An ecosystem services approach to determining suitable land-uses for red-zoned land in Sumner, Christchurch

Jessie Cross, Kristina Macdonald, Frank Manzano, Anna Needham, Rachel Robilliard

Geography 309: University of Canterbury

Table of Contents

Executive Summary

What are the ecosystem services provided by the feasible land-uses of the red-zoned land in Sumner?

Sumner is a seaside suburb approximately 10 kilometres from the city centre of Christchurch, New Zealand. The 2010 – 2011 Christchurch earthquake sequence has left significant areas of land in Sumner at risk of rockfall, rockroll and cliff collapse. Consequently this land has been 'red-zoned'. The majority of this land consists of steep cliff areas, as well as some flat (formerly residential) sites. This research was conducted in conjunction with Habitat Sumner to identify what ecosystem services are provided by the feasible land-use options for red-zoned public land in Sumner.

The primary objective of this study was to carry out an ecosystem services analysis of the potential uses for the red-zoned land. Investigation into what has been done with condemned land elsewhere, combined with observations at Sumner, allowed a list of possible land-use options to be complied. Eleven ecosystem services were identified as being most relevant to Sumner, and the impact on these was evaluated for each of the potential land-uses, based on current literature. Following this assessment, a survey was distributed to gauge community response and determine the ecosystems services that were most valued by the Sumner Community, along with the most desired land uses. Food, community identity and aesthetics were rated as the most important services. The ecosystem services analysis combined with the community's preferences enabled a short-list of the most desired and most environmentally-friendly land-use options for the red-zoned land in Sumner to be established. These were community gardens, forests and recreation.

Due to the limited time frame of this study, the extent of the research was restricted. Several limitations resulted, including the limited number of responses obtained by the survey. Information regarding the site-specific risk of the red-zoned land in Sumner is currently confidential and this limited the ability to make informed decisions. Consequently, some of the land uses identified by this study may not be feasible.

The results of this study have significant implications for future land planning in Sumner, and for other communities facing similar situations. The survey is still online and receiving responses. Future responses should be considered when making land-use decisions. The ecosystem service analysis approach could be repeated elsewhere for the purposes of determining what to do with reclaimed land in a post-disaster environment.

Introduction

Sumner is a seaside community located to the south east of central Christchurch (figure 1). Significant areas of land around Sumner were affected by the 2010-2011 Christchurch earthquake sequence. The Canterbury Earthquake Recovery Authority (CERA) has classified some areas in Sumner as 'red-zoned'. This is due to the ongoing risk of rockfall, rockroll and cliff collapse, posing significant risk to life (CERA, 2013). The red-zoned land consists of steep cliffs, and a lesser area of flat (formerly residential) land along Wakefield Avenue and Heberden Avenue. These areas are identified in figure 2. The risks associated with these areas are ongoing and fundamental to the feasibility of any future use of the land. This research investigates the potential uses for this land. This project was conducted in conjunction with Habitat Sumner, a research group formed to gather information to assist local organisations involved in projects such as recreation improvements, environmental restoration and local food production.

Research question

The overarching research question is: "What are the ecosystem services provided by the feasible land-uses of the red-zoned land in Sumner?"

Aims and objectives

The aim of this report is to identify feasible land use options for utilising and remediating the red-zoned areas in Sumner.

This was achieved through:

- Defining the concept of ecosystem services
- Identifying the ecosystem services most relevant to Sumner
- Conducting an in-depth ecosystem services analysis of the services provided by each land-use
- Gauging community response about the most valued ecosystem services and most desired land-uses
- Determining the most feasible land-uses in light of the ecosystem services analysis and community response

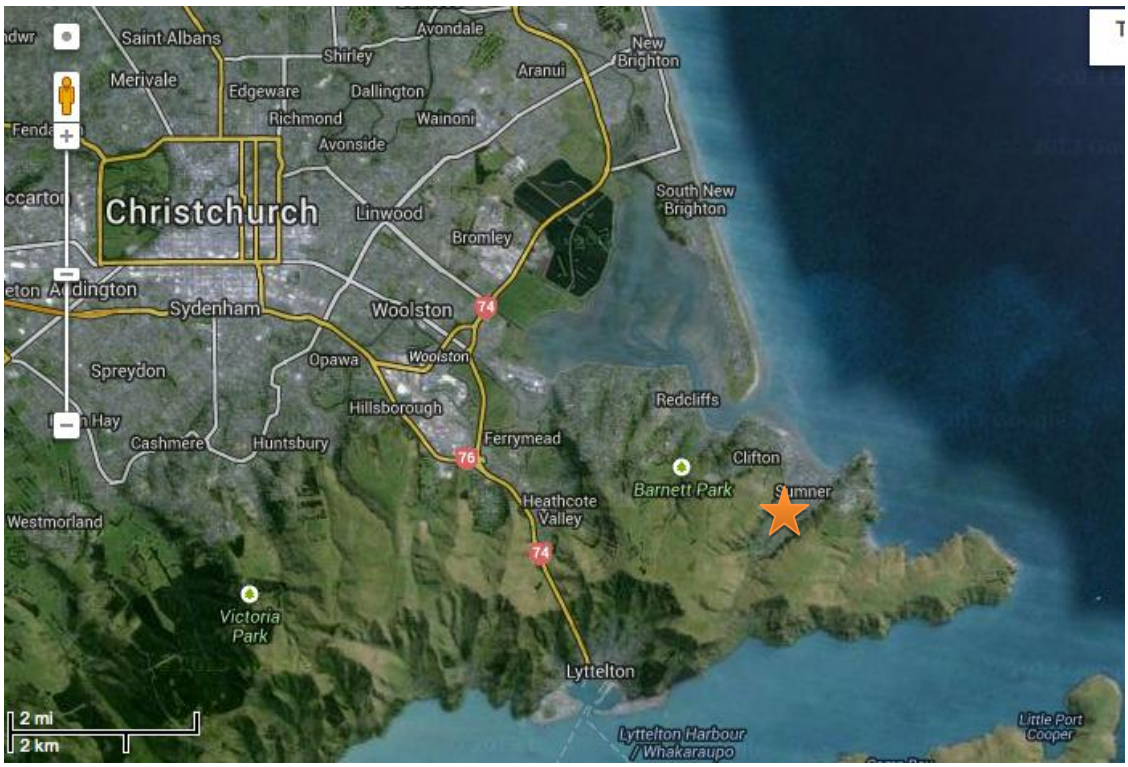


***Figure 1**: The orange star indicates the location of Sumner, Christhchurch, New Zealand. Retrieved from https://maps.google.co.nz/*

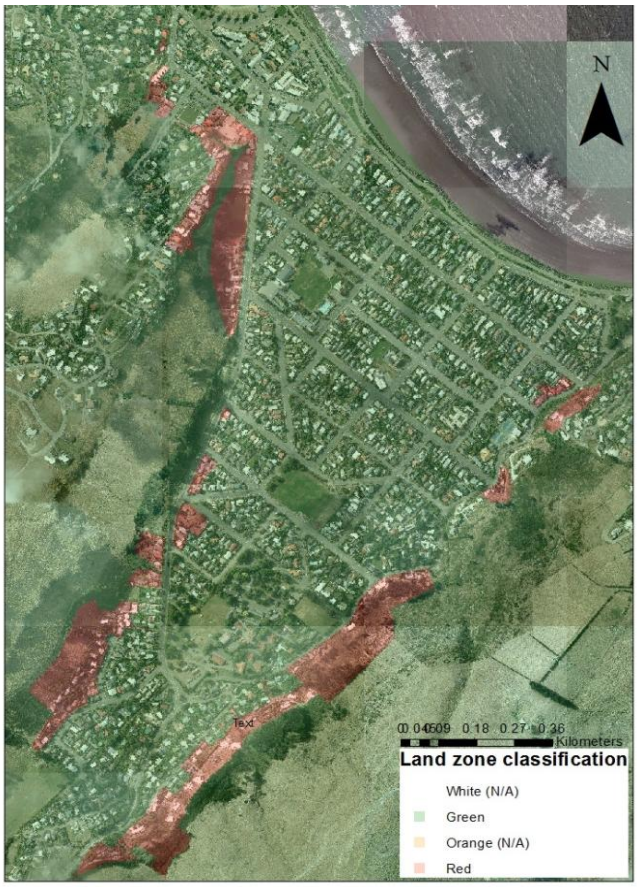


***Figure 2:** Satellite image showing Sumner land-zones. The red-zoned areas are shown in red. Retrieved from https://data.govt.nz/dataset/show/3088*

