 5 supermarkets across central Christchurch City; quietest and busiest 4hr periods as identified by Google popularity data.

Supermarkets		Busiest 4Hr Period (Continuous Period)				
		Monday	Tuesday	Wednesday	Thursday	Friday
New World South City Mall	A	4pm - 8pm	4pm - 8pm	4pm - 8pm	4pm - 8pm	4pm - 8pm
Countdown Moorhouse	B	2pm - 6pm	3pm - 7pm	2pm - 6pm	3pm - 7pm	2pm - 6pm
Pak n Save Moorhouse	C	4pm - 8pm	4pm - 8pm	4pm - 8pm	4pm - 8pm	3pm - 7pm
Super Value Stanmore Rd	D	No Data	5pm - 9pm	5pm - 9pm	5pm - 9pm	3pm - 7pm
New World Stanmore Rd	E	3pm - 7pm	4pm - 8pm	3pm - 7pm	4pm - 8pm	3pm - 7pm
	Average Time	3pm - 7pm	4pm - 8pm	4pm - 8pm	4pm - 8pm	3pm - 7pm
	Modal Time	4pm - 8pm	4pm - 8pm	4pm - 8pm	4pm - 8pm	3pm - 7pm
Supermarkets		Quietest 4Hr Period				
		Monday	Tuesday	Wednesday	Thursday	Friday
New World South City Mall	A	7am - 11am	7am - 11am	7am - 11am	7am - 11am	7am - 11am
Countdown Moorhouse	B	7am - 11am & 7pm - 11pm	7pm - 11pm	7am - 11am & 7pm - 11pm	7am - 11am & 7pm - 11pm	7am - 11am & 7pm - 11pm
Pak n Save Moorhouse	C	7am - 11am	7am - 11am	7am - 11am	7am - 11am	7am - 11am
Super Value Stanmore Rd	D	No Data	8am - 12pm	8am - 12pm & 12pm - 4pm	8am - 12pm	8am - 12pm
New World Stanmore Rd	E	7am - 11am	7am - 11am	7am - 11am	7am - 11am	7am - 11am
	Average Time	7am - 11am	7am - 11am	7am - 11am	7am - 11am	7am - 11am
	Modal Time	7am - 11am	7am - 11am	7am - 11am	7am - 11am	7am - 11am

Table 3: Shopping habits of 5 fast food outlets across central Christchurch City; quietest and busiest 4hr periods as identified by Google popularity data.

Fast Food Outlets		Busiest 4Hr Period (Continuous Period)				
		Monday	Tuesday	Wednesday	Thursday	Friday
Mc Donalds Moorhouse Ave	A	12pm - 4pm	9am - 1pm	9am - 1pm & 4pm - 8pm	11am - 3pm	7pm - 11pm
Burger King Moorhouse Ave	B	5pm - 9pm	11am - 3pm	12pm - 4pm	11am - 3pm	6pm - 10pm
Burger King Bealey Ave	C	11am - 3pm	12pm - 4pm	11am - 3pm	10am - 2pm & 5pm - 9pm	12pm - 4pm & 5pm - 9pm
Burger King Linwood Ave	D	No Data	6pm - 10pm	7pm - 11pm	Quiet All Day	6pm - 10pm
KFC Shirley Rd	E	5pm - 9pm	5pm - 9pm	5pm - 9pm	5pm - 9pm	5pm - 9pm
	Average Time	2pm - 6pm	1pm - 5pm	2pm - 6pm	12pm - 4pm	5pm - 9pm
	Modal Time	5pm - 9pm	No Frequent Time	No Frequent Time	11am - 3pm	6pm - 10pm
Fast Food Outlets		Quietest 4Hr Period				
		Monday	Tuesday	Wednesday	Thursday	Friday
Mc Donalds Moorhouse Ave	A	12am - 4am	12am - 4am	12am - 4am	12am - 4am	12am - 4am
Burger King Moorhouse Ave	B	7am - 11am	7am - 11am	8pm - 12am	12am - 4am	12am - 4am
Burger King Bealey Ave	C	7am - 11am	7pm - 11pm	7am - 11am	12am - 4am	12am - 4am
Burger King Linwood Ave	D	No Data	1pm - 5pm	7am - 11am	Quiet All Day	12am - 4am
KFC Shirley Rd	E	10am - 2pm	10am - 2pm	10am - 2pm	10am - 2pm	10am - 2pm
	Average Time	6am - 10am	10am - 2pm	9am - 1pm	3am - 7am	2am - 6am
	Modal Time	7am - 11am	No Frequent Time	7am - 11am	12am - 4am	12am - 4am

In addressing the most viable locations for a potential food market in Christchurch, investigations into market habits were also undertaken. The aim of these studies was to identify potential planning steps a developing market could take to promote market accessibility and interest. Analysis of shopping habits from 5 supermarkets and fast food outlets around the central city found that on average; supermarkets were busiest from 4pm – 8pm during the week, and from 2pm – 6pm over the weekends. Fast food outlets were noted as being busiest on average from 2pm – 6pm during the week and from 1pm – 5pm over the weekend. Tables 1 and 2 below shows the distribution of shopper’s busy periods between individual stores between Monday and Friday.

