How Do Aucklanders Value Their Parks?

A hedonic analysis of the impact of proximity to open space on residential property values

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Approved for Auckland Council publication by:

Name: Dr Lucy Baragwanath

Position: Manager, Research and Evaluation Unit (RIMU)

Name: Eva McLaren

Position: Manager, Economic and Social Research and Evaluation (RIMU)

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How Do Aucklanders Value Their Parks?
A hedonic analysis of the impact of proximity to open space on residential property values

Peter Nunns
Research and Evaluation Unit, Auckland Council / MRCagney

Jesse Allpress
Kyle Balderston
Research and Evaluation Unit, Auckland Council

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Executive summary

This research examines how much Aucklanders value their parks, by investigating whether home-buyers are willing to pay more to live close to them. This study has important implications for understanding both the amenity value of existing parks, as well as planning for the integration of parks in Auckland's future growth areas.

Housing markets are complex. The prices that people pay for dwellings are influenced by a wide range of supply- and demand-side factors, from planning regulations that enable housing development in some areas and discourage it in others, to migration and bank lending policies.

One important consideration when analysing housing markets is that housing (and land for housing) is not homogenous. It differs on a wide range of attributes, such as:

- Location – e.g. proximity to the city centre, other major employment centres, and regional amenities such as coastlines
- Neighbourhood characteristics – e.g. the presence of parks, historic buildings, or popular schools
- Dwelling characteristics – e.g. building typology, size, views, and condition.

These attributes in turn influence the prices that people are willing to pay for housing. In order to better understand *how*, this report undertakes a hedonic analysis of recent Auckland residential property sales, focusing on the impact of a variety of amenities and disamenities – most notably the role of parks and open spaces.

Auckland’s urban form is, in many respects, defined by its open spaces – from regional parks like the Waitakere Ranges to small suburban parks. Aucklanders are highly aware of the city’s open spaces. To understand how this awareness translates into the price people are willing to pay for housing, we ask three key research questions:

1. Does proximity to parks have a positive effect on sale prices for residential properties?
2. Does the impact of proximity to parks vary by park size or park type – e.g. is there evidence that regional parks have different effects than smaller local parks?[1]
3. Does the impact of proximity to parks vary between different types of dwellings – e.g. are apartment prices more affected than standalone house prices?

We also investigate the impact of a variety of other dwelling and neighbourhood characteristics that may be relevant to land use policy in Auckland, such as proximity of houses to industrial zones, which is expected to have a negative impact on property values.

Here, we summarise some key findings from the analysis, leaving a detailed discussion of methodology for the body of the report.

[1] We define these categories of parks using Auckland Council’s (2012) *Draft Open Space Level of Provision: Categorisation guidelines*.

Park proximity has a positive effect on apartment prices, but not on prices for houses or flats

We find evidence that proximity to parks and public open spaces has a positive impact on apartment prices.[2] That is, if we compare two apartments that were equivalent in all respects except distance to the nearest park, we would expect the apartment that was closer to the park to command a higher price. Higher prices in turn reflect the higher level of amenity that apartment owners (or occupants) receive from proximity to a park. Proximity to both regional parks and to local / neighbourhood parks has a positive impact, which suggests that parks of varying significance and size are valued by apartment-buyers.