Rationale of the ecosystem services concept

The Millennium Ecosystem Assessment (MEA) has identified that the Earth's ecosystems enhance the well-being of humans by the services they provide (MEA, 2005; Chapin et al., 2009; Costanza et al., 2007). The MEA developed the ecosystem service framework as a means to manage the human demands for ecosystem services and the capability of ecosystems to continue to provide these services (MEA, 2005).

Bolund and Hunhammer (1999) determined that ecosystem services generated by urban ecosystems will be site-specific. This will be important to consider in the assessment of ecosystem services for Sumner. Research by Dinnie, Brown and Morris (1993), and Aitkinson, Doick, Burningham and France (2013) regarding developing urban green spaces contributed to a more complete understanding of the concept.

Methodology

This research project has been conducted in two parts. The first part was an ecosystem services analysis of five potential land-use options for the red-zoned land in Sumner. The second part consisted of a community survey designed to gather feedback on the ecosystem services identified, and the potential land-uses.

The ecosystem services analysis involved identifying the ecosystem services that would be generated by the five land-use options for the red-zoned land. These land-use options were determined after a field trip to Sumner to observe the sites and their associated hazards, as well as research into what has been done with condemned land elsewhere. Most of the sites were positioned either on, or near, the steep cliff areas around Sumner. CERA was contacted to get information about the risks associated with the red-zoned land, to evaluate feasibility of potential land-uses, however no useful information was provided. Therefore broad information from the CERA website and information obtained from an ex-CERA employee was used. These sources stated that the red-zoned areas were subject to rockfall, rockroll and cliff collapse hazards.

Habitat Sumner directed that the focus of the research be on the ecosystem services analysis, rather than on the feasibility of the land-uses themselves. This is because there is a level of

uncertainty around the long-term plans for red-zoned land, and what may appear unfeasible now could become feasible in the long term.

The ecosystem services analysis involved using current literature to generate a list of common ecosystem services. These were then reduced to eleven services most relevant to Sumner. Further research was then conducted to determine the presence of these ecosystem services in each potential land-use.

In the second part of the research process a survey was used to ascertain the views of the Sumner Community. The first part of the survey contained a series of statements that related to each of the ecosystem services that were identified as most relevant to Sumner. These statements asked the participant to rank, on a scale of 1-5, how strongly they agreed with the statement. The purpose of this part of the survey was to quantify the value that Sumner residents attribute to each of the ecosystem services identified. The second part of the survey asked for feedback on the land-use options that were identified as most feasible for the red-zoned land. The survey was distributed via the online survey tool "Survey Monkey" to a database of approximately 600 Sumner residents.

The results of the ecosystem services analysis and the community survey were then compiled to generate a concept map of the most desirable and ecosystem service-enhancing land-uses, and where these could be placed in the red-zone.

Definition of Ecosystem Services

Ecosystem services are defined as the benefits human populations derive from the environment (Millennium Ecosystem Assessment [MEA] 2005a). The use of ecosystem services is growing rapidly and a large proportion of these services are being degraded or used unsustainably (MEA, 2005a). Eleven ecosystem services were identified as important to consider for the local Sumner Community.

The services were divided into three categories; provisioning, regulating and cultural services. Provisioning services are the products obtained from ecosystems. Regulating services are the benefits obtained from the regulation of ecosystem processes. Cultural services are the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development reflection, recreation, and aesthetic experiences (MEA, 2005a).

Provisioning services

Food has been selected as an important service for the Sumner area because Habitat Sumner considers access to mahinga kai fundamental. Mahinga kai is the traditional gathering of food in local areas with a focus on cultural enrichment and biodiversity (Panelli & Tipa, 2009).

The **Economic** value of a land use is important to consider because it is one of the main factors taken into consideration by government departments (MEA, 2005a). In this study this service has been defined as opportunities for the local economy. For example recreation could increase eco-tourism.

Regulating services

Water filtration refers to the purification of water and increased drainage. Urbanisation is a factor known to increase water pollution (Christchurch City Council [CCC], 2003). In urban areas high levels of impermeable surfaces and pollutants increase the pollution concentration in storm water, leading to highly polluted urban waterways which are directly connected to surrounding oceans (CCC, 2003). Sumner is a coastal urban suburb which could benefit from increased water filtration.

Biodiversity was identified as a key ecosystem service valued by Habitat Sumner. In this ecosystem assessment biodiversity refers to species abundance and richness, with a focus on native species and supporting ecosystem services (such as pollination and seed dispersal).

Carbon sequestration refers to the uptake of atmospheric carbon into carbon sinks (Schulze et al. 2000). This is an important ecosystem service because increasing atmospheric carbon levels have been identified as a leading cause of climate change and sea level rise (MEA, 2005). Increasing carbon sequestration in the Sumner Community would decrease atmospheric carbon, potentially reducing the effects of global climate change.

Air filtration is the interception of pollution particles in the local atmosphere (Beckett et al., 2000). This service is beneficial for the Sumner Community because high air pollution concentrations are found in urban Christchurch. This is of increasing concern for human health (Town, 2001).

Rock fall protection and slope stability was considered vital for this assessment due to the rock fall hazards in the red-zoned land areas. Land uses which can reduce these risks would be beneficial for the Sumner Community.

Recreation has been defined to include land-based recreational opportunities relevant to Sumner, such as walking and biking tracks, and gardening. This is because all of the red-zoned areas are on land.

Cultural Services

Community identity has been defined as the sense of belonging and non-material benefits provided by the surrounding landscapes. This was an important service to assess because this project aims to assist the local community.

Cultural and spiritual enhancement refers to ecosystem services that influence people's sense of kaitiakitanga (guardianship) for the environment (Chappin, 2009). This is particularly relevant when considering opportunities for mahinga kai (Panelli & Tipa, 2009).

Education has been defined as both the inherent knowledge gained from a land use (for example gardening) and personal educational experience, such as being exposed to natural landscapes.