A noticeable variance in busy periods between each respective fast food outlet was identified in the collation of data, whereas supermarkets have been interpreted as relatively uniform in busy and quiet hours between each store and also across the week. This variance in consumer busyness between the two food provider groups could be associated to the different services they provide. As consumers

use fast food outlets when they are hungry, the variance in busy hours could be interpreted as 'lunch rush' and 'dinner rush'.

Supermarkets are relatively consistent in both relative business and quietness across the week. Table 1 shows each day of the week; supermarkets are quietest between 7am - 11am which are the initial opening hours for these stores. Due to greater irregularity in open hours for fast food outlets, there was more diversity noted in quiet periods for these outlets. This can be attributed to some fast food outlets opening 24hrs a day or becoming 24hrs later in the week.

Tables 3a and 3b show busy and quiet shopping periods for supermarkets (Table 3a) and fast food outlets (Table 3b) between Saturday and Sunday. Busy periods for fast food outlets are again inconsistent between locations and days. Supermarkets are again identified as being consistently busiest in the afternoon and quietest in the early opening hours.

5.2. Vendors and Markets

Vendors are an important aspect of any market, without any vendors a market does not exist. This research also conducted informal interviews with some market vendors at the Riccarton Bush Market and Opawa Food Market, held on Saturday and Sunday mornings respectively. The vendors interviewed were asked about how they travelled to and from markets with produce and how the hours of operation for markets worked for them. These questions aimed to assess if market location and hours of operation were of primary concern to vendors.

Table 5a & 3b: Weekend shopping habits of 5 supermarket outlets (Left) fast food outlets (Right) across central Christchurch City; quietest and busiest 4hr periods as identified by Google popularity data

A		Supermarkets		Busiest 4Hr Period (Continuous Period)	
		Supermarkets	Busiest 4Hr Period (Continuous Period)	Saturday	Sunday
New World South City Mall	A		4pm - 8pm	4pm - 8pm	
Countdown Moorhouse	B		1pm - 5pm	2pm - 6pm	
Pak n Save Moorhouse	C		1pm - 5pm	2pm - 6pm	
Super Value Stanmore Rd	D		2pm - 6pm	2pm - 6pm	
New World Stanmore Rd	E		2pm - 6pm	2pm - 6pm	
		Average Time	2pm - 6pm	2pm - 6pm	
		Modal Time	1pm - 5pm	2pm - 6pm	
		Supermarkets		Quietest 4Hr Period	
New World South City Mall	A		7am - 11am	7am - 11am	
Countdown Moorhouse	B		7am - 11am & 7pm - 11pm	7am - 11am & 7pm - 11pm	
Pak n Save Moorhouse	C		7am - 11am	7am - 11am	
Super Value Stanmore Rd	D		5pm - 9pm	8am - 12pm	
New World Stanmore Rd	E		7am - 11am	7am - 11am	
		Average Time	7am - 11am	7am - 11am	
		Modal Time	7am - 11am	7am - 11am	

B		Fast Food Outlets		Busiest 4Hr Period (Continuous Period)	
		Fast Food Outlets	Busiest 4Hr Period (Continuous Period)	Saturday	Sunday
Mc Donalds Moorhouse Ave	A		11am - 3pm & 8pm - 12am	11am - 3pm	
Burger King Moorhouse Ave	B		2pm - 6pm	5pm - 9pm	
Burger King Bealey Ave	C		11am - 3pm	11am - 3pm	
Burger King Linwood Ave	D		1pm - 5pm	No Data	
KFC Shirley Rd	E		6pm - 10pm	2pm - 6pm	
		Average Time	1pm - 5pm	1pm - 5pm	
		Modal Time	11am - 3pm	11am - 3pm	
		Fast Food Outlets		Quietest 4Hr Period	
Mc Donalds Moorhouse Ave	A		3am - 7am	4am - 7am	
Burger King Moorhouse Ave	B		2am - 6am	7am - 11am	
Burger King Bealey Ave	C		3am - 7am	7am - 11am	
Burger King Linwood Ave	D		3am - 7am	No Data	
KFC Shirley Rd	E		10am - 2pm	10am - 2pm	
		Average Time	4am - 8am	7am - 11am	
		Modal Time	3am - 7am	7am - 11am	

After discussions with vendors at the fore-mentioned markets, all vendors interviewed did not seem to hold market location as a primary concern with regard to travel times and logistics. Most vendors were observed to arrive with their own methods of freight transport for product such as vans, ute's, and light commercial vehicles. The greatest influence to market choices vendors mentioned was the overall popularity of the market. All vendors interviewed mentioned the popularity of the markets they went to and why they chose to sell there. As for most vendors interviewed, the markets they sell at were their primary income sources. Because of this they all had a strong focus on ensuring they maximised sales at the markets they visited. One vendor interviewed mentioned they had stopped travelling to one market which was closer to where they grew their produce in favour of committing more time into another market which was more popular.

