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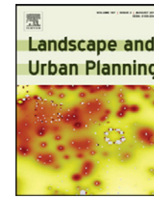

An analysis of the relationships between multiple values and physical landscapes at a regional scale using public participation GIS and landscape character classification

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HIGHLIGHTS

- ► We examine relationships between landscape values and physical landscapes.
- ► Different values are associated with specific landscape components at a regional scale.
- ► Results appear consistent with smaller and larger scale landscape perception studies.
- ► Findings can enhance regional social and environmental impact assessment methods.

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ABSTRACT

Human attribution of multiple values to landscapes is not well understood owing to the variability and complexity of both the landscape concept and the human valuation process. In this study, we extend psychophysical analysis of landscapes by examining the relationships between multiple landscape values and physical landscape character. Previous landscape research has tended to focus on the relationship between a single value such as landscape aesthetics and a single physical landscape component, such as vegetation or water. We spatially intersected eight landscape values collected through a regional public participation GIS (PPGIS) process with landscape components and classes from the New Zealand Land Classification (NZLC) system. We used chi-square residual analysis and correspondence analysis to identify significant spatial associations. The results indicate that the general public associate particular values with specific landscape components at a regional scale. Greater than expected landscape values were associated with urban areas, water features, indigenous landcover, and mountains. Fewer than expected landscape values were associated with flatter, agricultural landscapes. We discuss the benefits and limitations of these methods for landscape assessment in New Zealand, and in the absence of PPGIS data to directly measure landscape values, whether landscape components should be used to interpolate values for landscape assessment. We urge replication of the method in other regions to increase the external validity of the landscape value–physical landscape associations described herein.

1. Introduction

This study was designed to assist the New Zealand Department of Conservation (DOC) engage the public in the development of regional conservation plans. The agency is directly responsible for the management of public conservation lands while playing an advocacy role for conservation on all land in New Zealand (NZ). Under the Conservation Act of 1987 (the "Act"), DOC is required to develop 10-year strategic plans called Conservation Management Strategies (CMS). The purpose of a conservation management strategy is to implement integrated management of natural and historic resources, recreation, and tourism.

Effective conservation planning in NZ requires knowledge and understanding of landscape values such as aesthetic, recreation, and historical values that exist within a region. To date, it has not been practical to study every regional location for the presence or absence of different landscape values. This study examines whether landscape values can be inferred from landscape character, such as landform and landcover, based on empirical, spatial associations

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to provide an efficient method for assessing regional values. This research was designed around the following questions to assist DOC:

- What landscape values are spatially associated with different physical landscape characteristics?
- Can landscape assessment methods be enhanced by integrating public participation GIS (PPGIS) with a landscape character classification system?

There has been considerable research in the last decade to identify landscape values using participatory GIS methods. Landscape value research has been motivated by the need to inform and enhance land use planning and environmental management. For example, typologies of landscape values have been developed and implemented to inform forest management (Beverly, Uto, Wilkes, & Bothwell, 2008; Brown & Reed, 2000, 2009; Clement & Cheng, 2010), national parks and protected area management (Brown & Weber, 2011; Pfueller, Xuan, Whitelaw, & Winter, 2009), urban park planning (Tyrväinnen, Mäkinen, & Schipperijn, 2007), residential and tourism development (Brown, 2006; Raymond & Brown, 2007), coastal area management (Alessa, Kliskey, & Brown, 2008), rural development (Nielsen-Pincus, 2007; Pocewicz, Schnitzer, & Nielsen-Pincus, 2010), and climate change risk (Raymond & Brown, 2011).

The evolution of geospatial and internet technology has provided new opportunities to develop and implement practical methods for identifying landscape values. In this study, we examine whether these methods can be extended to describe intrinsic associations between landscape values with landscape character. These psychophysical methods combine human mental processes with physical landscapes and are arguably, the most valid method for landscape assessment (Daniel & Vining, 1983). Historically, the psychophysical approach to assessment has been expensive to implement because it requires both landscape character classification and a means of determining landscape preferences. As a result, expert judgements have dominated landscape assessment because they are expedient.

This paper will describe how PPGIS and a landscape character classification system can be used for landscape assessment at a regional scale in southern New Zealand (NZ). The paper begins by explaining key landscape concepts and is followed by a brief critique of landscape assessment methods with a particular emphasis on landscape assessment in NZ. Background information on PPGIS and the NZ Landscape Classification (NZLC) system is provided for study context. Following the study results, we discuss the theoretical and practical implications of the findings for future research.

1.1. Landscape and assessment

What is a landscape? In this paper, landscape is presented as a visual phenomenon, as defined in the 1970s by the Countryside Commission – "the spectacle presented by the countryside" (Countryside Commission, 1970, p. 2) or as described by Granö in 1929 (translated in 1997). Granö divides the perceived environment into "the proximity, which we perceive with all our senses, and farther away the landscape, which extends to the horizon and which we perceive by sight alone" (p. 19). The word "landscape" is becoming increasingly synonymous with the words "environment" or "geography" that are broad concepts. The generalization and conflation of the landscape concept with environment is undesirable because landscape, as a predominantly visual phenomenon, is an important distinction that needs to be maintained. The landscape concept based on distant views, aligns with the concepts of scenery and landscape aesthetics. Even with the more narrow definition of landscape as a visual phenomenon, the perceptual nature of landscape makes assessment challenging.

The visual landscape has many layers (landform, landcover, etc.) and it is the composition and perception of these layers that form the landscape. For practical reasons of description and communication, it is useful to deconstruct landscape into layers; however, the individual layers are not a landscape. The viewer's perception, which can involve place attachment, understanding, and preferences, are also layers of the landscape. Thus, both physical and perceptual layers comprise landscape. We label the physical landscape layers as landscape components and the perceiver's layers as landscape values. We use the term "landscape class" to describe a unique combination of landscape components. A landscape component will have multiple classification categories (e.g., component = landform, category = high mountain, hill, or plateau).

There are alternative research paradigms to interpret and understand landscape perceptions and values. For example, Zube, Sell, and Taylor (1982) describe the expert, psychophysical, cognitive, and experiential paradigms for understanding landscapes. The former two tend to be associated with landscape assessment, while the latter two are concerned with developing deeper theoretical understanding—the "how" and "why" questions associated with landscape perception. The expert paradigm presupposes that only trained and skilled observers can effectively assess landscape values and this is through objective assessment of landscape character. In the psychophysical paradigm, landscape values are the result of a stimulus–response mechanism between the landscape observer and landscape character. Cognitive research examines how thought processes between past experience, future expectations, and sociocultural conditioning determine landscape values. The experiential paradigm describes the experience of human–landscape interaction wherein both are shaping and being shaped in the process. The four paradigms are complementary and not mutually exclusive. For example, psychophysical and cognitive mechanisms may condition human–landscape experiences.

Although the psychophysical approach comes closest "...to meeting the criteria of the ideal assessment system" (Daniel & Vining, 1983, p. 79), its implementation can be expensive and difficult. Specifically, a landscape character classification system is not always available and study participants can usually only assess a small number of photos. The use of a landscape character classification system enables the results of landscape perception surveys to be extrapolated to other areas with similar character. In essence, a landscape classification system provides a frame of reference for communicating the results and improves the efficiency of regional landscape research.

1.2. Landscape assessment and research in New Zealand

In NZ, landscapes are primarily managed under the Resource Management Act (1991) which explicitly provides protection for nationally outstanding landscapes and scenic amenities. Local councils are also required to consult with the public under the Local Government Act (2002) for major land use decisions. As a result, there have been many landscape studies commissioned by local councils. Some of these studies have used preference surveys (e.g., Fairweather & Swaffield, 1999), but most have relied on expert judgement (Swaffield & Foster, 2000). The leading example of psychophysical research in NZ was conducted by Auckland Regional Authority in 1984 (Brown, 1984). Landscape preferences were recorded for natural areas, places close to the coast, and volcanic cones. The latter two are widely recognized landscape features of Auckland city. Other preference surveys have shown similar results, with preferences expressed for naturalness and water features, including rivers and lakes. High mountainous areas are also valued (Swaffield & Foster, 2000) as well as native forests and undeveloped coastlines (Peart, 2004).

Swaffield and Fairweather (2003) reviewed a number of landscape preference studies. Because many studies are specific and localized, landscape inferences are limited in the absence of a landscape character classification system. An exception has been research on wilderness perception mapping (Higham et al., 2001; Kliskey & Kearsley, 1993) and the use of the recreation opportunity spectrum (Joyce & Sutton, 2009). In addition to assessment research, there have been phenomenological studies, such as Stephenson (2008) who showed the complex nature of cultural landscapes in Bannockburn and Akaroa, and argued that landscapes values can be grouped into surface values based on the present physical character, and embedded values based on historical relationships.