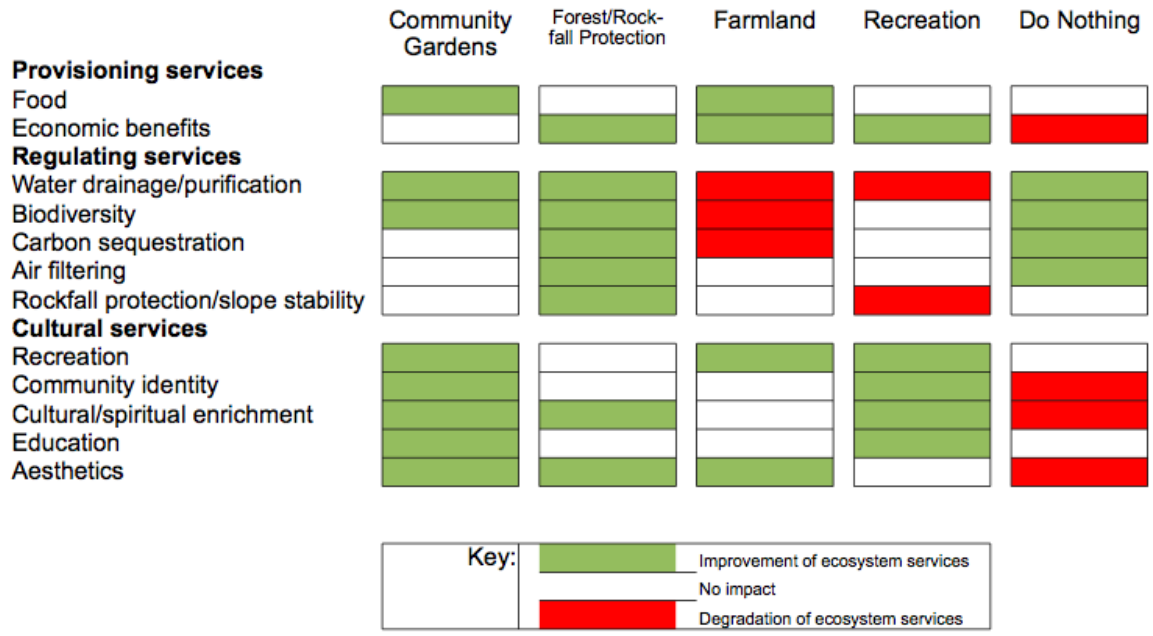
Aesthetic value is an important service to include in local environments (MEA 2005a). Aesthetic value was included in this assessment because of the current unattractive state of the Sumner red-zoned areas.

Results and Discussion

Ecosystem services analysis

From observations of the red-zoned sites, combined with background research, the following land-uses have been identified as being feasible options for the red-zoned land in Sumner. Table 1 shows a summary of the overall assessment of the impact of these land-uses on ecosystem services. The desktop analysis of ecosystem services has been approached with the main focus of determining the impact of five possible land-uses on the Sumner environment and community.

Table 1: Ecosystem services affected by potential land-uses in Sumner



Community gardens

Community gardens are cared for by the community and provide fresh organic produce for members of the community. They provide a way for people to become more involved in their local community and learn key gardening skills.

A study by Calvet-Mir et al. (2012) sought to find out what ecosystem services were provided by home gardens. While these are on a slightly larger scale than home gardens, they have many of the same benefits and ecosystem services.

Provisioning

Providing fresh, quality food is the most significant ecosystem services of community gardens (Calvet-Mir et al. 2012). Community gardens are based on voluntary work and do not focus on economic benefits (Calvet-Mir et al. 2012).

Regulating

Organic gardens remove xenic nutrients and compounds, enhancing water quality (Calvet-Mir et al., 2012). The small-scale of community gardening results in minimal impact on carbon sequestration and air filtering for ecosystems (Calvet-Mir et al. 2012). Biodiversity can be increased by gardening for food production (Calvet-Mir et al. 2012). The gardens would be situated on the flat red-zoned land rather than on the slopes, so would not increase or degrade slope stability.

Cultural

Gardening provides a hobby, an ecosystem service highly valued by community members in a study conducted by Calvet-Mir et al. (2012). There is a significant amount of literature that acknowledges the significance of mahinga kai, a cultural practice of food gathering, to Maori people (Ngai Tahu, 2013). Community gardens show that the land is being used productively, and gives the appearance of a tightly-knit community. Encouraging members of the community to become involved in seasonal planting, harvesting and weeding provides the opportunity for people to learn how to produce their own food (Calvet-Mir et al. 2012). Community gardens are aesthetic landscape features.

Forest/Rockfall Protection

Some of the red-zoned areas will not be appropriate for any development that involves human activity due to the significant rockfall risk. These risks led to investigation of rockfall protection options. The outcome of this research was that one of the best rockfall protection methods is protection forests, in combination with structural measures. These are most effective when made up of a range of different species, and could include native or exotic species.

Provisioning

The number of trees able to produce fruit would determine the value of the food ecosystem service. Forest ecosystems can increase tourism (Dymond et al., 2013), provide timber for sale and provide local fuelwood, enhancing the economy.

Regulating

The role of trees in carbon uptake through the process of photosynthesis is well understood and documented (Carswell et al., 2012). Urban trees can act as biological filters, intercepting and removing particulate matter which is of concern for human health (Beckett et al., 2000). Studies show that trees can reduce erosion (Dymond et al., 2013; Thompson et al., 2011) and reduce land slide occurrence (Douglas et al., 2013). Douglas et al. (2013) concludes that there was no significant difference between species. Vegetation, such as urban forests have been shown to act as biological filters for water (Zhang et al., 2011). Bremley and Farley (2010) and Thompson et al. (2011) found that native forests contain the most native biodiversity and supporting services. Exotic forests have more biodiversity than degraded land (Bremer & Farley, 2010).

Cultural

Education and recreation are not present in forests. The Ngai Tahu Iwi Management Report (2013) describes indigenous biodiversity and ecosystems as a fundamental part of culture and identity for the Maori community. Exotic plants have been part of local community identity for generations and recently a shift towards native vegetation has been prominent throughout New Zealand (Stewart et al., 2004). Natural views tend to be therapeutic compared with urban scenes in terms of reducing stress and anxiety (Smardon, 1988).

Farmland

There is farmland at the head of the Sumner valley, so a potential land-use would be to expand this around the red-zoned cliff areas.

Provisioning

Food is produced in any agricultural landscape (Sandhu et al., 2010). Agriculture enhances the local economy through employment (Sandhu et al., 2010).

Regulating

Nutrient inputs from fertilisers have widespread negative effects on water quality (Foley et al., 2005). Farmland results in the loss of native habitats, especially degrading the services of pollinators because of the homogeneity of species (Foley et al., 2005). Farmland increases atmospheric carbon (Bryne et al., 2007). Conventional agriculture has a very weak effect on both air filtering and slope stability (Sanhu et al., 2010).

Cultural

Some farms can provide recreational activities for local and international visitors through farm-stay accommodation (Sandhu et al., 2010). Conventional agriculture has a very weak effect on most cultural ecosystem services (Sanhu et al., 2010). Farmland enhances aesthetic appeal of landscapes (Sandhu et al., 2010).

Recreation

There are many walking and biking tracks around the Sumner area. These could be expanded into and through some of the red-zoned areas. For this to be feasible, there would have to be a certain amount of cliff-stabilisation and an in-depth risk assessment conducted.

Many of the possible ecosystem services depend on whether it would be possible for vegetation to grow in the areas surrounding the tracks. This will vary from area to area. In some areas used for recreation there may be abundant forest, while in others the predominant landscape may be farmland or barren rock. Recreation can be both a threat and a value to wilderness (Cole and Knight, 1990).

Provisioning

Provision of food relates entirely to the type of vegetation that could be planted around tracks. Open space and recreational tracks can draw local and international visitors, which can boost the local economy (The Government of the Hong Kong Special Administrative Region, 2011).

Regulating

Construction of trails intercepts drainage systems and reduces water filtration (Cole and Knight, 1990). Impact on biodiversity, carbon sequestration and air filtering relates largely to vegetation present in the area surrounding the recreational tracks. Trampling and compaction of

the ground alters soil structure, reducing its capacity to hold water, eventually leading to erosion and soil degradation (Hong Kong University, 2013).

Cultural

Parks allow people to be active on their own and serve as a gathering place for social groups and clubs (Han et al., 2013). Studies have recognised the importance of recreation as a basis of culture (Smith and Godbey, 1991). Physical recreation is a doorway to learning (Kemp et al., 2013). Aesthetics relate very strongly to the surrounding vegetation.