What was also interpreted from these discussions was the formal layout of a market did not appear to influence any vendor's decisions on which market they sold at. The Riccarton Bush market is held in the carpark of the Riccarton house and bush complex in the suburb of Riccarton, Christchurch on Saturday morning. The carpark is very narrow and only allows for foot traffic to pass between the stalls after everything has been set up (Figure 4.). However; the markets popularity has meant vendors still travel in to sell their wares.



Figure 4: Location of Riccarton Bush market (Google Maps 2016)

Both markets visited for interviews were open in the early morning, both closing at ~12pm. Analysis from shopper's habits (previously mentioned) suggested however that consumers who were interested in shopping for food types preferred to shop in the early afternoons on average. Vendors were also interviewed about the opening hours of markets and whether or not a market open in the early afternoon would be of interest to them. The predominant outcome of this however was not

positive; the vendors interviewed had either not actively considered afternoon markets as an option as they were not common in Christchurch, or they felt they would have to commit a full day to preparation. One vendor mentioned they enjoyed having some time available in the afternoons after everything from the morning market had been packed and sorted.

6. Results and Recommendations:

The buffer zones are best interpreted visually, whereas the intersection data is difficult to present in map form. The easiest way to interpret these is via examination of the tables created by the intersection analysis. From examination of the outputs created by the generated buffer zones it is clear to see that there are areas of the eastern suburbs which are not serviced as well as the central city. The main areas of deprivation can be seen from the tables to often be the main areas identified as food deserts as well. As can be seen from the service area image the areas identified as food deserts do not vary much from the areas identified as food deserts by the buffer zones.

Based on; literature studies, geo-spatial investigations of supermarket and fast food locations across central and eastern Christchurch, and analysis of shopping habits of consumers at these localities and interviews with market vendors, this report has found the following conclusions for market location and operation:

- Policy development is recommended to assist in education programmes and to promote healthy eating habits in food deserts.
- The market would best be situated in the suburbs of Aranui, Bromley, or Woolston South
- In order to service similar demographics as supermarkets, it should be open in the early afternoons (between 2pm and 6pm)
- Analysis of potential market popularity should be undertaken to identify possible revenue streams for interested vendors.

7. Future Research:

There is substantial research which has been removed from this research as the scope was too great. This however leads into significant future potential research as a result of the findings in this report. The census area centroids used in the analysis for this report were geometric centroids based on the shape of the census area units. If this were to be repeated an increase in accuracy may be seen from using mean population weighted centroids, displaying the point which has the smallest possible distance to all members of the area unit. In some areas this may have very little influence, however areas with large green spaces or unoccupied spaces would see a larger difference.

Research into the potential feasibility of a future market in any of the research areas identified would be an effective method of identifying how the market will be received in the community it would reside. Further investigations into vendor requirements would also be advised. As society begins to become more aware of issues such as climate change and food miles, an emphasis on food transport may become more prevalent (Dabbene, Gay, & Sacco, 2008; Vanek & Sun, 2008). This point, coupled with increasing improvements into refrigeration technology (Tassou, De-Lille, & Ge, 2009; Tassou, Lewis, Ge, Hadaway, & Chaer, 2010) could be investigated in small scale markets to see how future market developments could minimise impacts of greenhouse gas emissions as a result of food transport.