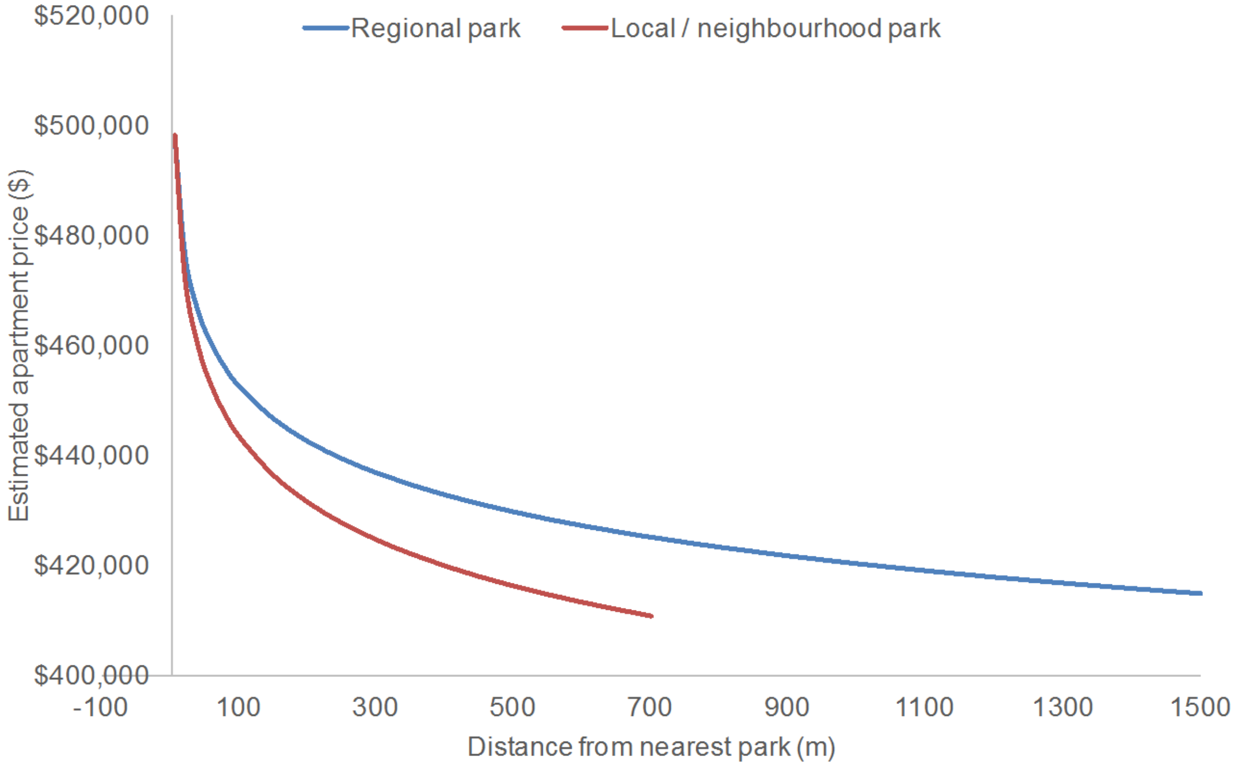
Based on coefficients from our preferred hedonic model, the following diagram shows how prices for an average apartment would vary with increasing distance to the nearest regional or local / neighbourhood park if we held all other attributes constant. An average apartment immediately adjacent to the nearest regional or local / neighbourhood is expected to sell for roughly $500,000. By contrast, an average apartment 500 metres away from the nearest regional park is expected to be 13.7 per cent less valuable, while an average apartment 500 metres away from the nearest local / neighbourhood park is expected to be 16.4 per cent less valuable.

These results are intuitively sensible. Apartments tend to have less private open space, in the form of yards or large balconies, and as a result their occupants may place greater value on the availability of public open space.[3] This may help to explain development outcomes around inner-city parks such as the Domain and Basque Park.

[2] Apartments are defined as units in multi-storey buildings on strata title. Most apartments are located in or around the Auckland city centre.

[3] Apartment prices are more responsive to the size of living areas and presence of a deck or balcony than either house or flat prices – suggesting that private living space is more important for apartments.

Figure 1: Estimated apartment sale prices as a function of distance from the nearest regional or local / neighbourhood park



However, proximity to parks appears to have a different effect on other dwelling types. There is no statistically significant relationship between distance to the nearest park and sale prices for standalone houses and flats.[4] In other words, if we compare two houses (or flats) that were equivalent in all respects except distance to the nearest park, we would expect them to sell for the same price.

Our findings about the impact of proximity to parks on property sale prices control for the influence of factors such as crime rates or other amenities such as proximity to the coast. To the extent possible with the available data, we have also controlled for differences in the significance of parks, by distinguishing between regionally significant parks and parks with local / neighbourhood significance. However, it has not been possible to control for all characteristics of parks, such as age and level of development.

Optimal park provision for a growing city

Hedonic analysis has been used to estimate and compare the value of competing goods, such as the availability of urban parks versus the availability of land for housing, in Reading, UK (Cheshire and Sheppard, 2002) and three Dutch cities (Rouwendal and van der Straaten, 2008). In some cases, these results have been interpreted as implying that

[4] Standalone houses are defined as fully detached or semi-detached houses on their own plot of land. Residential flats are low-rise units that do not have the appearance of houses, predominantly on cross-leased sites.

specific cities are over-supplied with parks relative to land for housing. But in our view, there are several other interpretations of the data that must be considered.