Doing Nothing

This option was chosen as a base-line against which to compare the other land-uses, to see the relative advantages of each of the other options, and to determine how strongly the community feels about changing the current state of the red-zoned areas.

Provisioning

Provision of food depends on the composition of plants originally in the area. Land abandonment leads to a decrease in local land values (Turcu, 2012).

Regulating

Vegetation intercepts surface runoff flows. The vegetation currently in the red-zones will therefore have a role in water drainage. Biodiversity, air filtering and carbon sequestration will increase as plants regenerate (Bradshaw, 2000). Slopes with significant rockfall debris tend to remain unstable (Bradshaw, 2000).

Cultural services

Recreation will not be enhanced as areas will remain inaccessible and potentially dangerous. Social problems manifest in areas with a poor physical and environmental setting such as derelict land (Turcu, 2012). Derelict land does not provoke positive feelings (Turcu, 2012). If left in its current state, the red-zoned areas will remain decrepit and visually unappealing.

Survey results, discussion and implications

The survey was distributed to the Sumner Community online via Survey Monkey, and has received a total of 37 responses over a period of three weeks. The following figures (3-6) display demographic information of the participants who responded to the survey.

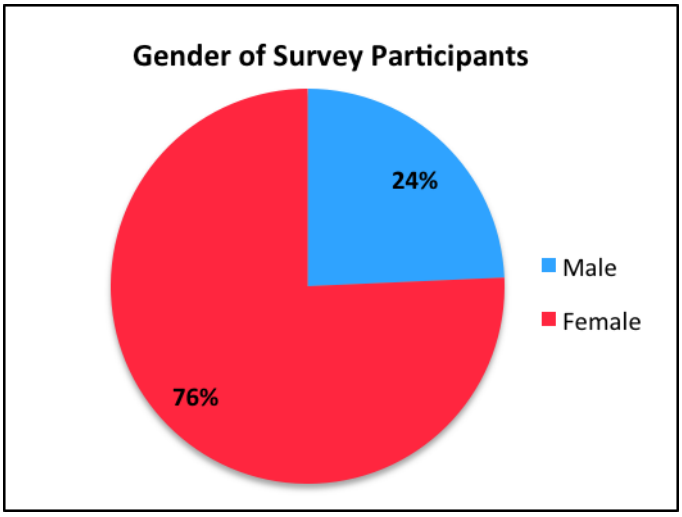


Figure 3: *Demographic information of the gender of the Sumner Community Survey Participants*

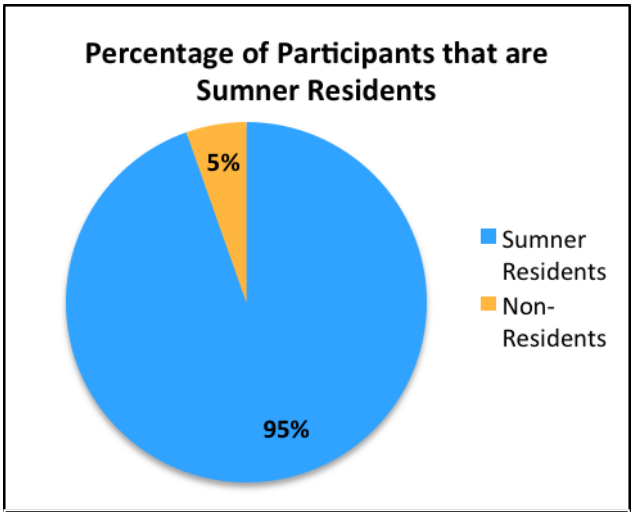


Figure 4: *The percentage of Sumner Community Survey Participants that are Sumner residents*

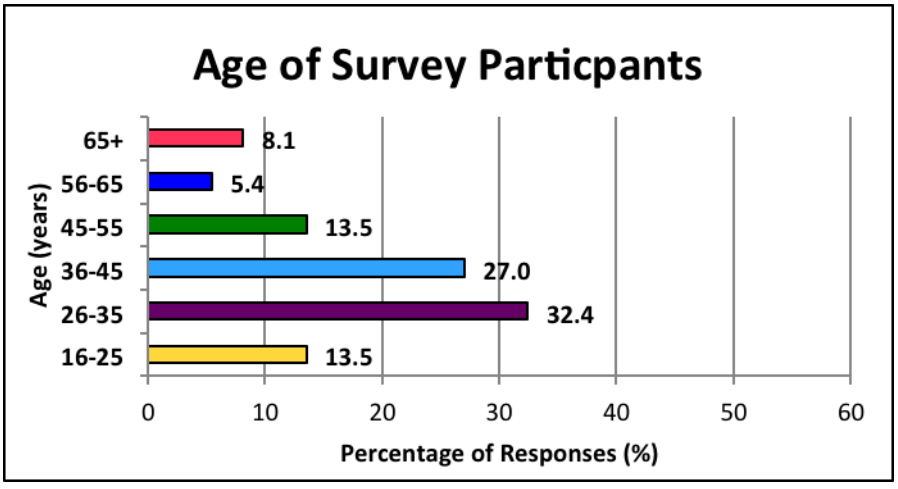


Figure 5: *Demographic Information of the age of Sumner Community Survey Participants*

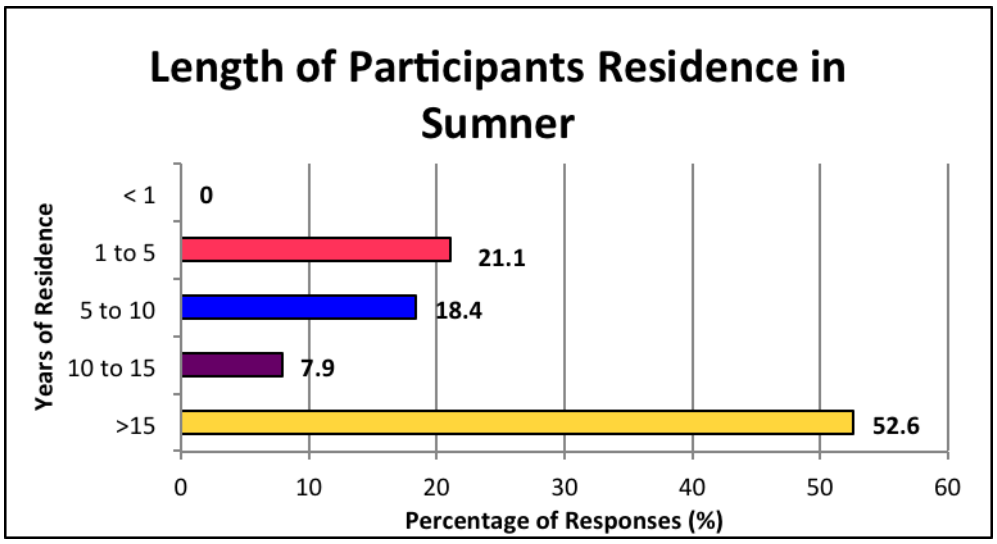


Figure 6: *Length of time that participants of the Sumner Community Survey have resided in Sumner.*

From the 2006 Census data, it can be found that the 37 participants who responded to the survey are a moderately representative sample of the Sumner population, despite the small sample size. The number of participants corresponds to approximately 1% of the total Sumner population. The median age of the survey sample was representative of that of the Sumner population. However, the percentage of female responses is over-representative of the population. The summary table (table 2) details the key demographic features of the sample in comparison to the population.

Table 2: *Summary table of the Key demographic features of the Survey sample and the Sumner Population – data sourced from stats.govt.nz.*

	Survey Participants	Total Sumner Population (2006 Census data)
Number of People	37	3981
Median Age Group	26 - 35	15 – 64
Mean Age	36	38
% Females	76%	51%
% Males	24%	49%

The purpose of the first part of the survey was to gauge response about the importance of different services provided by ecosystems to the Sumner Community. The data collected was qualitative in nature and reflected the opinion of the participants (figure 7).