8. Conclusions:

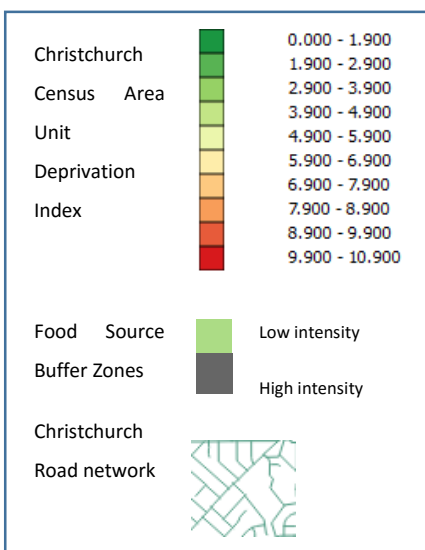
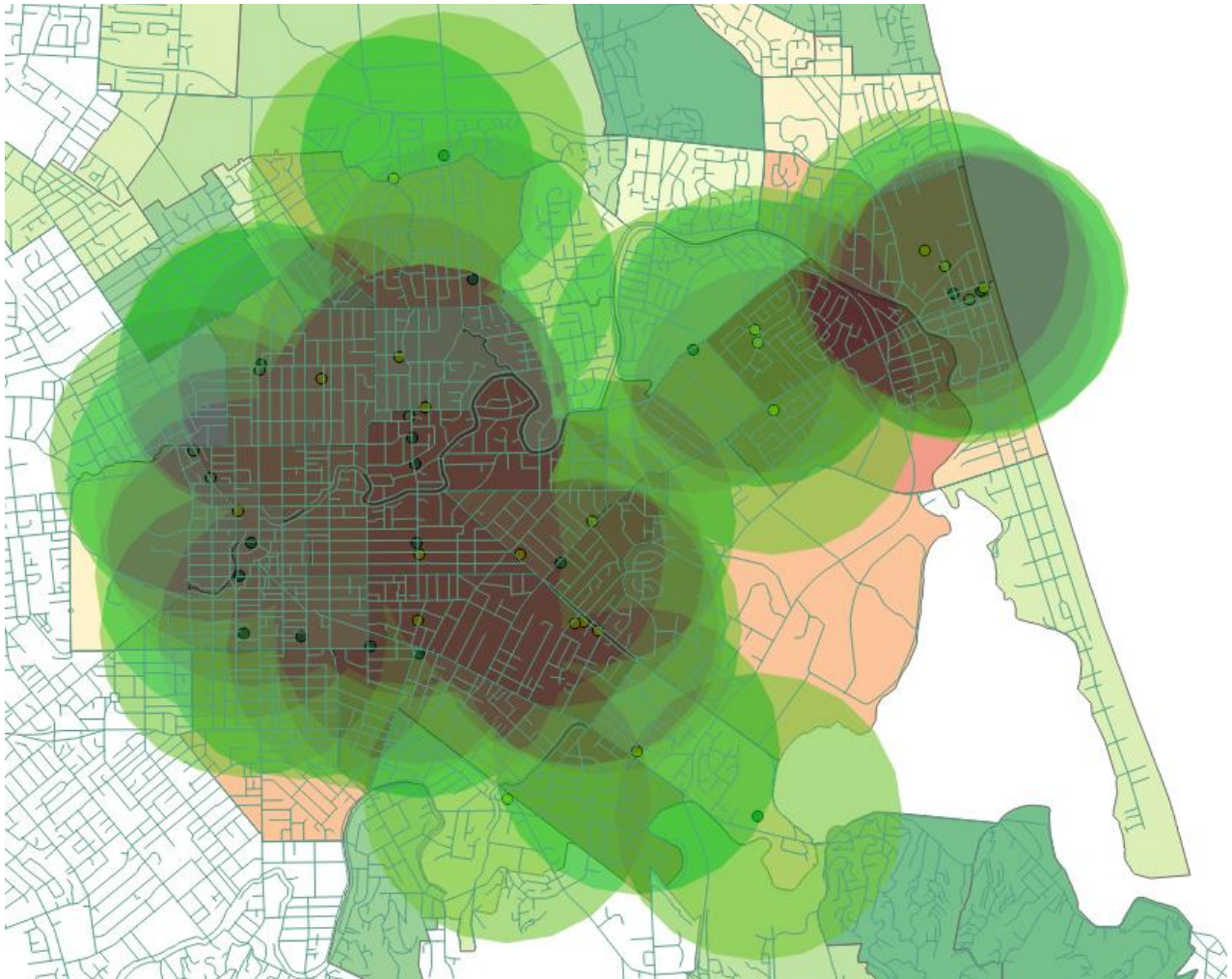
A food desert analysis was conducted in the central city and eastern suburbs of Christchurch city with the aim of identifying potential locations for new food markets. These new food market(s) would be tailored to service regions with identified food insecurities with healthier food groups. Results from geospatial buffer zone and service analysis investigations identified the suburbs of Aranui, Bromley, and Woolston South as the suburbs most likely to benefit from such a food market installation. Based on literature reviews it was found however, that increased accessibility to healthier food groups did not directly correlate to improved health in populations. Other factors such as government policies, advertising, and public education are all important factors in promoting healthy food choices in communities.

Interviews with vendors about food transport systems and market operation hours concluded that vendors are sufficiently happy with their current self-driven transport systems and do not directly weigh market location or layout as primary concerns when choosing potential sites to sell at. Vendors were concerned with hours of market operation and popularity. Vendors interviewed were not enthusiastic about opening stalls in the afternoons as the flexibility of morning markets allowed them to have free time at the end of the day. Popularity was by the far the most important factor for vendors when they chose what market to sell at. All vendors mentioned popularity in some context during interviews.

Future research based on this report could focus on feasibility studies for each suburb identified to begin to identify potential revenue streams. The results of these studies could be used in conjunction with market vendors to determine market potential. Research into changing types of food transportation systems with continuing developments in refrigeration systems and the food supply sector to investigate how potential markets can adapt with modern consciousness regarding global issues such as climate change.