New Zealand, like many other countries, has struggled with adopting valid and practical landscape assessments that can be widely applied. Landscape assessment has not been well funded despite the fact that NZ's landscapes provide for the health and well-being of over 4 million residents and attract nearly two million international tourists each year. In the absence of valid and replicable methods, an expert landscape assessment method has been built into Case Law by an Environment Court ruling (Wakatipu Environment Society Inc & Ors V Queenstown-Lakes District Council C180/99) calling for the assessment of natural science factors, memorability, naturalness, and expressiveness (legibility).

1.3. New Zealand Landscape Classification

This study uses the NZ Landscape Classification (NZLC) system developed by Brabyn (1996) and subsequently updated (Brabyn, 2009). The website (Brabyn, 2012) provides details and graphical displays of this classification. The NZLC is a classification of character, not quality, and is built from the unique combinations (spatial overlays) of six landscape components—landform, landcover, infrastructure, water, dominant landcover, and water views. The latter two components provide a wider experiential context of a place. The categories associated with each component are listed in Tables 4–9.

The purpose of landscape classification is to provide a frame of reference for communicating landscape research, just as a plant classification improves communication for botanists. The classification system uses common language to describe the landscape components and component categories. The six landscape components have the potential to produce many thousands of landscape classes—unique combination of components—which may be impractical for some applications. Consequently, a hierarchical structure is imposed on the classification system so users can select a level of generalization to meet their needs. This study uses the most detailed level (3a), which has 7209 classes and 426,734 discrete polygons for all of NZ. The NZLC is operationalized and accessed as a GIS database. The advantage of a GIS-based classification system is that statistics on the total area and relative abundance of each landscape class at a regional or national can be calculated to help interpret the results.

1.4. Landscape values

What is a landscape value? Landscape values are perceived attributes of a landscape that are thought to result from a transactional concept of human–landscape relationships (Brown, 2005; Zube, 1987). In the transactional model, humans are active participants in a landscape—thinking, feeling, and acting—leading to the attribution of meaning and the valuing of specific landscapes and places. This view is supported by Tuan's (1977) conception of place whereby people differentiate place from space by attaching meaning and values to space; places become "centres of felt values" that emerge through experience and are influenced by culture. Humans receive and process information from both observation and experience leading to perception of value. Individual perception is mediated by the sociocultural context in which the person exists and the individual's personal utility functions. Thus, humans associate a range of values with landscapes, but the mix of values and the weights placed on them may differ from individual to individual.

Landscape values are best viewed as a type of "relationship" value that bridges held and assigned values (Brown & Weber, 2012). In the process of associating meanings with place, what is personally important to an individual becomes fused with conceptions of what appears important to the individual in the physical landscape. In the PPGIS mapping process, individuals call upon their tacit, held values in the process of assigning values to landscapes such as those in southern New Zealand. In PPGIS, an operational definition for each landscape value is provided to the study participant.

Brown and Reed (2000) developed a landscape value typology for participatory mapping that consisted of 13 values (aesthetic, economic, recreation, life sustaining, learning, biological, spiritual, intrinsic, historic, future, subsistence, therapeutic, and cultural). Variations of this early value typology were subsequently adapted by other researchers to different planning contexts and alternatively labelled as ecosystem values, environmental values, or social values. The shifting terminology for the value typology appears to reflect the particular study context. The set of landscape values used in this study reflect values that are important to DOC for planning and managing conservation areas in NZ.

2. Methods

2.1. Study location

The two regions in this study are the Otago and Southland regions on the south island of New Zealand (see Fig. 1). The Southland region covers more than 3.1 million ha, has over 3400 km of coastline, and includes New Zealand's largest national park, Fiordland National Park. Southland is one of New Zealand's most sparely populated regions (approximately 94,200 in 2010) with an economy based in tourism, agriculture, fishing, forestry, and energy resources.

The Otago region covers approximately 3.2 million ha with an estimated population of 207,400 in 2010. Major centres of population include Dunedin, Oamaru, and the tourist centres of Queenstown and Wanaka. In the west of the region, high alpine

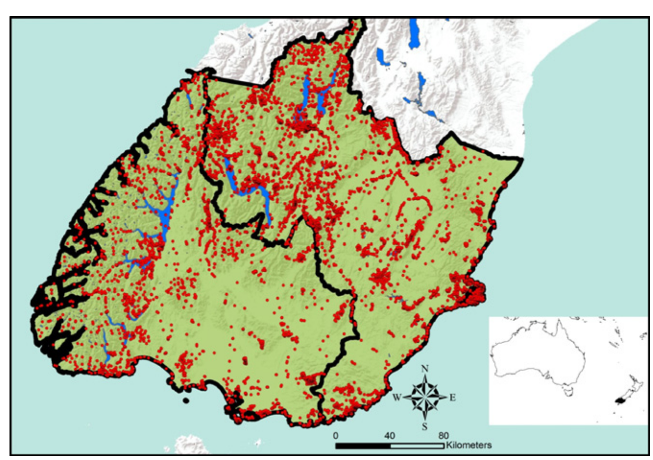

Fig. 1. Map of study area in New Zealand that includes the Otago and Southland regions. Mapped landscape values ($n \approx 9000$) appear in the study region as points.

mountains and glacial lakes dominate the landscape including Mt. Aspiring National Park. Tussock grasslands dominate the dry lands of the central region, while the hill country of the Catlins is located in the region's southeast. Key economic sectors include tourism, education, agriculture, and manufacturing.

2.2. PPGIS data collection

PPGIS websites for each of the regions were developed after consultation and pilot testing with DOC staff. PPGIS data collection consisted of two parts: (a) spatial attribute mapping using a custom Google® maps application and (b) general survey questions assessing participants' familiarity with conservation areas in the region and selected socio-demographic information. Participants were recruited January through March 2011 through a random mail sample of households in the Southland and Otago regions, by visitor contact at conservation areas, and by advertising in media outlets such as local newspapers.

The spatial attributes to be identified by participants included 30 landscape values, experiences, and development preference markers located in three panels on the left of the screen. Participants were instructed to drag and drop these markers to the appropriate location on a Google® base map. The map did not contain the information present in the NZLC but instead had shaded relief and standard topographical detail so that participants could accurately locate particular places. The list of markers and their associated definitions was identical for the two regions. Of relevance to this study was the list of 11 landscape values that appear in Table 1. These landscape values provide a broad range of values that are relevant to regional conservation and development issues in NZ. For purposes of this study, the two categories of recreation value were combined into a single recreation value while the two separate values of native vegetation and native wildlife were combined into a single *native flora/fauna* value category. Because the focus of this study is on the relationship between terrestrial landscapes and landscape values, the marine value category was not included in the analysis. Thus, eight landscape values (aesthetic/scenic, recreation, economic, ecological/life sustaining, native flora/fauna, social, historical/cultural, wilderness) were included in the analysis.

PPGIS mapping precision by participants was enforced by only allowing the placement of markers if the participant had zoomed-in to a predetermined zoom level (Level 12) in Google® Maps (approximately 1:100,000 scale). Respondents could optionally view the region in different Google® map views including "Map", "Terrain", "Satellite", "Hybrid" and 3-D "Earth". The default Google® map view, and the one in which the majority of markers were placed, was "Terrain".

2.3. Data analysis

To prepare the spatial data for analysis, we intersected the eight PPGIS landscape values with the six NZLC landscape components (landform, landcover, dominant landcover, water, water view, and infrastructure) and the NZLC landscape classes, which are combinations of the six landscape components. This produces a large table consisting of all the points collected, the landscape value associated with the point, the categories for each of the six landscape components, and the landscape class. This data was analyzed using four different techniques—frequency counts, residual analysis, correspondence analysis, and selected social landscape metrics (Brown & Reed, 2012).

2.3.1. Frequency counts

The numbers of landscape values falling within each landscape component and landscape class were summed. This identifies the most popular landscape components and classes associated with different landscape values. However, simple frequencies can be misleading when landscape classes are disproportionately over or under-represented in the study region. If a landscape class is uncommon but has many landscape values, or if a landscape class is abundant but does not have high value counts, these findings merit attention. To account for proportional differences in landscape classes, residual analysis is used.