First, our analysis suggests that almost all residential property sales in Auckland are close to parks. Over 95 per cent of property sales are within 500 metres of at least one local or neighbourhood park, and there are only 306 property sales that were further than one kilometre from the nearest park. Similarly, approximately 75 per cent of properties were within one kilometre of the nearest regional park. This reflects the widespread availability of parks throughout the urbanised area.

Consequently, our results for houses and flats may simply reflect the relative equality of proximity to parks throughout Auckland. Compared to other cities, Auckland may have few places that aren't close to parks. In this context, we may be unable to observe enough variation in access to parks to obtain meaningful estimates of the degree to which park proximity affects property values. This does not necessarily mean that parks are not valued in Auckland, but that their value accrues broadly to most Auckland houses and flats, regardless of whether they are immediately next to a park.

Second, our findings have implications for future urban growth and change. Because proximity to parks has a more positive impact on apartment prices than it does on prices for either standalone houses or flats, the social value of the city's parks will tend to rise if apartments are developed near them. Consequently, Auckland has an opportunity to gain additional value from its public open spaces as it continues to develop and change. Thus, we may think of Auckland's network of open spaces as a case of successful "future proofing" for the needs of a growing city. Even if parks are oversupplied relative to the needs of a city where most people live in standalone houses and hence have access to abundant private open spaces (i.e. backyards), the value of parks is likely to rise as apartments make up an increasing share of new development.

Industrial areas are a disamenity

On the other hand, proximity to industrial zoned land appears to have a negative impact on residential property values. This may reflect localised nuisances associated with industrial activities, such as noise, emissions, heavy vehicle movements, or poor urban environments.[5]

Even though the nature of Auckland's industrial economy has changed significantly in recent decades, with warehousing, distribution, and light manufacturing replacing polluting "smokestack" industries, these results suggest there may be an ongoing rationale to use zoning to separate out industrial and residential activities and to provide buffer zones between activities. This can provide benefits both to residents – who are less exposed to

[5] We controlled for local air quality through the inclusion of modelled estimates of PM_{10} concentrations at a suburb level from the HAPINZ model. This suggests that factors other than air quality are driving this result.

nuisances – and to industrial activities that may otherwise experience “reverse sensitivities”, or complaints about their operations from nearby sensitive residential uses.

Some future avenues for research

There are several areas for further empirical research into the determinants of property values in New Zealand. One implication of this study is that results from studies in other cities – such as a positive relationship between park proximity and house prices – may not necessarily occur in the New Zealand context, possibly due to differences in urban form or other social and economic factors. Consequently, there is a case to exercise caution when attempting to apply results from overseas studies for policy analysis in New Zealand, and potentially to conduct primary research to understand the relationships that apply locally.

Areas for future investigation may include analysing the impact of other urban amenities and disamenities, including public facilities, jobs and retail. De Groot et al (2015) undertake an especially comprehensive analysis that also addresses accessibility to employment, retail, and cultural facilities and events, as well as exploring the role of transport networks in shaping accessibility. Their analysis and methods present opportunities for further work in the New Zealand context.

A second area for further research is in the application of stated preference techniques, such as contingent valuation or choice experiments, conducted using data from surveys or focus groups, to further explore nuances in Aucklanders’ perceptions of the value of proximity to parks. For example:

- How do people account for proximity to parks when choosing where to live? Do they consider distance to the nearest park, the simple availability of a park in the neighbourhood, the density of open spaces in the area, or some other metric?
- How do people value individual parks (e.g. the Domain or Cornwall Park)? How do they value particular characteristics of parks?
- How do people view the trade-off between private open spaces (e.g. backyards and balconies) and public open spaces? Are parks substitutes for private open space, as implied by our results showing that park proximity had a positive impact on apartment sale prices but not on sale prices for standalone houses and flats?
- Do different groups of Aucklanders respond differently to proximity to parks?
- Is Auckland perceived as having abundant parks relative to other cities? If so, does this translate into a higher city-wide level of amenity for residents?

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1.0 Introduction

Housing markets are complex. The prices that people pay for dwellings are influenced by a wide range of supply- and demand-side factors, from planning regulations that enable housing development in some areas and discourage it in others to migration and bank lending policies. One important consideration when analysing housing markets is that housing (and land for housing) is not homogenous. That is, dwellings differ on a wide range of attributes, such as:

- Location – e.g. their proximity to the city centre, other major employment centres, and regional amenities such as coastlines
- Neighbourhood characteristics – e.g. the presence of parks, historic buildings, or popular schools
- Dwelling characteristics – e.g. building typology, size, views, and condition.