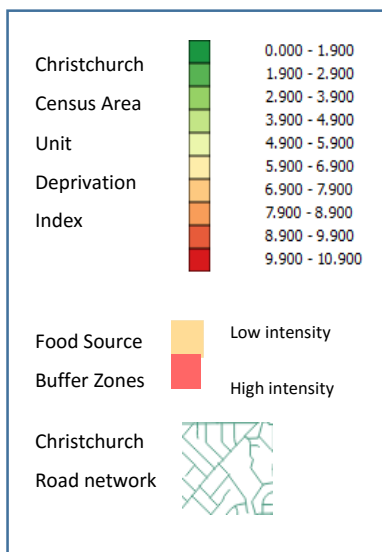
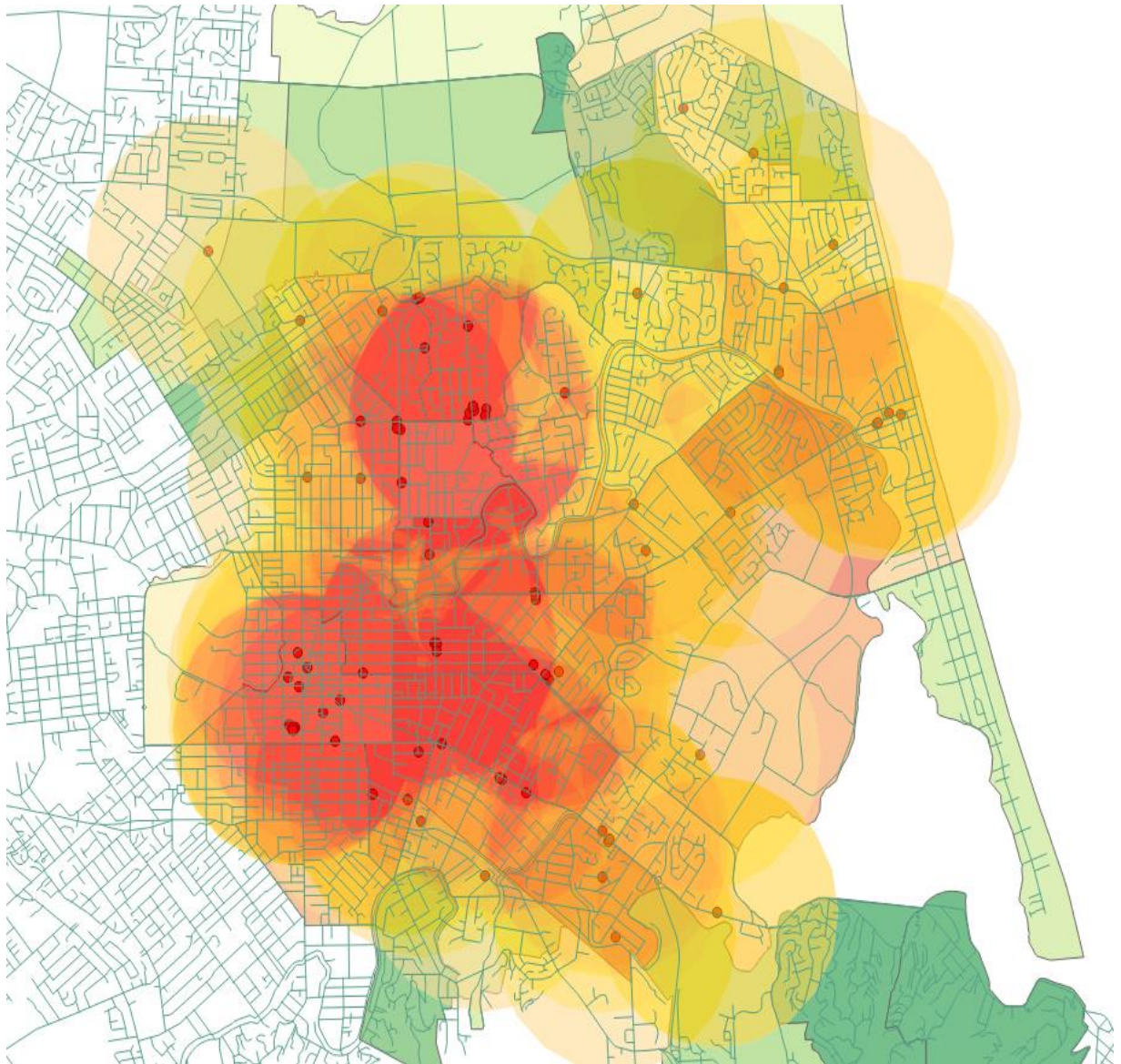
9. Appendix:

Figure 5: Buffer zone map for all 'healthy food sources'