2.3.2. Residuals analysis

The total area (ha) and the percentage area of the study site for each landscape component category were calculated using GIS summary functions. The landscape value counts, expressed as a percentage of the total count, were compared with the percentage area of the landscape to produce standardized residuals. Residuals analysis provides a way to assess the strength of association between two categorical variables and is often done following a statistically significant chi-square result to determine which pair-wise categorical relationships most contribute to the overall significant association. In this study, the chi-square statistics are not very helpful because one would expect the results to be statistically significant given the large number of observations and non-random spatial distribution of values. However, residuals analysis provides useful information by indicating which landscape values are significantly over or under-represented in the different landscape categories.

A residual is defined as the difference in the observed frequency and the expected frequency. A standardized residual is calculated by dividing the residual value by the standard error of the residual. Standardized residuals are a normalized score like a z score without units and if greater than 2.0, indicate significantly more landscape values than would be expected given the size of the area, while

Table 1
Landscape value definitions used in public participation GIS (PPGIS) process in New Zealand.

Landscape values
Scenic/aesthetic—these areas are valuable because they contain attractive scenery including sights, smells, and sounds.
Recreation (non-facility based)—these areas are valuable because they provide dispersed recreation opportunities where users are relatively self-reliant, i.e. tramping (trekking/backpacking), climbing, hunting/fishing or adventure activities.
Recreation (facility based)—these areas are valuable because they provide recreation activities through the provision of managed tracks, huts, campsites, and other facilities.
Economic—these areas are valuable provide because they provide income and employment opportunities through industries like tourism, natural resources, or other commercial activity.
Ecological/life sustaining—these areas are valuable because they help produce, preserve, and renew air, soil, and water.
Native wildlife—these are valuable because they provide areas for indigenous (native) wildlife to live and/or opportunities for humans to observe.
Native vegetation—these areas are valuable because they sustain areas of indigenous (native) plants.
Marine—these areas are valuable because they support marine life.
Social—these areas are valuable because they provide opportunities for social interaction.
Historical/cultural—these areas are valuable because they represent history, NZ identity, or provide places where people can continue to pass down memories, wisdom, traditions, OR a way of life.
Wilderness—these areas are valuable because they are wild, uninhabited, or relatively untouched by human activity.

standardized residuals less than −2.0 indicate fewer landscape values based on the size the area.

Standardized residuals provide an indicator of over- or under-representation of landscape values, but cautious interpretation is warranted because expected counts are based on landscape component areal proportions. Because PPGIS participants do not randomly locate landscape values, there is not an a priori expectation that the landscape values be distributed by areal proportionality. We included analysis of standardized residuals to account for the possibility of distributional bias based on landscape component area within the study region.

2.3.3. Correspondence analysis

In this study correspondence analysis is used to determine whether some of the landscape component categories are similar to each other as well as whether some of the landscape values are similar. Correspondence analysis is a technique to describe the relationship between two nominal variables in a contingency table while simultaneously describing the relationships between the categories of each variable. Mathematically, correspondence analysis decomposes the chi-square measure of association of the nominal data into components, much like principal components analysis of continuous data. It computes row and column scores and produces normalized plots based on the scores. Landscape categories and values that are similar to each other appear close to each other in the plots. In the plots, it is relatively easy to see which categories of a variable are similar to each other and which categories of the two variables are related. In this study, we plotted the relationships between the categories for each of the six landscape components and the eight landscape values in two-dimensional spaces. Visually, the landscape values that appear nearest to the landscape component categories have a stronger association.

2.3.4. Social landscape metrics

Several social landscape metrics described by Brown and Reed (2012) are calculated for the landscape classes with the largest number of landscape values. Social landscape metrics quantify human perceptions of place resulting from collection of PPGIS data. The metrics used in our analysis include the dominant landscape value, the value diversity index (a.k.a., Shannon's diversity index), Simpson's evenness index, and the dominance index. These indices have no units but reveal the most frequent landscape value within a class, the diversity of values within a landscape class (higher index value = more value diversity), how even the landscape values are distributed within a landscape class (1 = most even distribution, 0 = least even distribution), and the closeness of the second most frequently mapped landscape value to the dominant landscape value (0 = first and second values have same frequency, 1 = there is only one landscape value in the class). Together, these indices provide a more comprehensive view of the distribution of landscape values within the landscape classes.

3. Results

3.1. Participant characteristics and number of landscape values

A total of 14,370 landscape attributes were identified by 608 PPGIS participants in the Otago and Southland regions. This spatial data was prepared for analysis by eliminating markers placed outside the two study regions and by filtering markers unrelated to the eight landscape values in study, leaving a total of 8824 landscape value points available for analysis. This is a large number of participants compared to traditional landscape perception studies in NZ. For example Fairweather and Swaffield (1999) study of perceptions in the Coromandel region had 88 participants.

Of the 354 participants that responded to socio-demographic questions following the PPGIS mapping activity, 94% were New Zealand residents and 6% were international visitors. The New Zealand participants were 62% male (NZ census 49%), had a median age of 48 years (NZ census 36 years), with 41% reporting a bachelor's degree or higher in formal education (NZ census 13%) (Statistics New Zealand, 2012). Thus, PPGIS participants were more male, older, and more formally education than the general NZ population. These results are consistent with other internet PPGIS studies reporting higher participation by older males with more formal education (Brown, Montag, & Lyons, 2012; Pocewicz et al., 2012).

PPGIS participants were also disproportionately represented by individuals with a self-reported "good" or "excellent" knowledge of places in the region (68%), compared to "average" (26%) or "below average" knowledge (5%). Thus, PPGIS participants report a relatively high level of familiarity with the regional landscape, a finding consistent with other PPGIS studies (see e.g., Brown, 2005; Brown et al., 2012; Brown & Weber, 2012).

3.2. Relative frequency of landscape values

Table 2 provides a count of the number of points collected for each landscape value. There are three landscape values that dominate—recreation, aesthetic, and native flora/fauna, with counts of 3343, 1814, and 1750, respectively. Outdoor recreation is a significant means by which people experience valued landscapes and therefore planners need to be particularly sensitive to change in landscapes in areas associated with outdoor recreation.

These results confirm that aesthetics maintain an important association with multiple landscapes. Natural landscapes are highly valued for a mix of recreation, aesthetics, and native flora/fauna values and is confirmed by the correspondence analysis. Interestingly, historical values are relatively low in count, yet the study area has many important historical sites (e.g., see Stephenson's (2008) Bannockburn study). The results indicate that historical/cultural landscape values may not as important as some researchers would suggest (Stephenson, 2008). The low number of wilderness values can be explained by the relatively low number of people who actively engage in wilderness activity, even though the study area contains some of the largest wilderness areas in NZ—Fiordland and Aspiring National Parks.

3.3. Values associated with landscape character

Landscape values were identified in 2761 unique landscape classes in the study area. Results for the top 25 valued landscape classes are shown in Table 3. Tables 4–9 provide the frequency counts and residual scores for each of the six landscape component categories while Fig. 2 graphically illustrates the residual scores for each landscape component, making it easy to visually compare deviations of mapped values from expected counts. Although we have argued that an individual landscape component, such as landform, is not a landscape, it is practical to present the results at the

Table 2
Number of records by landscape value.

Landscape values	Count
Scenic/aesthetic	1814
Recreation (non-facility based)	3343
Economic	193
Ecological/life sustaining	526
Native flora and fauna	1750
Social	258
Historical/cultural	479
Wilderness	461
Total count	8824

Table 3
Top 25 landscapes with most abundant landscape values in region. Shaded cells indicate significantly more (green) or less (pink) landscape values in the category than expected based on standardized residuals.