The prices that people pay for housing reflect the value that they place on these attributes. However, estimating the separate values for these attributes is challenging as attributes are bundled together into one single commodity, i.e. the dwelling.

Hedonic analysis is an approach to measure the utility that people derive from the physical and tangible characteristics of a house, including environmental amenities or proximity to parks. Hedonic analysis may be implemented through econometric techniques such as ordinary least squares (OLS) regression or spatial regression, which model dwelling sale prices as a function of the measurable attributes of the dwelling and location.

The purpose of this report is to apply hedonic analysis to understand the impact of proximity to parks and open spaces on residential property prices in Auckland. Auckland's urban form is defined by its open spaces – from regional parks like the Waitakere Ranges to small suburban parks – and Aucklanders are highly aware of the city's open spaces (Auckland Council, 2014). We therefore ask three research questions:

1. Does proximity to parks have a positive effect on sale prices for residential properties?
2. Does the impact of proximity to parks vary by park size or park type – e.g. is there evidence that regional parks have different effects than smaller local parks?
3. Does the impact of proximity to parks vary between different types of dwellings – e.g. are apartment prices more affected than standalone house prices?

We also investigate the impact of a variety of control variables related to dwelling and neighbourhood characteristics, such as proximity of houses to industrial zones, which is expected to have a negative impact on property values, and variables for dwelling characteristics such as decks and garages, which may have different effects on the value of different types of dwellings.

This report builds upon a recent hedonic analysis of Auckland property sales (Nunns, Hitchins, and Balderston, 2015) that was more narrowly focused on the impact of proximity to pre-1940 ("heritage") buildings on prices for standalone houses. It also draws upon previous survey-based research on Aucklanders' awareness of parks and open spaces and relevant studies of the impact of proximity to parks on residential property values in other cities. A more complete review of the literature on the impact of public facilities and localised amenities / disamenities on property values is presented in Appendix B.

1.1 Aucklanders' awareness of parks

Recent survey-based research suggests that Aucklanders are highly aware of parks and open spaces, and consider them when making choices about where to live. In July-August 2014, the Auckland People's Panel conducted an online survey of 2835 Aucklanders on the subject of "protecting and improving Auckland's natural environment" (Auckland Council, 2014). The survey asked participants the following question:

> *When you think of the Auckland environment, what are the areas of aspects of the environment that come to mind?*

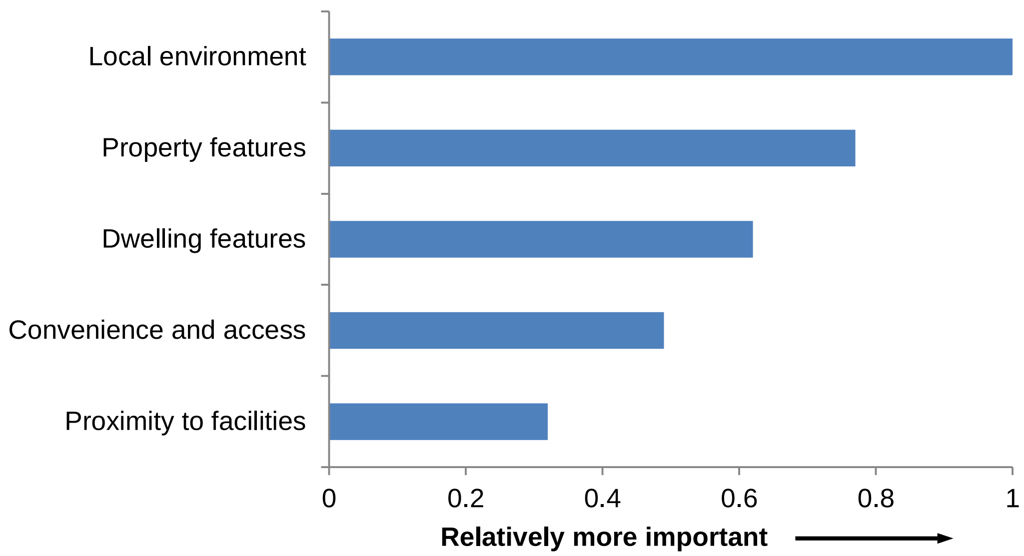
Overall, 91 per cent of participants mentioned aspects of the natural environment, while 62 per cent mentioned man-made or urban features. Green spaces, including parks and playgrounds, were the second most-mentioned aspect of Auckland's environment, after coastal areas – potentially reflecting the perceived abundance of these features in Auckland (see Table 1). Furthermore, 92 per cent of survey respondents answered that they had visited a beach in the last 12 months, 89 per cent said that they had visited their local park or a reserve, and 80 per cent said that they had visited a regional park. The People's Panel also conducted a survey on parks, open spaces, sports and recreation in June 2013. This survey found that a plurality of respondents (44%) visited local/neighbourhood parks once a week or more (Auckland Council, 2013c).