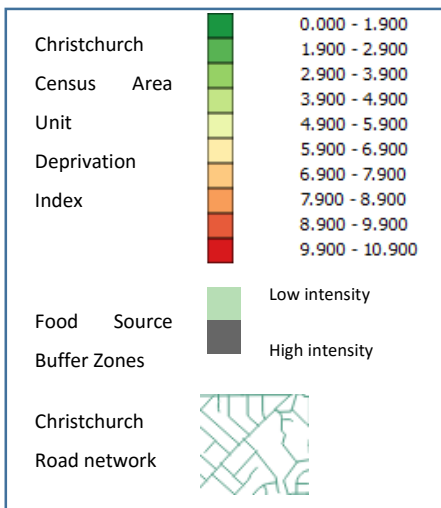
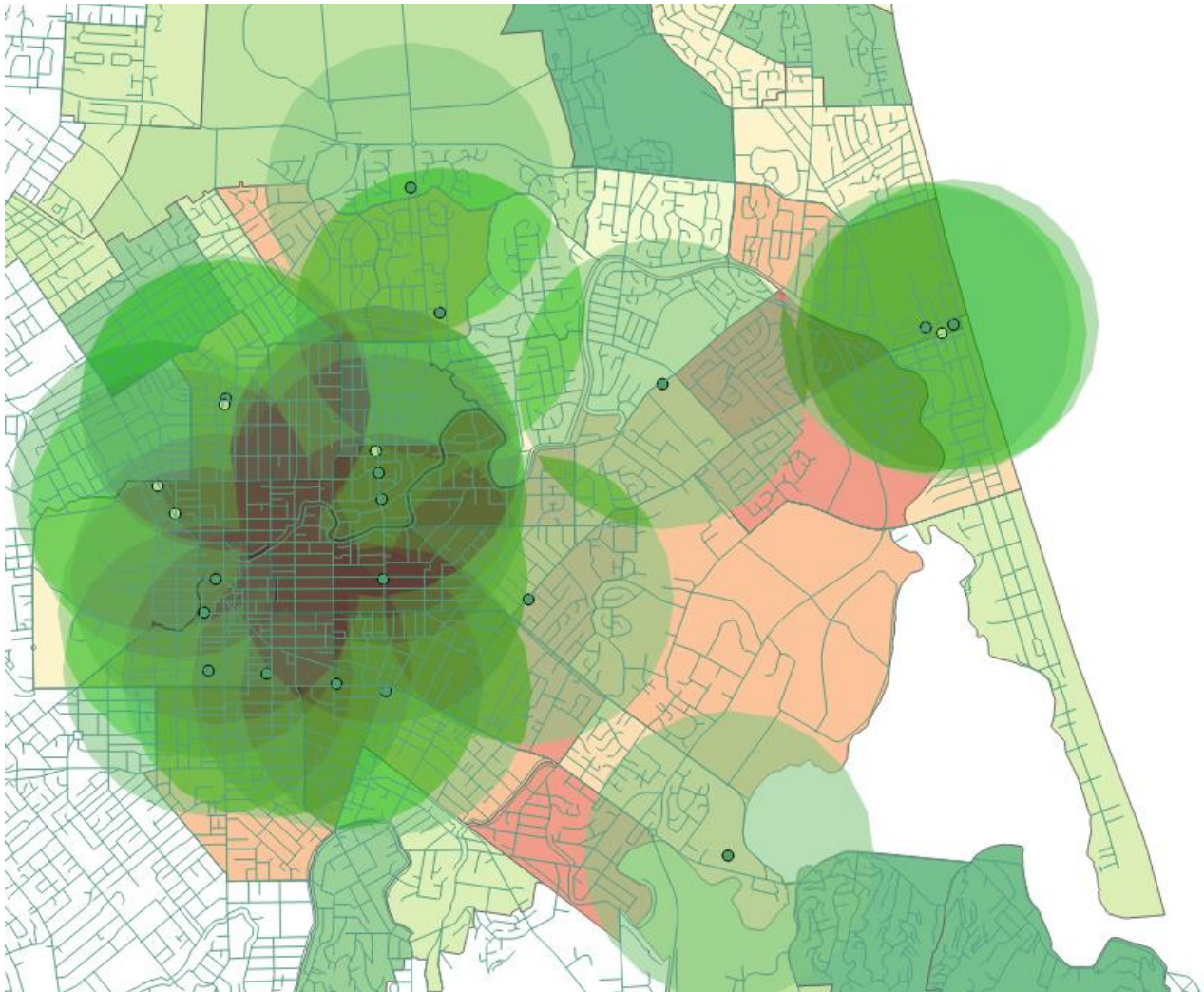
This output displays buffer zones around the food sources classified as healthy, sources classified as healthy food sources for the purpose of this examination were supermarkets, community markets, food banks, food co-ops, and community gardens.