Landscape Description	% Area	Actual Count (all values)	Expected Count (all values)	Residual (all values)	Relation (all values)	Shannon Diversity Index	Simpson's Evenness Index	Dominant Value	Dominance Index
Very High Mountain, Tussock, Dominated by Indigenous Landcover	5.48	422	497	-3.38	less	1.63	0.86	Recreation	0.41
Very High Mountain, Indigenous Forest, Dominated by Indigenous Landcover	2.22	382	202	12.68	more	1.51	0.83	Recreation	0.45
High Mountain, Tussock, Dominated by Indigenous Landcover	4.22	355	383	-1.43	same	1.56	0.82	Recreation	0.43
Mountain, Tussock, Dominated by Indigenous Landcover	4.67	353	424	-3.46	less	1.57	0.85	Recreation	0.43
Mountain, Indigenous Forest, Dominated by Indigenous Landcover	5.83	300	529	-9.96	less	1.38	0.77	Recreation	0.48
High Hill, Indigenous Forest, Dominated by Indigenous Landcover	3.13	262	284	-1.30	same	1.58	0.85	Flora/fauna	0.00
Open Valley with Mountain, Large Lake	1.70	229	154	6.01	more	1.64	0.86	Recreation	0.40
High Plateau, Tussock, Dominated by Indigenous Landcover	1.19	219	108	10.70	more	1.71	0.90	Recreation	0.36
Mountain, Low Producing Grassland, Dominated by Semi Developed Agriculture	2.85	176	259	-5.16	less	1.64	0.88	Recreation	0.14
Enclosed Sea	1.52	164	138	2.23	more	1.77	0.91	Aesthetic/scenic	0.39
High Hill, Low Producing Grassland, Dominated by Semi Developed Agriculture	3.51	162	319	-8.77	less	1.69	0.88	Recreation	0.38
High Hill, Indigenous Scrub, Dominated by Indigenous Landcover	0.62	150	56	12.60	more	1.31	0.74	Recreation	0.63
High Mountain, Indigenous Forest, Dominated by Indigenous Landcover	1.76	139	160	-1.67	same	1.38	0.76	Recreation	0.59
High Hill, High Producing Grassland, Dominated by Developed Agriculture	5.61	130	509	-16.81	less	1.74	0.91	Recreation	0.24
Low Hill, High Producing Grassland, Dominated by Developed Agriculture	8.06	114	732	-22.83	less	1.86	0.95	Recreation	0.33
Mostly Flat, High Producing Grassland, Dominated by Developed Agriculture	5.65	93	513	-18.55	less	1.84	0.94	Recreation	0.21
Low Hill, High Producing Grassland, Dominated by Developed Agriculture, View of Open Ocean	0.19	93	17	18.14	more	1.66	0.88	Aesthetic/scenic	0.20
Mountain, Indigenous Forest, Dominated by Indigenous Landcover, View of Large Lake	0.75	93	69	2.96	more	1.62	0.85	Recreation	0.31
Very High Mountain, Alpine Rock, Dominated by Indigenous Landcover	1.31	93	119	-2.38	less	1.49	0.83	Recreation	0.14
Estuarine	0.17	88	16	18.36	more	1.52	0.85	Flora/fauna	0.54
Hill, High Producing Grassland, Dominated by Developed Agriculture, View of Open Ocean	0.12	69	11	18.01	more	1.56	0.83	Flora/fauna	0.45
Plateau, Tussock, Dominated by Indigenous Landcover	0.60	68	55	1.77	same	1.52	0.84	Recreation	0.41
Mountain, Indigenous Forest, Dominated by Indigenous Landcover, View of Enclosed Sea	1.67	66	152	-6.96	less	1.40	0.78	Flora/fauna	0.11
High Hill, High Producing Grassland, Dominated by Developed Agriculture, View of Open Ocean	0.17	64	16	12.24	more	1.29	0.78	Recreation	0.41
Open Valley with Mountain, Low Producing Grassland, Dominated by Semi Developed Agriculture	0.10	63	9	17.86	more	1.70	0.91	Recreation	0.11

Table 4
Distribution of landscape values by landform. Shaded cells indicate significantly more (green) or less (pink) landscape values in the category than expected based on standardized residuals.

Landform	Area (Hectares)	Percent of area	Aesthetic/scenic	Residual	Recreation	Residual	Economic	Residual	Ecological/life sustaining	Residual	Native flora/fauna	Residual	Social	Residual	Historical/cultural	Residual	Wilderness	Residual
Very High Mountain	789283	12.22	338	7.82	591	9.03	32	1.73	50	-1.78	226	0.83	27	-0.81	44	-1.90	135	10.48
High Hill	1387112	21.47	337	-2.66	666	-1.93	23	-2.86	91	-2.06	377	0.06	50	-0.72	109	0.61	78	-2.11
Mountain	1381375	21.38	275	-5.73	590	-4.67	20	-3.31	75	-3.53	315	-3.06	23	-4.33	53	-4.88	83	-1.57
High Mountain	642042	9.94	208	2.06	433	5.53	17	-0.50	38	-1.97	102	-5.45	22	-0.72	31	-2.41	43	-0.42
Open Valley with Mountain	216907	3.36	177	14.88	350	22.44	32	10.03	53	8.41	138	10.34	34	8.61	50	8.46	25	2.42
Low Hill	727519	11.26	109	-6.67	164	-10.95	28	1.34	40	-2.50	128	-4.92	28	-0.20	74	2.73	21	-4.29
Hill	159150	2.46	101	8.42	111	3.16	2	-1.26	25	3.35	152	16.58	13	2.64	24	3.55	11	-0.11
Mostly Flat	473511	7.33	69	-5.55	109	-8.69	15	0.23	69	4.90	124	-0.38	31	2.78	34	-0.19	7	-4.61
High Plateau	111813	1.73	64	5.82	99	5.41	1	-1.28	33	7.92	62	5.76	5	0.25	19	3.72	25	6.03
Plateau	288664	4.47	59	-2.45	81	-5.59	2	-2.26	25	0.31	63	-1.72	6	-1.63	9	-2.68	9	-2.56
Open Valley with Hill	204600	3.17	41	-2.17	81	-2.42	16	4.00	17	0.08	35	-2.74	15	2.39	24	2.27	6	-2.25
Very High Plateau	37172	0.58	17	2.03	40	4.73	2	0.84	2	-0.59	10	-0.02	0	-1.22	4	0.75	15	7.58
Large Open Lake	19536	0.30	11	2.35	16	1.85	3	3.16	5	2.70	12	2.92	3	2.51	3	1.29	1	-0.33
Low Plateau	21663	0.34	8	0.78	12	0.24	0	-0.80	3	0.93	6	0.05	1	0.14	1	-0.48	2	0.37
Total			1814		3343		193		526		1750		258		479		461	

Table 5
Distribution of landscape values by landcover. Shaded cells indicate significantly more (green) or less (pink) landscape values in the category than expected based on standardized residuals.

Landcover	Area (Hectares)	Percent of area	Aesthetic/scenic	Residual	Recreation	Residual	Economic	Residual	Ecological/life sustaining	Residual	Native flora/fauna	Residual	Social	Residual	Historical/cultural	Residual	Wilderness	Residual
Tussock	1387215	21.47	417	1.39	752	1.27	28	-2.09	112	-0.09	313	-3.24	51	-0.59	59	-4.32	155	5.63
Indigenous Forest	1408679	21.81	335	-3.04	823	3.48	28	-2.17	109	-0.53	610	11.69	39	-2.30	69	-3.47	143	4.24
Low Producing Grassland	801580	12.41	289	4.26	419	0.21	25	0.22	47	-2.26	151	-4.49	21	-1.95	101	5.39	46	-1.48
High Producing Grassland	1866450	28.89	253	-11.84	375	-19.01	27	-3.85	91	-4.95	206	-13.32	44	-3.54	103	-3.01	26	-9.29
Indigenous Scrub	223317	3.46	146	10.52	304	17.53	13	2.45	30	2.77	167	13.69	17	2.71	22	1.34	23	1.77
Lake	155120	2.40	88	6.73	154	8.23	15	4.82	33	5.73	71	4.47	16	3.94	14	0.74	10	-0.32
Urban	21642	0.34	65	23.90	110	29.52	42	51.43	11	6.96	28	9.14	49	51.78	51	38.99	2	0.37
Alpine Rock	141158	2.19	50	1.65	65	-0.94	2	-1.08	13	0.44	19	-3.11	0	-2.37	1	-2.93	16	1.87
Exotic Forest	187921	2.91	48	-0.66	94	-0.33	4	-0.68	5	-2.63	40	-1.53	9	0.55	15	0.29	1	-3.39
Exotic Scrub	44890	0.70	30	4.90	50	5.55	0	-1.16	2	-0.87	21	2.53	4	1.65	13	5.30	1	-1.23
River	32720	0.51	29	6.54	79	15.10	4	3.06	35	19.82	28	6.43	3	1.48	4	1.01	11	5.67
Saltwater wetland	4081	0.06	16	13.90	20	12.33	0	-0.35	12	20.27	34	31.33	1	2.08	5	8.55	2	3.17
Sub Alpine Scrub	109145	1.69	16	-2.64	33	-3.12	0	-1.81	4	-1.64	16	-2.49	2	-1.13	3	-1.79	8	0.08
Permanent Snow and Ice	26213	0.41	13	2.08	10	-0.97	1	0.24	0	-1.46	5	-0.79	0	-1.02	1	-0.68	13	8.13
Freshwater wetland	41250	0.64	10	-0.47	36	3.17	0	-1.11	20	9.08	36	7.42	1	-0.51	7	2.25	4	0.61
Mine or Dump	1700	0.03	4	5.14	5	4.43	0	-0.22	1	2.33	0	-0.67	0	-0.26	5	13.82	0	-0.35
Coastal Sand	1986	0.03	3	3.25	8	6.84	0	-0.24	0	-0.40	5	6.05	0	-0.28	2	4.80	0	-0.38
Horticulture	4879	0.08	2	0.53	6	2.17	3	7.45	1	0.95	0	-1.15	1	1.82	4	6.03	0	-0.59
Total			1814		3343		193		526		1750		258		479		461	

Table 6
Distribution of landscape values by infrastructure. Shaded cells indicate significantly more (green) or less (pink) landscape values in the category than expected based on standardized residuals.