Table 1: Areas / aspects of Auckland's natural environment that were mentioned by survey participants (Source: Auckland Council, 2014)

Area / aspect	% of responses
Coastal – beach, coast, marine, harbour	73%
Greenspace – open space, gardens, botanic gardens, sportsgrounds, playgrounds, parks	60%
Urban – suburban, cityscape, streets, commercial/industrial, waterfront, urban living – cafes, restaurants, theatres, etc	30%
Native bush – trees, forests, flora, DOC land, natural environment	25%
Waterways – rivers, estuaries, lakes, wetlands, mangroves	22%
Regional Parks – Ambury, Waitakere, Hunua	19%
Volcanoes / hills	19%
Air – fresh air, air quality, blue sky	18%
Water / water quality	13%

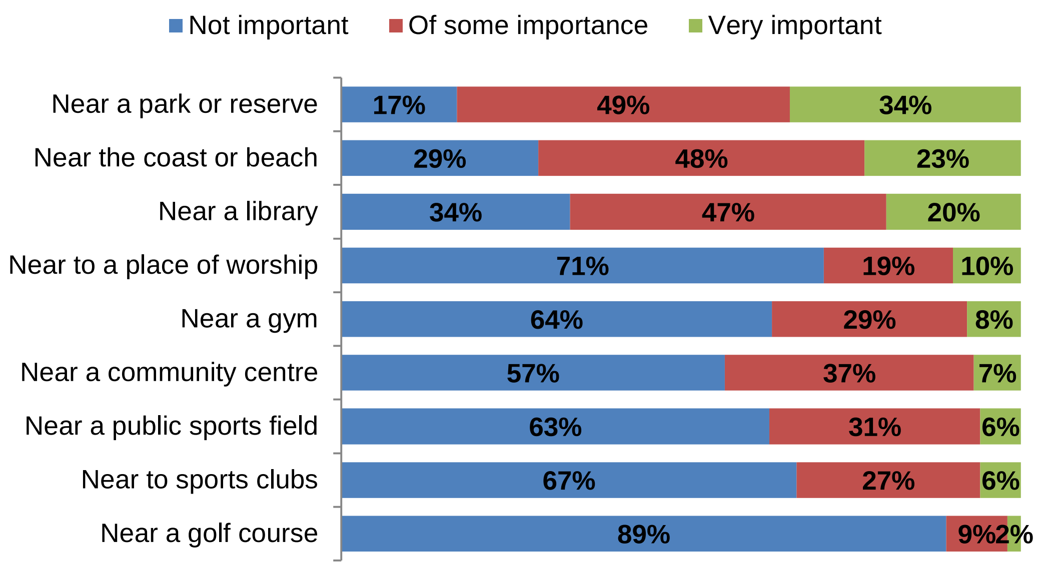
In October-December 2014, the *Housing We'd Choose* study commissioned by Auckland Council and conducted by Market Economics and Research First surveyed 1497 Aucklanders on their housing preferences and trade-offs (Yeoman and Akehurst, 2015). The aim of the survey was to understand which aspects of dwellings and neighbourhoods are most important to Aucklanders. One finding from the first stage of the study was that proximity to facilities, including parks, was generally less important than other characteristics of dwellings and neighbourhoods. This is illustrated in Figure 2, which shows the weighted importance of five categories of dwelling and neighbourhood attributes.

Figure 2: Overall importance of different types of features of dwellings and neighbourhoods (Source: Yeoman and Akehurst, 2015)



However, within the category on proximity to facilities, proximity to parks and reserves was the most important feature for survey respondents, followed by proximity to coasts and beaches, and to libraries (Figure 3). Being close to a park or reserve was "very important" to 34 per cent of respondents and "of some importance" to 49 per cent of respondents, while proximity to the coast or beach was "very important" to 23 per cent of respondents and "of some importance" to 48 percent.