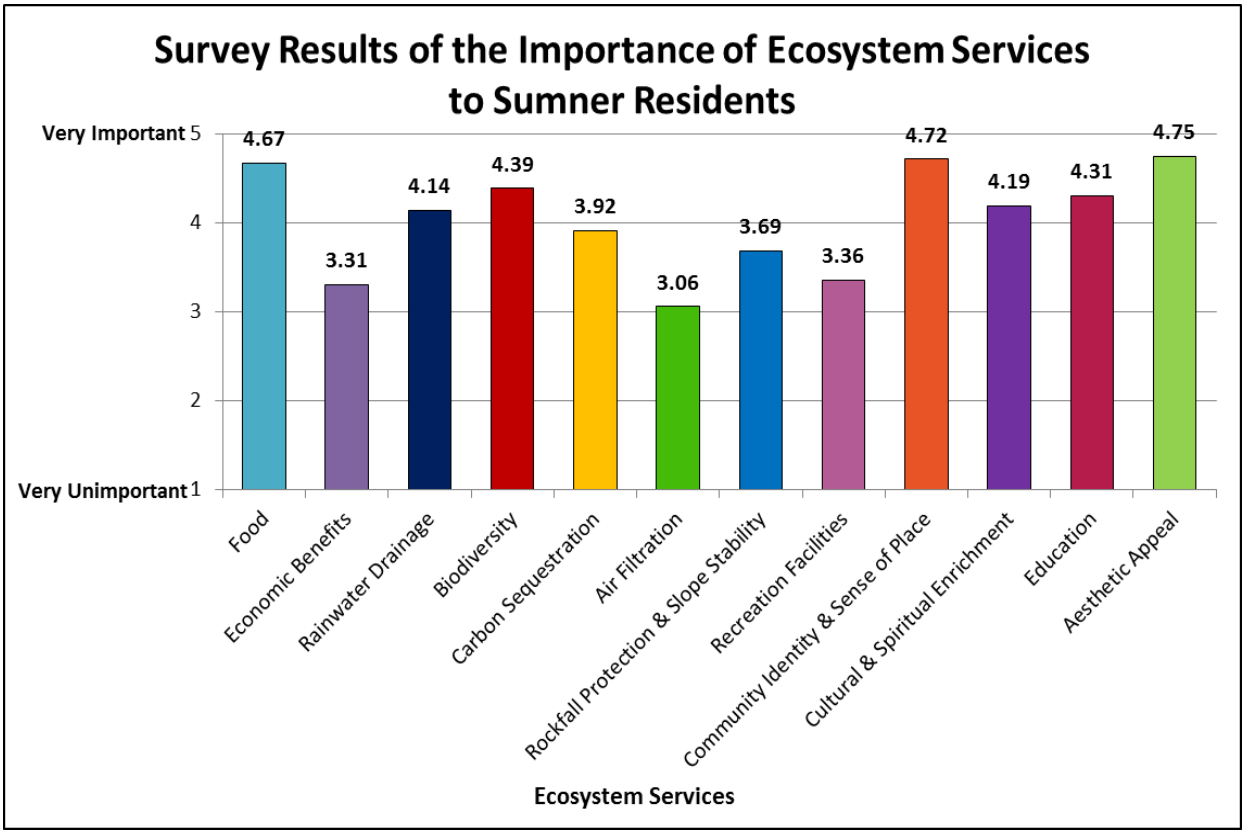


Figure 7: *Sumner Community survey results of the importance of individual ecosystem services to residents.*

Participants ranked community identity and sense of place, food, and aesthetic appeal with the highest importance (figure 7). A number of comments made by the participants also expressed a strong desire for food forests and community gardens, along with the planting of native forests. These comments reinforce the importance of the top three ecosystem services, but also the strong value placed on biodiversity, education, and rainwater drainage. Air filtration and economic benefits were considered the least important services. The mean response of participants regarding whether air pollution in Sumner was a concern to them was 'neutral', suggesting that the residents do not want forestation primarily for the regulatory services it would provide, but instead for provisioning and human based services such as aesthetics and education. Some of the comments left by participants expressed an interest in remediating the red-zoned land for displaced businesses, however the majority indicated a strong preference for

'making the red-zone green' – such as creating green spaces, forests, and community gardens. 70% of residents agreed that they felt safe with the rock fall and slope stability protection measures already in place in Sumner.

The second part of the survey inquired about the resident's opinion about five hypothetical land uses for remediation of the red-zoned land (figure 8).

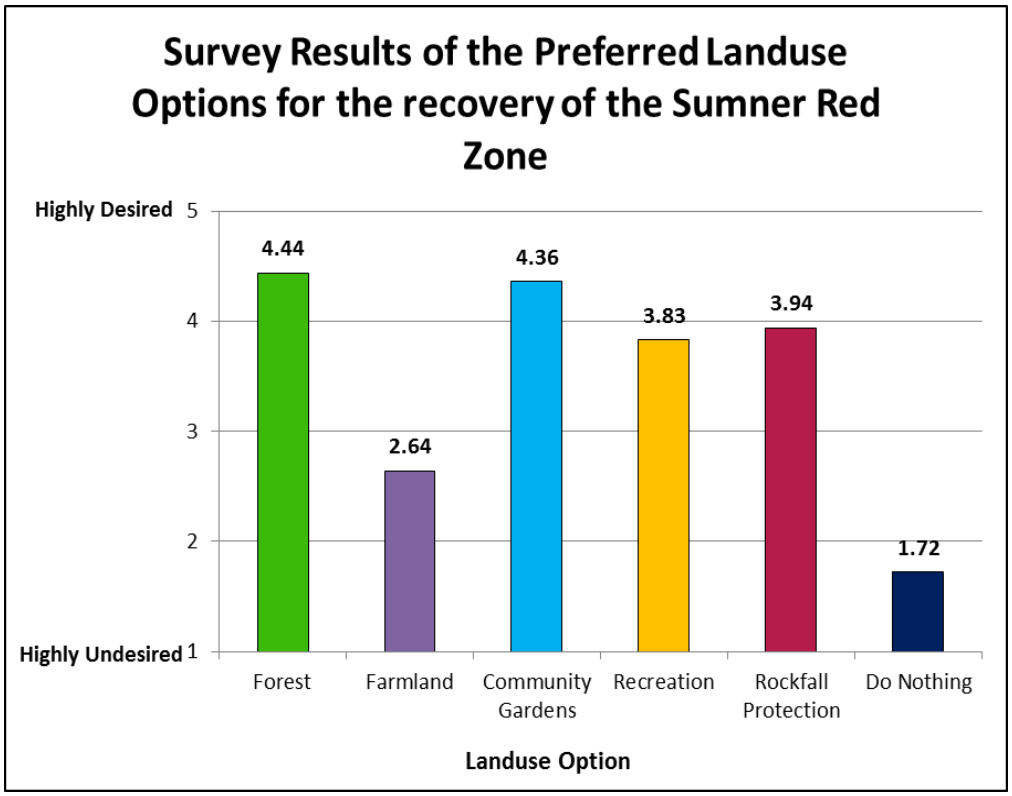


Figure 8: *Results from the Community Survey detailing the participants preferred potential land uses for the recovery of the Sumner Red zones.*

The results obtained from this part of the survey reflected the results found from the ecosystem services section. The most desired land uses were forestation, community gardens, and rock fall protection (figure 8). During the course of this project it was determined that the most relevant rock fall protection was a protection forest, used in combination with rock fall fencing. Subsequently, rock fall protection and forest were combined as a single land use. Comments made by many participants expressed a desire for planting native vegetation as opposed to exotic forest. Native planting is in agreement with the research which found that the most effective protection forests are generally uneven multilayered stands with a mosaic of all sizes and ages (Dorren et al., 2004). The third most desired land-use was extending existing

recreation facilities such as cycle ways and walkways. Converting the red-zone areas into farmland and leaving it as it is are the least desired options. This is reflected by the ecosystem services survey results.