Infrastructure	Area (Hectares)	Percent of area	Aesthetic/scenic	Residual	Recreation	Residual	Economic	Residual	Ecological/life sustaining	Residual	Native flora/fauna	Residual	Social	Residual	Historical/ cultural	Residual	Wilderness	Residual
No infrastructure except urban	6194058	95.88	1681	-1.42	3107	-1.75	159	-1.91	503	-0.10	1659	-0.48	218	-1.87	426	-1.59	441	-0.05
Natural with Vehicle Track	77504	1.20	40	3.90	73	5.19	2	-0.21	8	0.67	18	-0.66	6	1.65	8	0.93	7	0.62
Natural with Unsealed Road	27192	0.42	29	7.73	54	10.64	4	3.54	4	1.20	31	8.70	14	12.39	8	4.21	10	5.78
Highway	33352	0.52	21	3.80	22	1.14	13	12.03	1	-1.04	6	-1.01	8	5.78	7	2.87	1	-0.89
Transmission Line	92964	1.44	17	-1.78	47	-0.16	6	1.93	5	-0.94	15	-2.03	7	1.71	7	0.04	0	-2.58
Railway	31294	0.48	11	0.75	10	-1.54	7	6.28	5	1.53	12	1.21	3	1.57	19	10.94	0	-1.49
Natural with Sealed Road	1997	0.03	9	11.25	10	8.80	1	3.84	0	-0.40	4	4.69	0	-0.28	4	9.98	1	2.27
Natural with Mast	854	0.01	5	9.81	7	9.96	1	6.15	0	-0.26	3	5.81	0	-0.18	1	3.75	1	3.84
Natural with Overhead Cable	1846	0.03	1	0.65	6	5.11	0	-0.24	1	2.17	3	3.50	0	-0.27	0	-0.37	0	-0.37
Natural with Ski Lift	195	0.00	1	4.05	8	24.94	0	-0.08	0	-0.13	0	-0.23	2	22.65	0	-0.12	0	-0.12
Total			1815		3344		193		527		1751		258		480		461	

Table 7
Distribution of landscape values by water classification. Shaded cells indicate significantly more (green) or less (pink) landscape values in the category than expected based on standardized residuals.

Water	Area (Hectares)	Percent of area	Aesthetic/scenic	Residual	Recreation	Residual	Economic	Residual	Ecological/life sustaining	Residual	Native flora/fauna	Residual	Social	Residual	Historical/ cultural	Residual	Wilderness	Residual
Land	6226735	96.38	1678	-2.57	3094	-2.15	173	-1.40	450	-3.12	1598	-3.03	237	-0.66	454	-0.66	436	-0.71
Large Lake	139273	2.16	73	5.23	119	5.55	14	4.67	27	4.49	51	2.00	14	3.60	12	0.47	6	-1.29
Enclosed Sea	100398	1.55	54	4.69	33	-2.62	10	3.92	10	0.55	33	0.99	3	-0.49	8	0.16	14	2.49
River	32720	0.51	29	6.41	79	15.12	4	2.98	35	19.50	28	6.30	3	1.49	4	0.98	11	5.61
Estuarine	11785	0.18	17	7.42	17	4.43	0	-0.60	14	13.12	36	18.15	0	-0.68	7	6.50	1	0.16
Island in Lake	1446	0.02	12	18.15	14	15.48	1	4.56	6	17.05	32	50.39	2	8.18	2	5.79	2	5.91
Medium Size Lake	10307	0.16	11	4.67	25	8.51	1	1.20	2	1.22	6	1.86	2	2.48	1	0.25	3	2.60
Small Coastal Island	6451	0.10	5	2.31	0	-1.83	0	-0.45	0	-0.74	2	0.16	0	-0.51	4	5.04	0	-0.68
Small Lake	5539	0.09	4	1.91	10	4.21	0	-0.41	4	5.18	14	10.05	0	-0.47	1	0.90	1	0.94
Large Coastal Island	37876	0.59	2	-2.69	2	-3.97	0	-1.08	2	-0.66	19	2.63	0	-1.23	1	-1.09	2	-0.45
Total			1885		3393		203		550		1819		261		494		476	

Table 8
Distribution of landscape values by dominant landcover. Shaded cells indicate significantly more (green) or less (pink) landscape values in the category than expected based on standardized residuals.

Dominant Landcover	Area (Hectares)	Percent of area	Aesthetic/scenic	Residual	Recreation	Residual	Economic	Residual	Ecological/life sustaining	Residual	Native flora/fauna	Residual	Social	Residual	Historical/ cultural	Residual	Wilderness	Residual
Indigenous Landcover	3388937	52.46	1101	4.84	2174	10.037	86	-1.52	281	0.31	1068	4.95	116	-1.66	154	-6.14	393	9.72
Developed Agriculture	2109384	32.65	363	-9.42	652	-13.303	51	-1.51	168	-0.29	477	-3.95	81	-0.35	177	1.65	29	-9.90
Semi Developed Agriculture	742318	11.49	236	1.91	316	-3.475	15	-1.52	43	-2.24	121	-5.65	19	-1.95	114	7.95	31	-3.02
Large Lake	139274	2.16	73	5.42	119	5.527	14	4.82	27	4.65	51	2.16	14	3.58	12	0.52	6	-1.25
Urban	8840	0.14	27	15.55	53	22.625	26	50.05	4	3.86	13	6.85	28	46.50	19	22.64	0	-0.79
Exotic Forest and Scrub	71594	1.11	14	-1.36	29	-1.321	1	-0.78	3	-1.17	20	0.14	0	-1.69	3	-1.00	2	-1.38
Total			1814		3343		193		526		1750		258		479		461	

Table 9
Distribution of landscape values by water view classification. Shaded cells indicate significantly more (green) or less (pink) landscape values in the category than expected based on standardized residuals.

Water View	Area (Hectares)	Percent of area	Aesthetic/scenic	Residual	Recreation	Residual	Economic	Residual	Ecological/life sustaining	Residual	Native flora/fauna	Residual	Social	Residual	Historical/ cultural	Residual	Wilderness	Residual
No close View of Lake or Sea	6226735	85.93	1165	-9.97	2340	-9.94	98	-5.27	391	-2.87	1091	-10.64	136	-5.76	326	-4.22	365	-1.56
View of Large Lake	139273	3.74	207	16.88	368	21.71	37	11.08	17	-0.61	140	9.20	59	15.88	27	2.14	30	3.07
View of Open Ocean	100398	2.31	186	22.28	231	17.51	14	4.52	39	7.71	268	35.81	21	6.17	64	15.92	32	6.55
Lake	32720	2.40	88	6.73	154	8.23	15	4.82	33	5.73	71	4.47	16	3.94	14	0.74	10	-0.32
View of Medium Size Lake	11785	1.26	67	9.24	96	8.31	5	1.65	12	2.09	41	4.04	4	0.42	11	2.02	7	0.50
View of Enclosed Sea	1446	2.91	43	-1.34	69	-2.85	18	5.23	12	-0.84	77	3.67	10	0.92	22	2.17	7	-1.75
View of Estuarine	10307	0.24	33	13.88	33	8.94	5	6.73	12	9.66	34	14.70	5	5.63	10	8.34	1	-0.08
View of Small Lake	6451	1.22	25	0.62	52	1.77	1	-0.88	10	1.42	28	1.45	7	2.18	5	-0.35	9	1.43
Total			1814		3393		193		526		1750		258		479		461	