Figure 3: Rating of proximity to different types of facilities (Source: Yeoman and Akehurst, 2015)



These results suggest that many Aucklanders care about proximity to parks and reserves to some degree. However, a comparison across other categories suggests that these features are not as important to as many Aucklanders as other features such as a safe neighbourhood (very important to 87 per cent of respondents), living in an unpolluted area (69%), owning a freehold title (63%), access to natural light (77%), ease in heating (73%), or easy access to shops (41%) and place of work (40%).

1.2 Hedonic analysis of property values

Hedonic analysis is commonly used to measure peoples' willingness to pay for attributes of dwellings, neighbourhoods, and locations. It has been applied to study a number of issues in Auckland and overseas cities, showing that property values can be influenced by a broad range of public amenities and disamenities.

Nunns, Hitchins and Balderston (2015) reviewed the previous empirical literature on determinants of property values in Auckland. Key findings from this review include:

- Larger lots and larger buildings are associated with higher sale prices – i.e. home-buyers value having more space. Interestingly, prices seem to be more responsive to building size (floorspace) than they are to land area.

- Building quality features affect sale prices – including the age of buildings and features such as decks or garages.
- Proximity to the city centre is associated with higher sale prices, as is proximity to the coast and school zoning.
- Auckland's Metropolitan Urban Limit is associated with a boundary discontinuity in land values. This reflects three potential effects: (1) the effect of limiting land supply, which pushes up prices inside the boundary; (2) the effect of regulatory restrictions on density, which push up demand for fringe land; and (3) the positive effect from preserving local amenities at the city fringe – i.e. access to open space.
- Neighbourhood-level amenities, such as landscaping on adjacent properties and views of water, affect property values.

More recently, in a study of the impact of various dwelling and neighbourhood characteristics on reported residential satisfaction in the New Zealand General Social Survey, Torshizian (2016) finds that after controlling for other variables, proximity to parks (access to green spaces and the state of green spaces) does not significantly affect residential satisfaction, although better access to schools, shops, libraries, and medical services is associated with higher residential satisfaction.

While there has been no New Zealand-specific hedonic analysis of the impact of parks and open spaces on property values, there is a sizable international literature on this topic, which is partially summarised in Table 14 in Appendix B. Previous hedonic analyses in this area have employed several alternative measures of proximity to parks, as follows:

- Straight-line distance from the dwelling to the nearest park (e.g. Jim and Chen, 2007; Nicholls and Crompton, 2005)
- Straight-line distance from the dwelling to the nearest park, and size of the nearest park (e.g. Cho, Bowker and Park, 2006; Morancho, 2003)
- Density of parks within a set radius around each dwelling (e.g. Geoghegan, 2002; Rouwendal and van der Straaten, 2008).

Some studies also considered the "interaction" between proximity to parks and other variables, such as distance to the city centre or local crime rates (e.g. Anderson and West, 2006; Troy and Grove, 2008). One insight from these studies is that the value of proximity to parks may depend upon other location or neighbourhood attributes – e.g. proximity to parks may have a positive value in low-crime areas but a negative value in high-crime areas, e.g. in inner-city Baltimore, as they are perceived as being unsafe.

The studies summarised in Table 14 find that proximity to parks has a positive impact on residential property values. Crompton (2001) reviewed 30 studies and found that all but five reported positive impacts on property values – albeit with impacts that varied considerably depending upon park attributes. In a similar vein, Brander and Koetse (2011) undertook a meta-analysis of contingent valuation and hedonic analysis of the value of urban open space.[6] Based on an analysis of 12 studies that reported estimates of the effect of proximity to parks, they conclude that proximity to parks is associated with higher property values. Moreover, their meta-analysis suggests that proximity to parks is more highly valued in densely populated areas – a finding reinforced by Anderson and West's (2006) findings on variations in the value of proximity to parks between neighbourhoods of different density in Minneapolis.

1.3 How to read this report

The rest of this report is organised as follows:

- Section 2.0 outlines our methodology for hedonic analysis and describes the data we have used to estimate our model. This section is intended primarily for technical readers with greater familiarity with econometric methods; however, our discussion of park proximity measures in Section 2.2.3 may provide useful context for all readers.
- Section 3.0 describes our findings, including descriptive statistics on the dataset and the results of hedonic analysis of the impact of proximity to parks on property values in Auckland. This section is intended to provide a non-technical overview of the data and the key findings.
- Section 4.0 discusses the findings, including potential implications for policy and avenues for further research.