In summary, the results obtained from the survey provide a useful insight into the preferences of the Sumner residents in regard to the future of the red-zoned land. The survey results were used to identify the most important ecosystem services and the most desired land uses.

Combining the results of the ecosystem services analysis and survey

When comparing the land use options with reference to the ecosystem services assessment, community gardens and forest/rock fall protection are the most beneficial to implement (figure 9). Both land uses improve eight ecosystem services and cause no degradation. Recreation and farmland mostly improve ecosystem services, but degrade a number of services at the same time (figure 9). The 'do nothing' land use is the worst option, both improving and degrading the same number of services (figure 9).

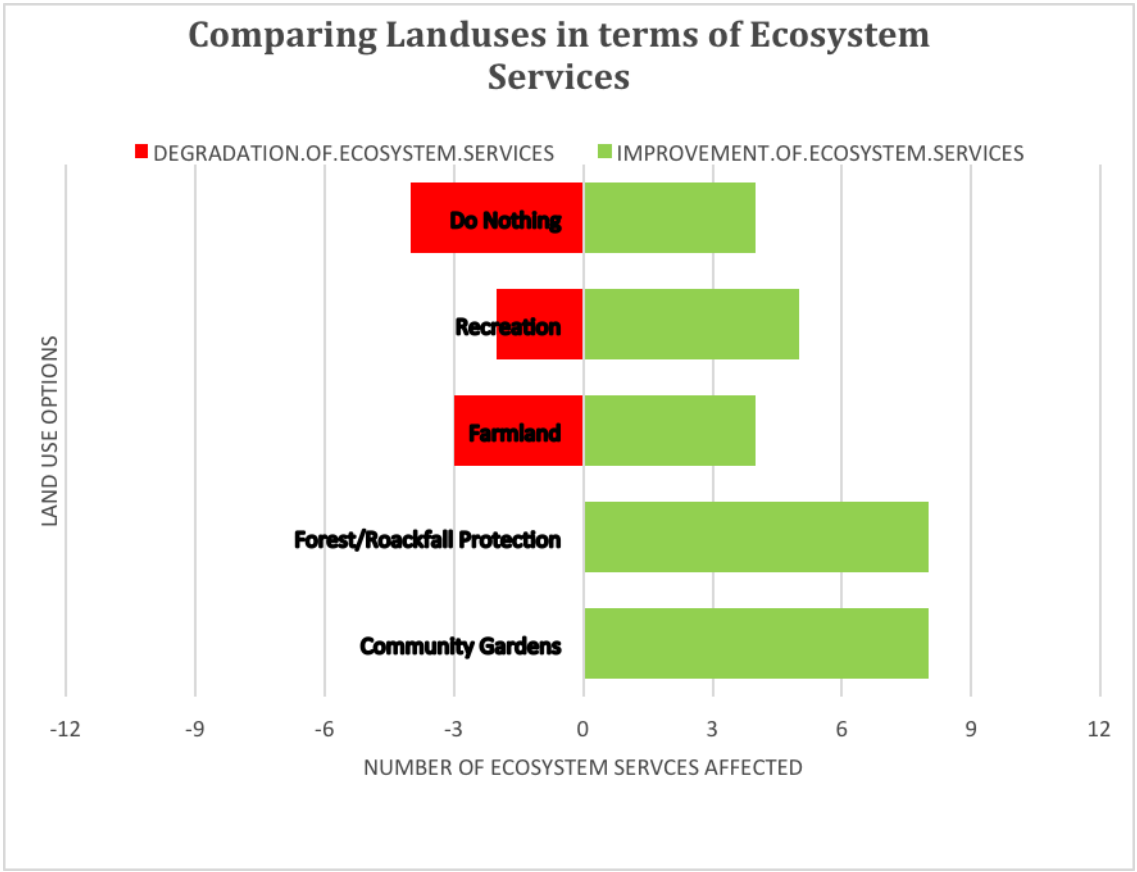


Figure 9: *The comparison of land uses in terms of ecosystem services. This figure shows the number of ecosystem services improved (green) or degraded (red) by a specific land use.*

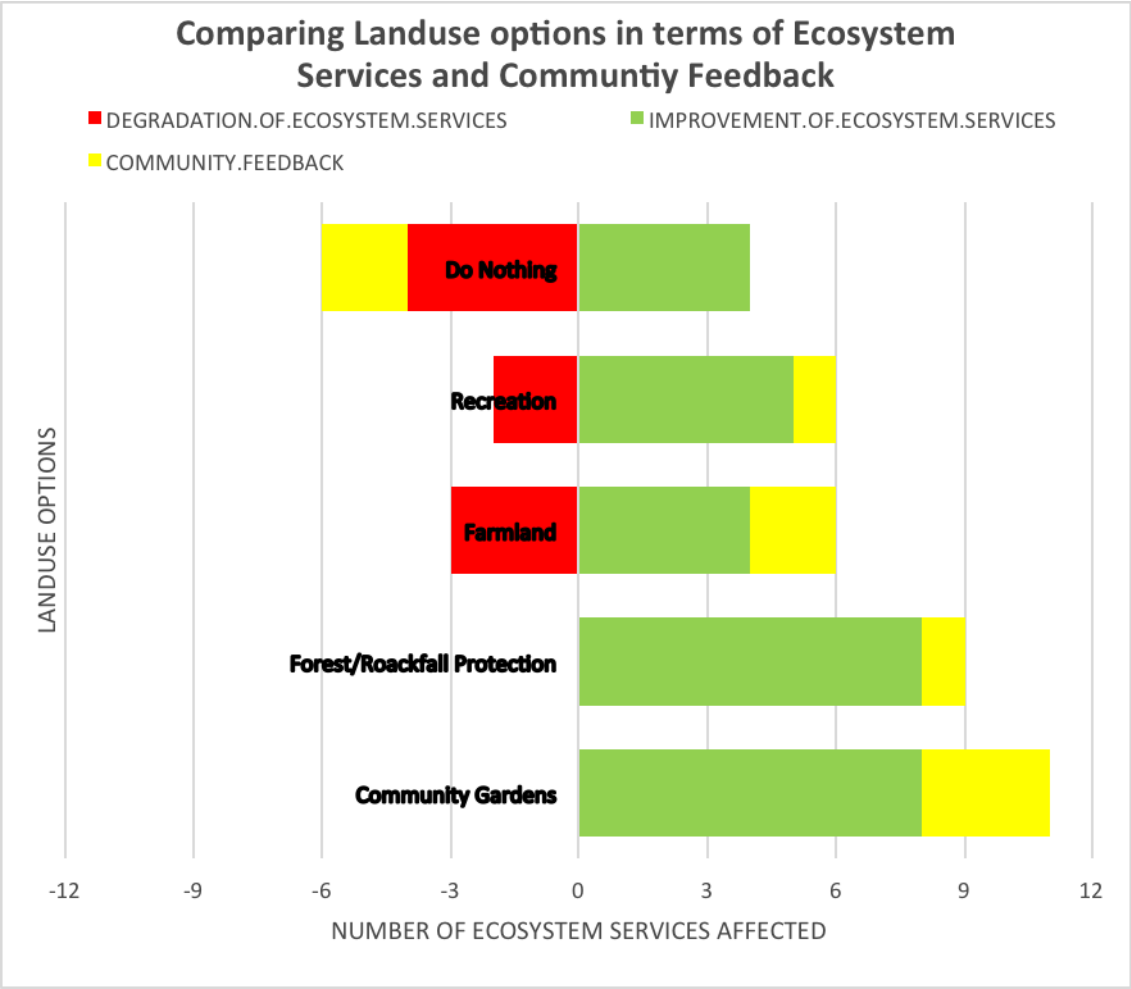


Figure 10: *The comparison of land uses in terms of ecosystem services and community feedback. This figure shows the number of ecosystem services improved (green) or degraded (red) by specific land uses, giving extra weighting to the most highly valued ecosystem services. The three services most valued by the community (aesthetic appeal, community identity and sense of place, and food) were given a double weighting shown in yellow.*

Figure 10 shows the comparison of the land use options with reference to the ecosystem services assessment and community feedback. The ecosystems services most valued by the community were given extra weighting. This figure shows that implementing community gardens would improve the ecosystem services the most, followed closely by forest and rockfall protection. Recreation and farmland have the same positive impact, but recreation has a less degrading impact on ecosystem services. Doing nothing is more degrading than beneficial for ecosystem services.