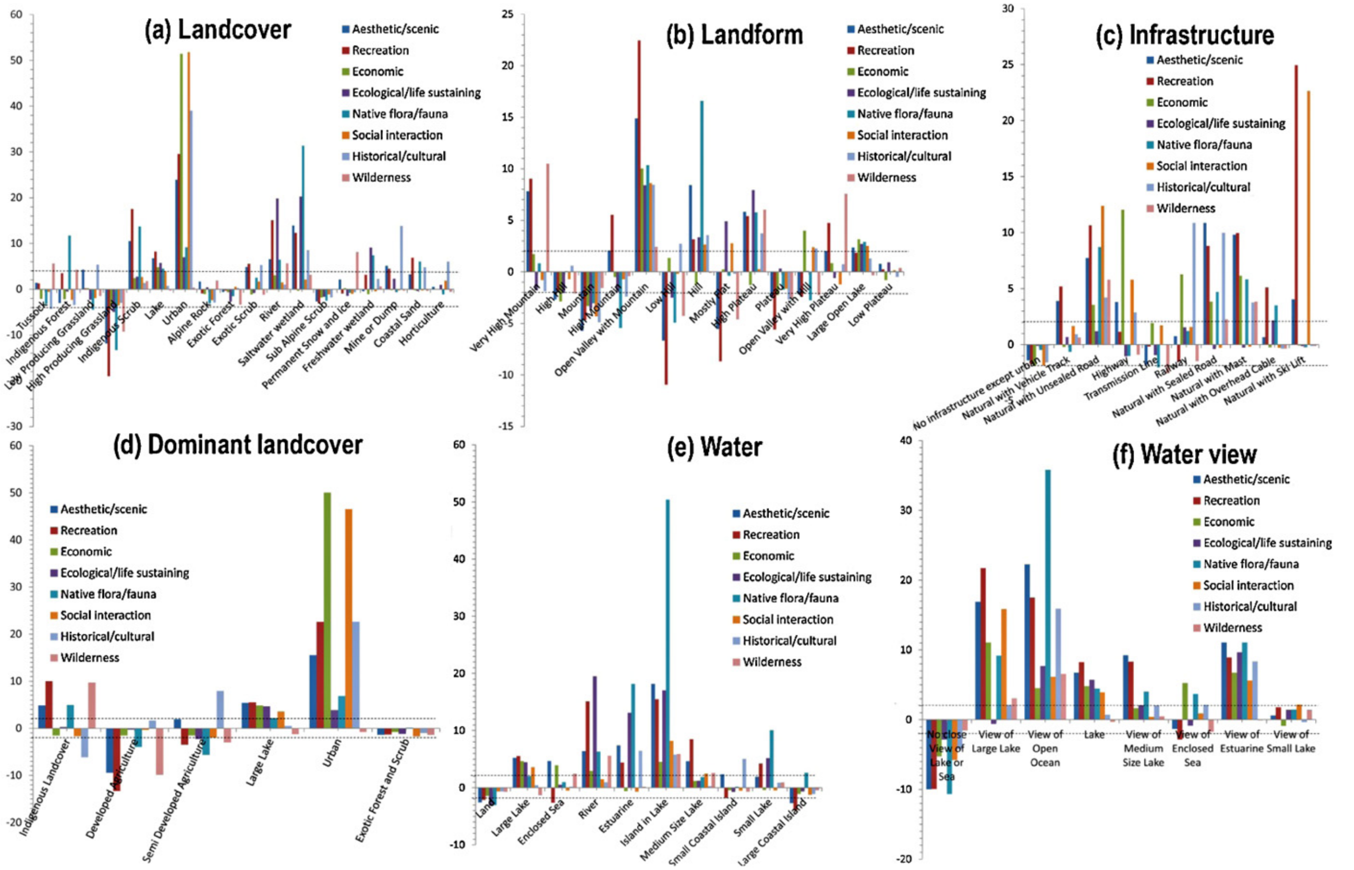

Fig. 2. Relationship of landscape values to physical landscape attributes. Chi-square analysis residuals are displayed on the *y*-axis. Residual values greater than 2.0 indicate the observed landscape values from PPGIS are significantly more than expected while residual values less than −2.0 indicate observed values from PPGIS are significantly less than expected.

landscape component level. These tables provide evidence for the importance of a range of landscapes values for landscape planning. The following summary reflects our key findings from these tables.

From the top 25 landscapes classes valued (Table 3), water in the form of lakes, estuaries, and views of the ocean and enclosed sea appear most frequently (8 times). Water is a known landscape attraction and this study confirms the importance of water in the landscape. Water is valued in a range of landcover and landform contexts, even in agricultural areas with low topography. Mountainous areas, particularly high mountains with glaciers and alpine tussock are also highly valued (e.g., 14 of the top 25 landscapes include mountains and high plateaus). Many of these landscape classes are dominated by indigenous vegetation. These findings are consistent with previous landscape perception studies dating back to the 1800s and early 1900s that describe the high country as picturesque and sublime (Nightingale & Dingwall, 2003). Swaffield and Foster's (2000) review of South Island's (NZ) high country found that low intensity farming (low producing grassland) in the mountains provides iconic landscape views. Our results show moderate landscape values associated with developed grassland (6 out of 25) even with low topography and without water. This finding has not been substantiated in previous studies in NZ but should not appear surprising. People enjoy the vernacular landscape, perhaps because they are common and easily accessible.

A review of the individual landscape component tables confirms some of the findings from the top 25 landscape classes. Larger value counts are associated with high topography, natural vegetation, and water. The values associated with landform are predominantly recreation and aesthetic and these values are mostly linked with high topography. Wilderness values are also moderately high for these landforms. Open valleys with mountains are a major feature of the mountains just east of the Southern Alps (the central mountain range of the South Island). They consist of large braided rivers with wide river flats, and are often farmed with low intensity because of easy stock access up the river flats. This landform category has a moderately large value count and a very high residual score for aesthetics and recreation (14.8 and 22.4, respectively). This landform also features in the top 25 landscape classes in association with low producing grassland and lakes. This landform is typical of high country farming landscapes that have iconic status in NZ. Further, the quality of openness is regarded as a positive attribute of landscape (Weitkamp, Berg, van den Bregt, & Lammeren van, 2012) and relates to Appleton (1975) refuge—prospect theory that explains preference for open savannah landscapes.

An interesting result with landcover is the moderate value count for urban areas, given that perception studies have shown a general preference for natural landscapes. The residual analysis shows this count is disproportionally larger for all values, but particularly for economic, social and historical values. Recreation value is the most frequent value and is explained by popular tourist towns such as Queenstown and Wanaka in the study area that are havens for outdoor adventure activities such as skiing, bungy jumping, and paragliding. Because these and other urban activities are commercial, it is not surprising that urban landscapes are perceived as having high economic value.

An additional confounding factor for the urban results is that many urban areas in the region are situated by the coast or by lakes with landforms and water components that attract people. Of the landscapes containing urban areas, the top 11 for aesthetic values contain a water feature. Urban areas also have high ecological and native flora/fauna values, a result that NZ councils work hard to promote (Clarkson, Wehi, & Brabyn, 2007).

The disproportionate representation of all landscape values in urban areas warrants further explanation. One would logically expect greater representation of social, economic, and historical/cultural values in and near urban areas but the over-representation of all values except wilderness can be explained by the theory of spatial or place-based discounting (Norton & Hannon, 1997; Perrings & Hannon, 2001). According to the theory, humans tend to discount across both time and space, placing higher value on places that are more proximate. In testing this theory, Brown, Reed, and Harris (2002) found landscape values to be unevenly distributed across a regional landscape in Alaska, with significant spatial clustering of values near communities. Similarly, in this study, landscape values also spatially clustered in and near urban areas in the region (i.e., Dunedin, Queenstown, and Invercargill).

The majority of the landscape values were not associated with water components, which is to be expected because apart from the large lakes and islands in the region, the water categories have small spatial extents. There were moderate value counts for many water categories but because of the small spatial extents, the residual scores were large. The study area has some remote, large islands located off the coast of Fiordland National Park but most people would not have visited these islands. One might expect that large islands would have larger value counts in other parts of NZ where the islands feature more prominently. Islands in lakes show a disproportionally large value count for aesthetics, recreation and especially native flora/fauna (residual value = 50). These islands exist on Lakes Te Anau, Wakatipu and Wanaka and are 1–2 km^2 in size and often less than 200 m wide. These results indicate that a reasonably detailed level of spatial accuracy is possible using PPGIS and the NZLC.