In addition, there are two Appendices that provide additional information for interested readers:

- Appendix A presents full model outputs for hedonic analysis.
- Appendix B presents a broader review of the literature, including hedonic studies of the impact of public facilities, land uses such as parks and industrial zones, and various localised amenities and disamenities on property values. This Appendix situates this research paper in the broader empirical literature.

[6] Contingent valuation methods involve surveying people about how they think they would behave in hypothetical situations – in this case, their willingness to pay to maintain open spaces, or, conversely, their willingness to accept payments in exchange for reduced open space. This is also described as a stated preference survey, as it asks people to state the value that they place on amenities. It is typically contrasted with revealed preference methodologies such as hedonic analysis.

2.0 Methodology

In this section we describe our approach to analysis, including our hedonic regression model and the data we used to estimate it. We began by testing ordinary least squares (OLS) models, finding a preferred model that optimised the trade-off between goodness of fit and degrees of freedom as measured by Akaike's Information Criterion (AIC). The preferred model includes interaction terms between an indicator of dwelling type and a variety of control variables and variables of interest. We then tested for spatial dependence (i.e. correlations between model residuals for nearby properties) using Moran's I.

We then tested four alternative spatial regression models to control for spatial dependence in model residuals. This included both spatial error and spatial lag models that employed two alternative definitions of neighbouring properties. Once again, we employed AIC to identify a preferred spatial regression model. As spatial regression models proved to be too computationally intensive to run on the full dataset, we estimated them on a randomly selected subset of 10,000 property sales. All analysis was conducted in R, an open source statistical analysis package, using the car, lmtest, sp and spdep packages; code is available upon request.

2.1 Econometric models

We began by testing OLS models that took on the following form and which employed alternative measurements of proximity to parks (see Section 2.2.3 below).

Equation 1: OLS regression model

$$\log(Price_i) = \alpha + \beta D_i + \delta N_i + \gamma P_i + \theta T_i + \varepsilon_i$$

The dependent variable is the natural logarithm of sale price, excluding the value of chattels, D_i is a vector of characteristics of the dwelling that influence the sales price, e.g. lot size, living area; N_i is a vector of environmental and neighbourhood variables, e.g. crime, meshblock population density; P_i is a vector of proximity variables to parks, industrial zones, coastlines, and the city centre; T_i is a vector of time dummies that control for price trends in the Auckland housing market; and, ε_i is a residual term with mean zero, constant variance and no correlation in time and space. The parameters α, β, δ, γ, and θ are coefficients to be estimated in the model.

All variables were interacted with dummy variables for dwelling type (standalone house, residential flat, or apartment).[7] This allowed us to test whether proximity to parks (and

[7] In econometric parlance, a dummy variable is created to represent the presence or absence of a particular attribute. A value of 1 indicates that the attribute is present – in this case, that the sale was recorded with zero land – and a value of 0 indicates that it is absent. It is also commonly referred to as an indicator variable, categorical variable, or binary variable.

other dwelling and neighbourhood characteristics) has a different impact on sale prices for different types of dwellings.

After selecting a preferred OLS model on the basis of the trade-off between goodness of fit and model complexity (measured by AIC score), we tested for spatial dependence using Moran's I. We then applied spatial regression techniques to address spatial dependence in model residuals. There are two main approaches to spatial regression that treat the spatial processes underlying the data in slightly different ways:

- Some types of models treat spatial processes as a nuisance to be eliminated or controlled. This is the approach underpinning a spatial error model.
- Other types of models treat spatial processes as a substantive effect of interest. They build spatial relationships into the model as parameters to be estimated. This approach underpins a spatial lag model (as well as other types of models such as geographically weighted regressions).

A spatial error model examines spatial dependence between the residuals of neighbouring data points. Residual ε_i of Equation 1 is decomposed into two parts: a spatially autocorrelated component and a remaining uncorrelated component:

Equation 2: Decomposition of error term in spatial error model

$$\varepsilon_i = \lambda W_{ij}\varepsilon_j + \xi_i$$

where ε_j is a vector of error terms for $j \neq i$, weighted using spatial weights matrix W_{ij} (based on a selected definition of neighbouring properties – see Section 2.1.1 below), λ is the spatial error coefficient, ξ_i is a vector of uncorrelated error terms, and $j=1,2,\ldots,n,\ j\neq i$ are index values for property sales records.