Figure 6: Buffer zone map for fast food services



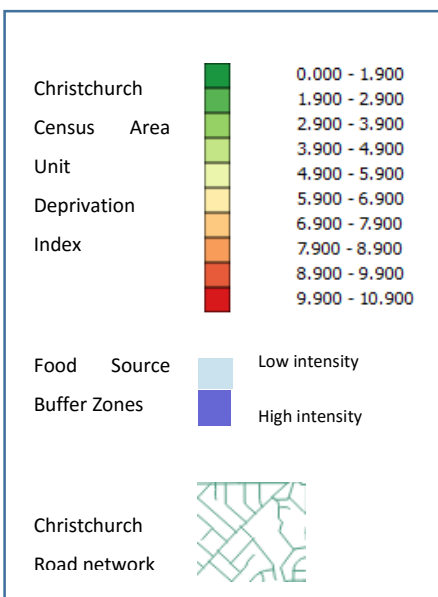
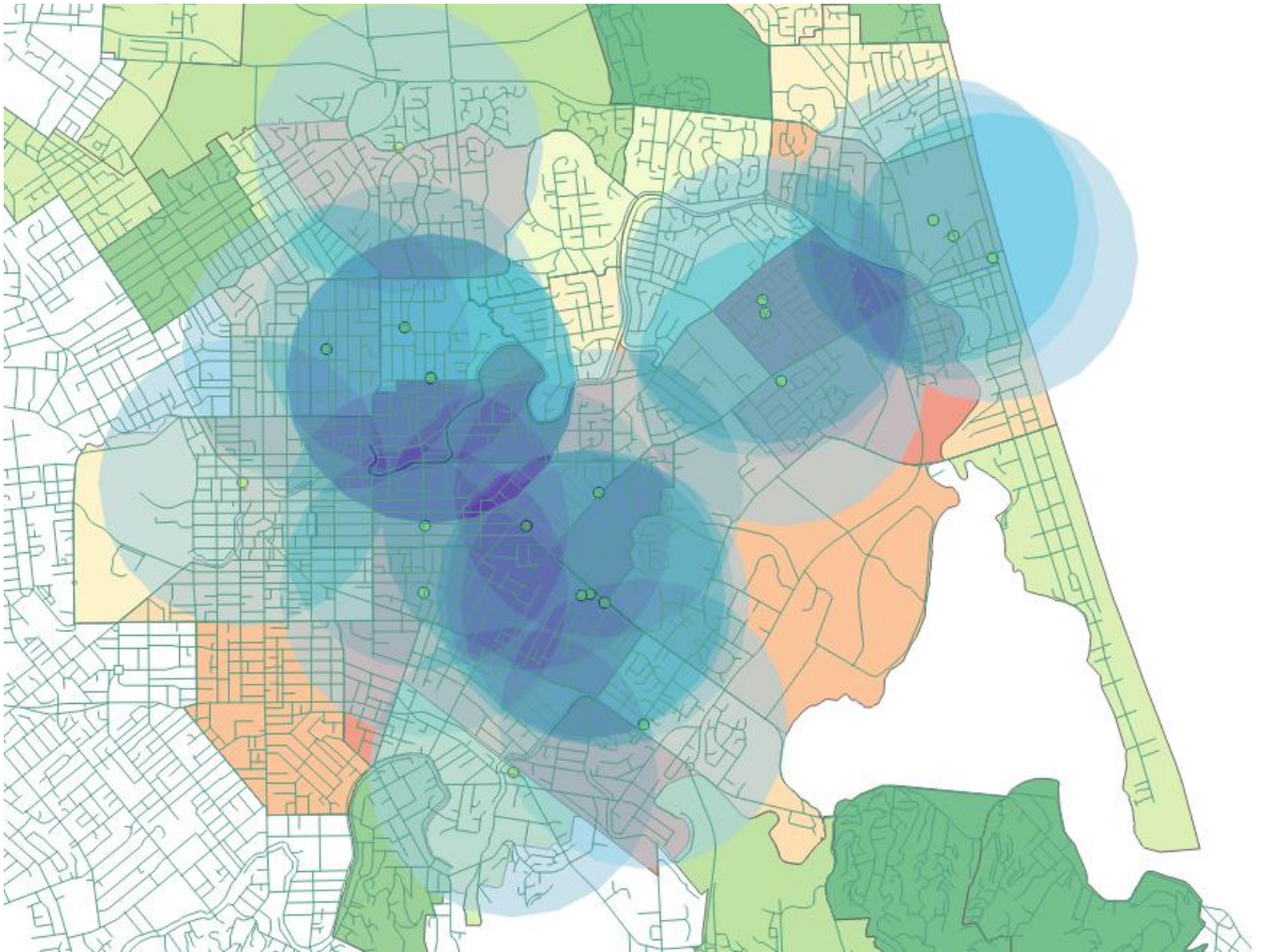
This image displays the buffer zones around fast food sources and the intensity of their concentration.