Infrastructure is difficult to represent in landscape character classification because of the linear nature of roads, powerlines, and railways, and the specific point locations of communication masts. Some landcover types, such as urban areas agricultural land, have associated infrastructure such as roads and powerlines. The NZLC does not include this infrastructure, but rather classifies infrastructure that is not generally associated with a landcover type or may be regarded as “out of place”. This includes large infrastructure such as highways, transmission lines, and railways that alter the character of the landcover or that are located in predominantly natural landcover settings. Many of these infrastructure categories have relatively small spatial extents. The value counts are generally low but because of the small spatial extents, have moderately large residual scores. Areas with no “out of place” infrastructure have by far the largest value count (1681 and 3107 for aesthetic and recreation value, respectively). The categories of “natural with unsealed roads” and “natural with vehicle track” (4 wheel drive tracks) have moderately large value counts for aesthetic and recreation. These results are understandable given that vehicle tracks provide easy access to recreational settings. The study area also has many ski facilities with large residual scores for recreational value.

The dominant landcover component is a generalized interpretation of landcover and provides an overall context for an area. For example, small urban areas such as small towns are removed and replaced by the dominant landcover in the vicinity which may be forest or grassland. Consequently, urban areas are limited to the large cities and towns. Small forest or grassland patches are also removed. This explains why the urban dominant landcover category has fewer counts, across all landscape values, than the urban category that is part of the specific landcover component. This finding suggests that people value small towns that have been removed from the dominant landcover. Overall, the values associated with the dominant landcover component show similar patterns to the specific landcover components.

The water view component is similar to the specific water component in that the spatial extent of these areas is small with most value points located outside these areas. And yet, the results show moderately large counts for views of large lakes and open ocean. The residual analysis indicates that water views are disproportional valued, with the exception of enclosed sea. Enclosed sea in the study area consists of the inner Fiordland coast and Otago Harbour. The inner Fiordland coast has a large spatial extent but is inaccessible and remote which may explain the low value counts and low residual scores for the enclosed sea category. In general, one would expect enclosed sea throughout NZ (e.g., Marlborough Sounds and the Bay of Islands) to be highly valued landscapes. Most of the value points with views of enclosed sea in the study region are associated with Otago Harbour, an important recreation and aesthetic site that occupies a relatively small proportion of the study area.

3.4. Correspondence analysis

The graphical representation of the correspondence analysis is shown in Fig. 3(a)–(f). These graphs show significant associations between landscape values and landscape character components. We have annotated the graphs with dashed ellipses to highlight significant grouping and patterns.

Wilderness and recreation values are clearly associated with mountainous settings that have natural vegetation and are free from major infrastructure. Wilderness in particular is linked with alpine settings that include glaciers and bare rock. This finding may have implications for DOC’s Recreational Management Spectrum (Joyce & Sutton, 2009) that maps wilderness using remoteness from access and facilities, and naturalness, but does not include any topography. In this study region, high topographical relief is associated with wilderness but this may not be the case in other areas.

Aesthetic value is associated with recreation value across most landscape components. Aesthetic value is also associated with low level intensity farming and managed forestry areas, a non-intuitive finding that may be explained by greater landscape accessibility and familiarity.

Virtually all landscape values have similar associations with water. The study area is known for lakes, both large and medium in size. The economic and social values have strong association with large lakes because Queenstown, Te Anau, and Wanaka are important tourist destinations that are located on the shore of large lakes. Not surprisingly, social and economic values are clearly associated with the less natural, urban, low relief, agricultural, and major infrastructure landscapes. Historical value shows similar associations with the exception of major infrastructure. Many historical sites are located near towns and areas of early agricultural development and resource extraction in NZ. In general, historical values are associated with areas with low relief and good access.

3.5. Social landscape metrics

The social landscape metrics in Table 3 provide some additional insights into landscape relationships described previously. The Shannon diversity index indicates relatively high landscape value diversity for the most value–abundant landscape classes. The diversity derives from the mix of recreation, aesthetics, and native flora/fauna values in landscape classes that are more natural and mountainous. Recreation value is the most frequent value for most of these mountainous and natural landscapes, but aesthetics and native flora/fauna values are also abundant as shown by the Simpson’s evenness index, which is generally high, and the Dominance Index, which is generally low. These values can usually coexist without too much conflict provided there is wise

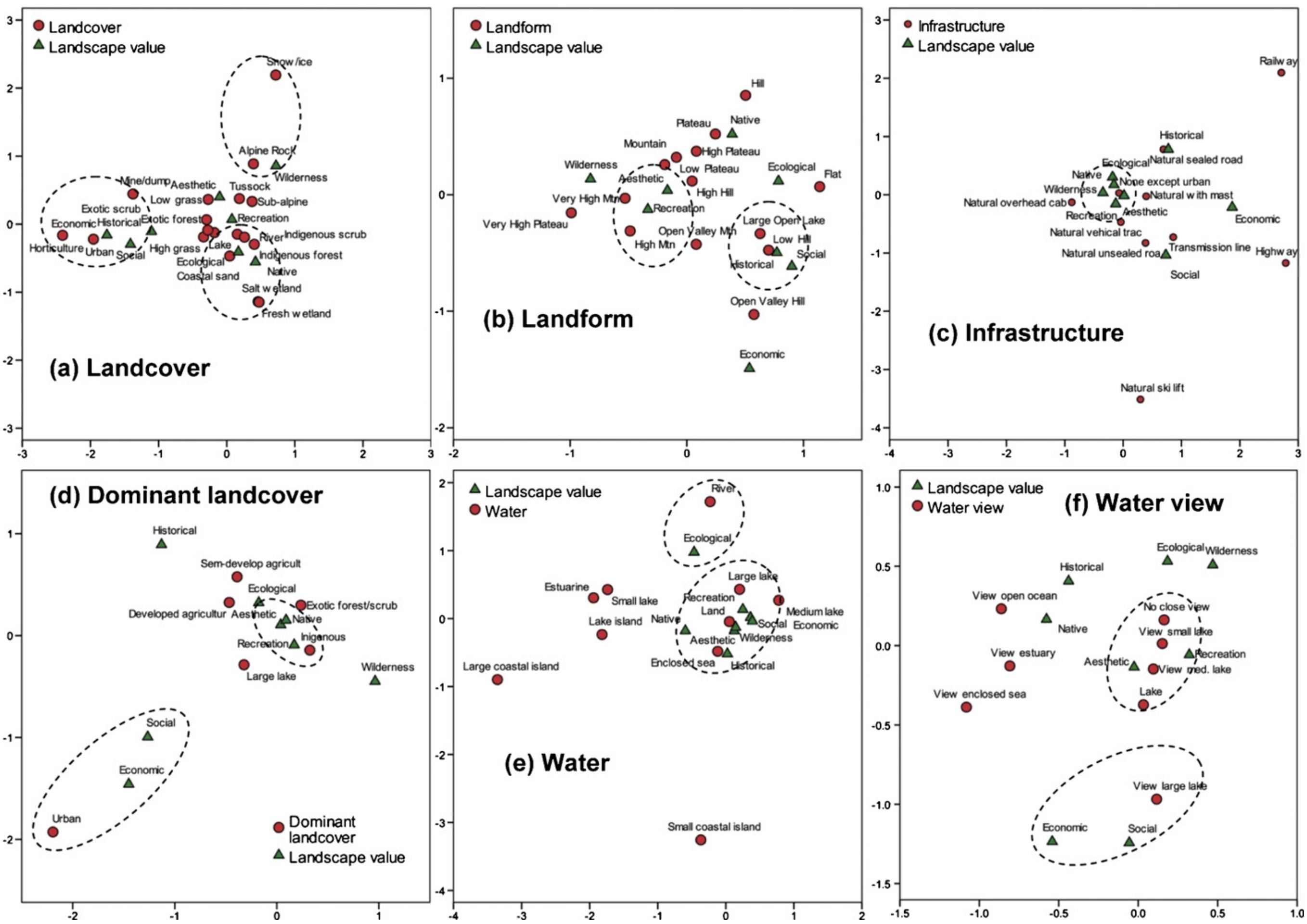

Fig. 3. Results of correspondence analysis between landscape values and landscape components.

management such as providing boardwalks to protect native flora from excessive trampling from recreation.

One interesting result from the social landscape metrics is that more developed agricultural landscapes with low relief have a diverse mix of values as shown by the slightly larger diversity scores (1.70–1.85) and the lower dominance scores. These landscapes have significant economic and social values in addition to aesthetic and recreation values. This mix of values may create problems for land use in these areas because these values often conflict; e.g., noisy farm tractors working near hikers seeking serenity.