Best land uses

A mixture of community gardens, forest/rockfall protection and recreation would be the most valued selection of land uses and provide the most significant improvement in ecosystem services. This research suggests that doing nothing would have a net negative effect on the ecosystem services identified as valuable for the Sumner Community. Therefore leaving the red zoned land unmodified is not advised because it is likely to be detrimental for the Sumner Community.

The red-zone areas encompass various land types, including flat ex-residential land, cliff slopes and cliff bottoms, so there is the potential to include each of these land-uses. The GIS map below (figure 11) indicates the potential locations for each of these land-uses.

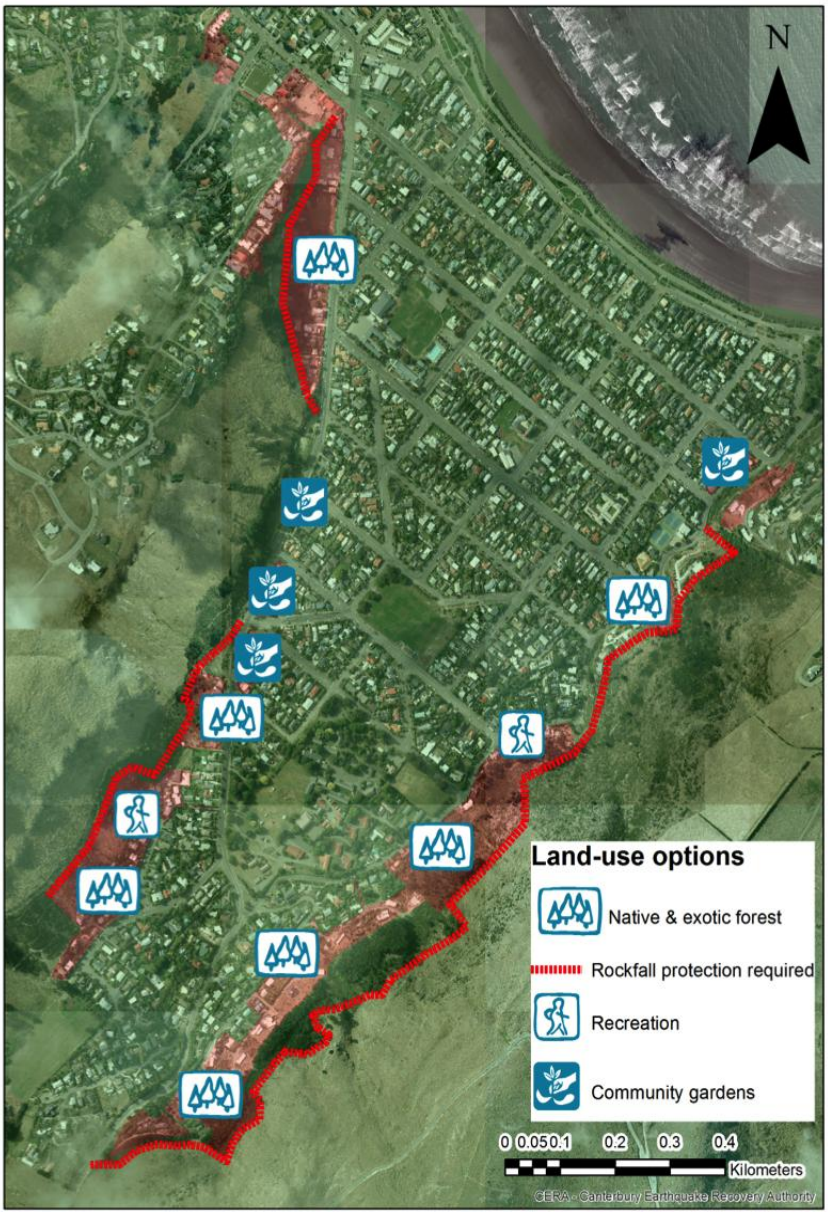


***Figure 11**: GIS Map detailing potential locations for the best land uses for the red-zoned land in Sumner*

Native & Exotic Forest: Much of the red-zoned land is cliff slope, cliff bottoms and the run-out zone of potential rock fall hazards. The most suitable option for these locations is forestation, providing some rockfall protection. The topography and hazardous nature of these sites indicates that any other land use is likely to be unfeasible.

Rock Fall Protection: Rock fall protection is required on both sides of the Sumner Valley where there is a considerable hazard to underlying land and houses. This could be a combination of protection forest and structural measures.

Recreation: These sites have been chosen to correspond with the extension of existing walkways and cycle tracks in Sumner. The feasibility of this land-use is contingent on the extent of the rockfall risk in these areas.

Community Gardens: Potential sites for community gardens are located along Wakefield and Heberden Avenues on land that was formerly residential. These areas have been chosen as they have flat topography and are located away from the immediate run-out zone of the cliff. There is still considerable rock fall hazard on these sites so further risk assessment is required.

Limitations

The most significant limitation of the results stems from the short time-frame that was available to conduct the study. This restricted the extent of the investigation in a number of ways, in particular by limiting the number of responses obtained during the survey period. With more time, the survey could have been distributed to a greater proportion of the Sumner Community to receive a larger sample. However, as noted above, the sample obtained was a relatively adequate representation of the Sumner population.

The limited time frame also prevented any response being obtained from CERA. Information from the CERA website was not site-specific, resulting in uncertainty as to the feasibility of the land-uses identified.

An important step of successful environmental assessment is early consultation and engagement with communities (Baker et al., 2013). Due to the nature of this research, this was not considered beneficial and was instead left until the final stages to provide community feedback to accompany the ecosystem services analysis.

Initial confusion about the objective of the study reduced the time frame further. The initial focus was on the feasibility of different land-uses. After the limited response from CERA regarding the risk associated with red-zoned land, combined with feedback from Habitat Sumner, the research was modified to focus on an ecosystem services analysis. This was a complex concept that is not readily understood without background knowledge. This issue was mitigated during the survey by describing ecosystem services in a series of simple statements.

Conclusion

The main findings of this research have been that the ecosystem services most valued by the Sumner Community are aesthetics, community identity/sense of place, and food. The most suitable land-uses for the red-zoned areas in Sumner are community gardens, forest and rockfall protection, and extending recreational areas. These land-uses incorporate the most valued ecosystem services, and provide the greatest overall improvement of ecosystem services.

In conducting this research project, avenues for a variety of future research possibilities were identified. Further research into the risks associated with each land-use option should be considered. For example, a risk assessment analysis should be conducted for establishing community gardens near cliff faces. Continuous collection and analysis of survey data should continue in order to achieve a wider and more representative sample of the Sumner population. This data can then be used for further statistical analysis. For example, research can be conducted to determine if there is a relationship between the most valued ecosystem service and the community group an individual belongs to. Research into spatial patterns can also be conducted by adding a spatial based question to the survey.