Figure 7: Buffer zone map for supermarkets



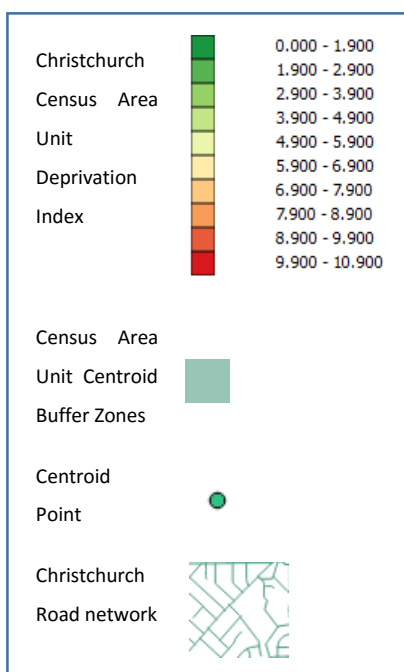
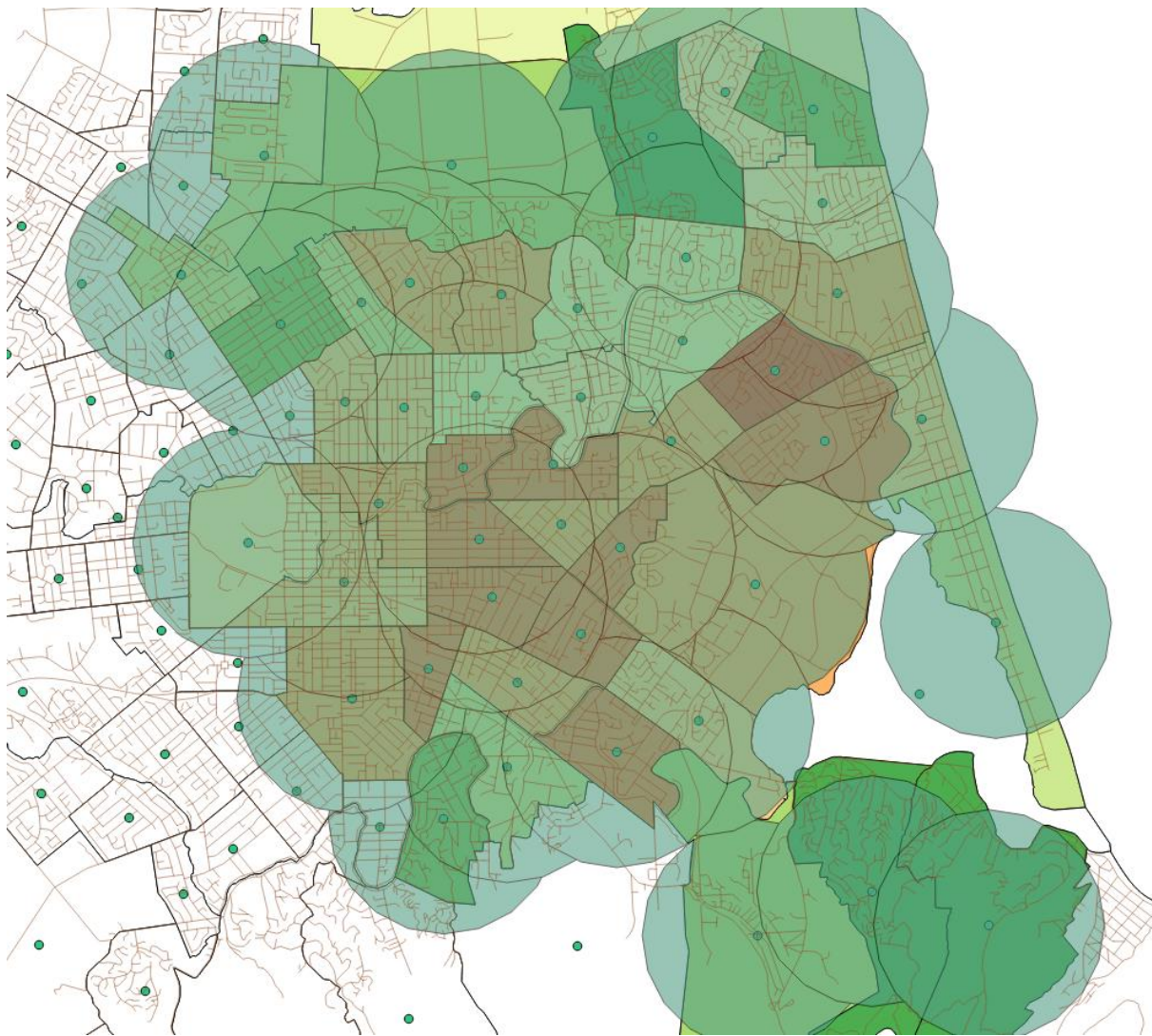
This image displays buffer zones around supermarkets and their concentration

Figure 8: Buffer zone map for community initiatives



This image displays buffer zones around community initiatives and their concentration. For the purpose of this display community initiatives include community markets, food banks, food co-ops, and community gardens.

Figure 9: Buffer zone map for census area centroids



This image displays the centroid for each area unit as well as a buffer zone around each of these centroids, an intersection was run with these buffer zones and the food supply locations in order to determine the number of healthy food options for each census area unit.

Table 6: Access to number of stores classified as 'healthy' compared to deprivation for each census area unit

Suburb	Healthy Food Access	Deprivation
Aranui	4	10
Avon Loop	17	8
Avondale	4	5
Avonside	11	9
Bexley	4	9
Bromley	0	8
Burwood	2	5
Cathedral Square	8	7
Chisnall	5	8
Dallington	4	6
Edgware	8	7
Ensors	4	8
Ferrymead	1	7
Hagley park	6	6
Linwood	13	9
Linwood East	4	9
Linwood North	8	8
Mairehau	3	4
Marshland	2	3
Mona Vale	0	1
Mt Pleasant	0	7
New Brighton	5	7
North Beach	0	6
Opawa	0	4
Phillipstown	9	9
Rawhiti	5	8
Richmond North	7	5
Richmond South	9	9
Rutland	2	2
Shirley East	3	8
Shirley West	3	8
St Albans East	7	7
St Martins	0	2
Sydenham	4	8
Travis	0	5
Waltham	5	9
Woolston South	0	9
Woolston West	6	9

Dimension of deprivation	Description of variable (in order of decreasing weight in the index)
Communication	People aged <65 with no access to the Internet at home
Income	People aged 18-64 receiving a means tested benefit
Income	People living in equivalised* households with income below an income threshold
Employment	People aged 18-64 unemployed
Qualifications	People aged 18-64 without any qualifications
Owned home	People not living in own home
Support	People aged <65 living in a single parent family
Living space	People living in equivalised* households below a bedroom occupancy threshold
Transport	People with no access to a car

*Equivalisation: methods used to control for household composition.

Figure 10: Census identification criteria of deprivation for respondents

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