4. Discussion

The method used in this study has produced results that are plausible and consistent with previous landscape perception studies in New Zealand. In addition, the scale of this study exceeds other landscape perception studies in NZ; we analyzed 8824 landscape value points from 608 participants providing information on 2761 unique landscape classes. The method demonstrated the capacity to assess small landscapes features, such as islands and ski lifts, as well as large mountainous landscapes. Our analysis confirmed previous studies indicating human preferences for landscapes with natural features, mountains, and water. Our analysis also revealed more subtle relationships landscape relationships not previously published.

The combination of PPGIS data with a landscape classification system provides a powerful, alternative for landscape assessment compared to traditional psychophysical landscape assessments that use photos. The method described herein provides an efficient method for assessing landscapes at the regional scale and could be replicated in other regions or countries that have a landscape classification system. The use of classification systems is common in the natural sciences because these systems provide an important frame of reference for communication, and yet, their adoption in the social sciences has lagged. Without the NZLC, our detailed examination of the relationships between landscape values and physical landscapes would not have been possible. To advance landscape research, the development of landscape character classification systems appears essential. Similar landscape classifications such as the Recreation Opportunity Spectrum have shown their worth over time (Joyce & Sutton, 2009; Kliskey & Kearsley, 1993).

The NZLC is relatively new and has yet to be fully utilized. This research has provided a type of validation for its construction and application—it yielded logical and consistent findings with previous landscape research. The classification system, constructed from six core components with multiple categories, provided a useful typology for understanding landscape value and physical landscape relationships. The arrangement of the components into a hierarchy of landscape classes provides an important mechanism to parse the contribution of different physical landscape features that contribute to value perceptions. Low relief landforms, even semi-developed ones, were highly valued if water is in the vicinity. Mountainous areas with natural vegetation were the most highly valued landscapes, and considerably more valued than flat areas with natural vegetation or mountains with grassland. The power of the NZLC is the capacity to assess and measure both univariate and multivariate relationships between landscape values and physical landscape features.

Our analyses produced a large amount of data on landscape value and feature interactions. The challenge was how to best communicate this information. We opted to use several different, but complementary methods to analyze and present the results. The use of residual analysis augments raw frequency counts because the method accounts for areal differences in landscape components; without this analysis, the significance of landscape values associated with smaller landscape components would not appear in the results. Correspondence analysis provides a useful, graphical display of the landscape value/feature associations. Social landscape metrics are helpful to identify landscapes with high levels of complexity resulting from multiple, and sometimes conflicting values, such as working landscapes with significant aesthetic appeal.

The findings of this study occupy the scale middle ground between studies that examine how humans react to specific natural environments (e.g., Kaplan & Kaplan, 1989), and studies that assess human preference for large biomes (e.g., Han, 2007). The disproportional values expressed for regional landscapes with water, mountains, and open valleys surrounded by mountains is generally consistent with scene-specific perceptual studies that show preferences for landscapes that are both aesthetically pleasing and that possess restorative qualities. The disproportionate values expressed for landscapes classes containing indigenous forest vis-a-vis landscapes with grassland are consistent with Han's (2007) findings where study participants favoured forest biomes over grassland biomes. In general, our analysis supports the conclusion that human perceptions and value for landscapes can reasonably scale-up from site-specific assessment and scale-down from broad biome-based assessment.

The infrastructure landscape component appears the least directly related to the values that people express for landscapes. And yet, infrastructure, especially transportation, enables increased access to landscapes which greatly influences the quantity and distribution of landscape values. Infrastructure appears to acts like a "catalyst" for landscape values, strongly influencing their distribution, but the direct influence of the infrastructure footprint itself is difficult to detect in a regional study.

4.1. Implications

The viability of a regional landscape valuation methodology that uses participatory GIS may enhance social and environmental impact assessment for landscapes. A key question for any potential landscape change, anthropogenic or otherwise, is what values are going to be affected by the change. The interpolation of landscape values based on empirical value–landscape relationships is the concept behind SolVES, a model that transfers values to areas where PPGIS survey data are unavailable (Sherrouse, Clement, & Semmons, 2011). Their initial model was based on the relationship between landscape values and four physical landscape attributes: slope, elevation, distance to roads, and distance to water. The results of our study, based on the NZLC, provide evidence of associations between landscape values and more complex landscape components that can improve such interpolative models. For example, our results would appear to support a general relationship between elevation and landscape values, but elevation itself appears to be too general. The role of elevation through association with particular landscapes (e.g., mountains vs. hills) provides more useful information. Similarly, distance to water would appear related to landscape values, but more useful information is the type of water body and in particular, views of the water.

The types of value–landscape relationships described in this paper are particularly relevant to New Zealand where the Resource Management Act of 1991 explicitly requires the "protection of outstanding natural features and landscapes from inappropriate subdivision, use, and development (s6(b)). Further, the Act requires regional councils to establish, implement and review objectives and policies to achieve the integrated management of natural and physical resources in their regions that include landscape and amenity values (s30(1)(a)). In order to achieve this outcome, regional councils need to assess the relative values of landscapes within their region including identifying any landscapes or natural features considered to be outstanding. It would be relatively easy to generate maps showing the location of particular landscapes with outstanding landscapes based on a range of value criteria. To date, there has been no systematic methodology for assessing landscape values across regional New Zealand. Landscape assessments have been implemented using a variety of methods, but predominantly through consultancies that rely on expert judgement. These assessments lack a key strength of science—replicability. The combination of the NZLC and the PPGIS methodology reported herein provides the capacity to identify and rank landscape classes in an assessment process that appears defensible in the face of contentious proposals for change in land use.

4.2. Limitations

The PPGIS survey did not ask the participants to identify their ethnicity and therefore we cannot make conclusions regarding different ethnic groups. This is a limitation for research in NZ because the Resource Management Act requires that that local Māori, in particular, are consulted with regard to landscape planning. It is likely that our research did include people that identify as Māori but it is not possible to know the number. Future research in NZ should include a question about participant ethnicity.

This research assumes that participants made deliberative choices about the type and location of landscape values but we acknowledge that some participants may have used cognitive associations as a heuristic short-cut when doing the value mapping. The potential effect of this practice on the results is unknown. All social surveys involving human subjects are subject to the limitations of participant time, effort, and cognitive abilities. The use of PPGIS to identify landscape values is based on memory recall and thus generalized impressions about the location of various landscape values. Although the Google® base maps provide reasonably detailed landscape features and imagery for the participant to orient themselves within the study landscape, and the application enforces a minimum mapping resolution, there will be spatial error in the placement of specific value markers. And yet, the spatial error may be within acceptable tolerances given the types of generalized value attributes being mapped. In a related publication, the spatial error of PPGIS mapping of native vegetation in the same region was relatively low (6%) thus providing some confidence that PPGIS is a viable approach for identification of landscape attributes, even if based on memory recall (Brown, 2012). But it must be acknowledged that the magnitude of spatial error in participant identification of other landscape value attributes is unknown and could influence the relationships reported herein.

We have noted in the results the general tendency for participants to favour the proximate, a phenomenon called spatial or geographic discounting. Spatial discounting leads to larger counts of landscape values near urban areas and locations with easy access, areas that are generally more familiar to participants. We do not regard this familiarity as a bias or limitation of the method. It simply reflects what people value and is consistent with Stephenson's (2008) model of embedded values that result from deeper understanding of landscapes over time.

4.3. Future research

An obvious question is whether these results can be extrapolated to other settings and populations—the concept of external validity. Do the value–landscape relationships found in this study only reflect the particular setting of southern New Zealand and residents of the region? The orthodox response must be in the negative, that study replication is needed in other settings with other populations to confirm the results. A more nuanced response would argue that residents of southern New Zealand are not exceptional on most social variables of importance and that the New Zealand regional landscape provides a good study area with sufficient variability and contrast to identify meaningful differences in value–landscape relations. From a science perspective, there is merit in replicating the methodology in a variety of geographic settings.

We urge caution in using interpolated models of landscape values for important land use decisions. The variability of relationships within specific landscape components and classes can mask important conclusions about the effects on landscape values resulting from change in specific locations. Decisions that would result in significant changes to landscapes from anthropogenic activities warrant a place-specific, empirical measurement of landscape values without resort to interpolation. The cost of developing and implementing a sub-regional PPGIS system appears small relative to the social cost of underestimating changes in landscape values.

The concept of landscape character is widely viewed as subjective and by implication, beyond the reach of collective judgement regarding the value of landscapes. Our results suggest otherwise. Patterns of association between physical landscape qualities and specific landscape values were evident in our findings. With sufficient sampling of a regional population using PPGIS, significant relationships between landscape values and physical landscape features emerge despite individual variability in mapping responses. Replication of this research in other regions will show the validity of the landscape value–physical landscape associations we have described and provide additional insights.

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