The ecosystem services model of environmental assessment can be used elsewhere to determine what can be done with reclaimed or condemned land, especially in a post-disaster environment.

Acknowledgements

We would like to thank Shane Orchard and Bailey Peryman from the Habitat Sumner Project, and Eric Pawson from the Department of Geography at the University of Canterbury for their assistance in conducting this research project.

References

Aitkinson, G. Doick, K.J. Burningham, K. France, C. (2013). Brownfield regeneration to greenspace: Delivery of project objectives for social and environmental gain. *Urban Forestry & Urban Greening*.

Beckett, K., Freer-Smith, P. H., & Taylor, G. (2000). The capture of particulate pollution by trees at five contrasting urban sites. *Arboricultural Journal*, 24(2-3), 209-230.

Bolund, P., Hunhammer, S., 1999. Ecosystem services in urban areas. *Ecological Economics* 29 293-301.

Bradshaw, A. (2000). The use of natural processes in reclamation – advantages and difficulties. *Landscape and Urban Planning*, 51(2-4), 89-100.

Bremer, L. L., & Farley, K. A. (2010). Does plantation forestry restore biodiversity or create green deserts? A synthesis of the effects of land-use transitions on plant species richness. *Biodiversity and Conservation*, 19(14), 3893-3915.

Byrne, K., Kiely, G. & Leahy, P. (2007). Carbon sequestration determined using farm scale carbon balance and eddy covariance. *Agriculture, Ecosystems & Environment,* 121(4). 357-364.

Calvet-Mir, L., Gomez-Baggethun, E., Reyes-Garcia, V., 2012. Beyond food production: ecosystem services provided by home gardens. A case study in Vall Fosca, Catalan Pyrenees, Northeastern Spain. *Ecological Economics*, 74 153-160.

Canterbury Earthquake Recovery Authority (2013). CERA Land Zones and DBH Technical Classes (NZTM). Retrieved from https://data.govt.nz/dataset/show/3088.

Canterbury Earthquake Recovery Authority (2013). *Land zones.* Retrieved from http://cera.govt.nz/land-information/land-zones.

Carswell, F., Burrows, L., Hall, G., Mason, N., & Allen, R. (2012). Carbon and plant diversity gain during 200 years of woody succession in lowland new zealand. *New Zealand Journal of Ecology*, 36(2), 191-202.

Christchurch City Council (2003). *Water, wetlands and drainage guide – Part B design - Impacts of development.* Retrieved from: http://resources.ccc.govt.nz/files/2.%20Impacts%20of%20Development.pdf

Colding, J. (2007). 'Ecological land-use complementation' for building resilience in urban ecosystems. *Landscape and Urban Planning, 81*(1–2), 46-55. doi: http://dx.doi.org/10.1016/j.landurbplan.2006.10.016

Cole & Knight (1990). Impacts of recreation on biodiversity in wilderness. *Natural Resources and Environmental Issues,* Vol. 0, Article 6.

Costanza, R., dArge, R., deGroot, R., Farber, S., Grasso, M., Hannon, B., . . . VandenBelt, M. (1997). The value of the world's ecosystem services and natural capital. *Nature, 387*(6630), 253-260.

Costanza, R., Paruelo, J., Raskin, R., Sutton, P., vandenBelt, M., dArge, R., ONeill, R. (1997). The value of the world's ecosystem services and natural capital. *Nature, 387* (6630), 253-260.

Dinnie, E. Brown, M. Morris, S. (2013). Community, cooperation and conflict: Negotiation the social well-being benefits of urban greenspace experiences. *Landscape and Urban Planning*, 112, 1-9.

Dorren, et al. (2004) Integrity, Stability and management of protection forests in the European Alps. *Forest Ecology and Management*. Vol 195, pp 165 - 176.

Douglas, G. B., McIvor, I. R., Manderson, A. K., Koolaard, J. P., Todd, M., Braaksma, S., & Gray, R. A. J. (2013). Reducing shallow landslide occurrence in pastoral hill country using wide- spaced trees. *Land Degradation and Development*, 24(2), 103-114.

Dymond, J. R., Ausseil, A-GE., Kirschbaum, M. U. F., Carswell, F. E., & Mason, N. W.H. (2013). Opportunities for restoring indigenous forest in New Zealand. *Journal of the Royal Society of New Zealand*, 43(3), 141.

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Gordon, B., Carpenter, S. R., . . . Snyder, P. K. (2005). Global Consequences of Land Use. *Science*, 309(5734), 570-574.

Geography Department, Hong Kong University (2013). Contemporary Global Environmental Issues. Retrieved from http://geog.hku.hk/undergrad/geog1003/1003impcfull.htm.

Google maps (2013). Sumner, Christchurch, New Zealand. Retrieved from https://maps.google.co.nz/

Han, Cohen & McKenzie (2013). Quantifying the contribution of neighbourhood park to physical activity. *Preventative Medicine*, http://dx.doi.org/10.1016/j.ypmed.2013.06.021

Kemp, Smith, DeKoven, Segal,. (2013). Play, Creativity and Lifelong Learning. Retrieved from http://www.helpguide.org/life/creative_play_fun_games.htm

Millennium Ecosystem Assessment (2005). Ecosystems and Human Well-Being: A Framework for Assessment. Island Press, 26-48, Washington, DC.

Millennium Ecosystem Assessment (2005a). Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Ngai Tahu. (2013). Mahaanui Iwi Management Plan 2013. Retrieved from http://mkt.co.nz/mahaanui-iwi-management-plan/

Panelli, R., & Tipa, G. (2009). Beyond foodscapes: Considering geographies of indigenous well-being. *Health and Place, 15*(2), 455-465

Sandhu, H.S., Wratten, S.D., Cullen, R. 2010. Organic agriculture and ecosystem services. *Environmental Science & Policy,* 13 1-7.

Schulze, E., Wirth, C., & Heimann, M. (2000). Managing forests after kyoto. *Science,* 289(5487), 2058-2059.

Smardon, R C. (1988) Perceptions and aesthetics of the urban environment: Review of the role of Vegetation. *Landscape and Urban Planning.* Vol 15. Pp85 -106

Smith & Godbey, (1991). Leisure, Recreation and Tourism. *Annals of Tourism Reseach,* vol.18.

Stewart, G. H., Ignatieva, M. E., Meurk, C. D., & Earl, R. D. (2004). The re-emergence of indigenous forest in an urban environment, Christchurch, New Zealand. *Urban Forestry and Urban Greening*, 2(3), 149-158.

The Government of the Hong Kong Special Administrative Region, (2011) Hong Kong Planning Standards and Guidelines. Retrieved from http://www.pland.gov.hk/pland_en/tech_doc/hkpsg/full/index.htm

Thompson, I. D., Okabe, K., Tylianakis, J. M., Kumar, P., Brockerhoff, E. G., Schellhorn, N. A., & Nasi, R. (2011). Forest biodiversity and the delivery of ecosystem goods and services: Translating science into policy. *Bioscience*, 61(12), 972-981.

Town, G. I. (2001). The health effects of particulate air pollution - A christchurch perspective. *Biomarkers, 6*(1), 15-18.

Turcu, C (20120). Local experiences of urban sustainability: Researching Housing Market Renewal interventions in three English neighbourhoods. *Progress in Planning*, 78(3), 101-150.

Zhang, J., Yu, M., Shan, Q., Chen, G., Wei, W., Wang, Y., & Li, Z. (2011). Develop urban forest shelter belts to prevent NPS pollution in coastal region. Paper presented at the *5th International Conference on Bioinformatics and Biomedical Engineering, iCBBE 2011*.