By contrast, a spatial lag model treats spatial dependence in terms of the characteristics of neighbouring data points, that is, the spatial dependence manifests on the dependent variable and not the residuals. For example, a spatial lag model would explore whether the sale price of an individual dwelling is correlated with the sale price of neighbouring dwellings. Spatial lag models incorporate a spatially lagged variable on the right hand side of the regression equation, as follows:

Equation 3: Spatial lag model

$$\log(Price_i) = \alpha + \beta D_i + \delta N_i + \gamma P_i + \theta T_i + \rho W_{ij}\log\left(Price_j\right) + \varepsilon_i$$

where $\log(Price_j)$ is the natural logarithm of the sale price for dwelling j, where $j \neq i$ weighted using spatial weights matrix W_{ij}, ρ is the spatial coefficient, and ε_i is an error term with no spatial correlation.

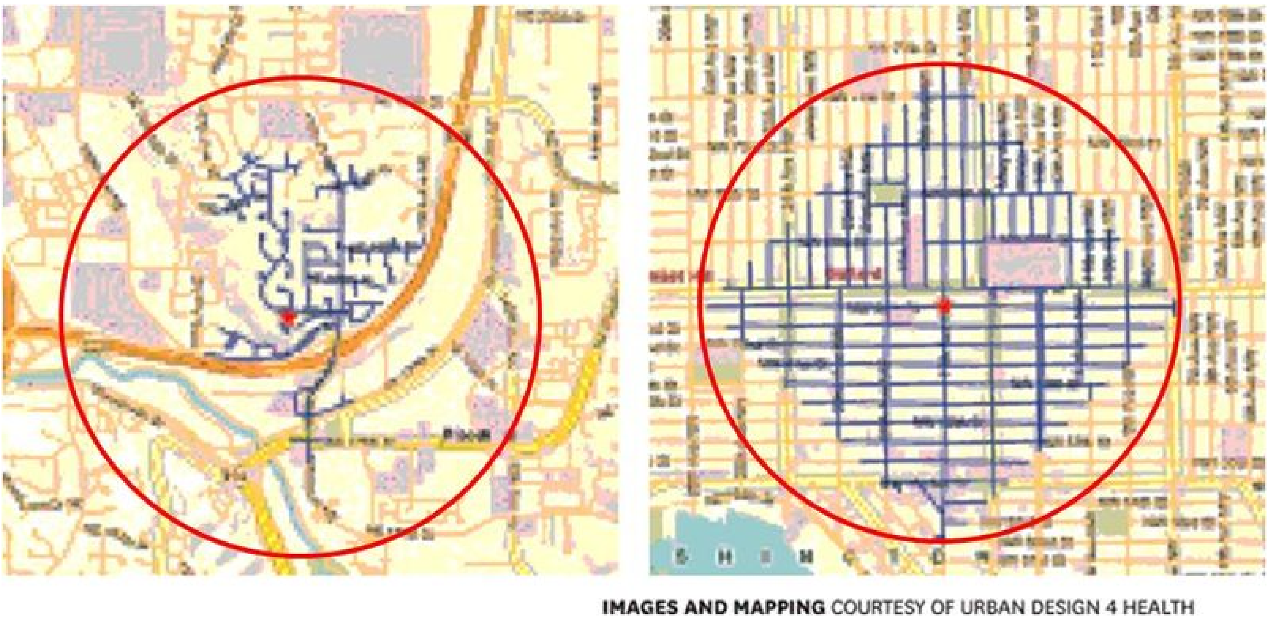
2.1.1 Defining neighbourhoods for spatial regression models

There are multiple ways to define neighbourhoods around properties for purposes of spatial analysis (Harris, 2013). In this paper, we consider two definitions of a property's neighbourhoods for purposes of analysis following earlier work by Torshizian (2016):

- Sale records located within a one kilometre radius (K1KM)
- Sale records located within the same meshblock (KMB).

Torshizian recommends a "dynamic" definition of a neighbourhood that uses road network analysis to identify properties located within a 15-minute walking distance. We follow Nunns, Hitchins and Balderson (2015) in using a one kilometre radius around to approximate 15-minute walking distance from residential properties. We have assumed that people walk, on average, one kilometre every twelve minutes, and that the structure of street networks (illustrated in) will tend to mean that people cannot simply walk in a straight line. However, this approach may overestimate walking catchments in some areas and underestimate them in others.

Figure 4: Walking catchments vary depending upon street networks and natural barriers (Source: Wieckowski, 2010)



We used spatial analysis tools in R to identify neighbouring properties using each of these definitions. We then created two spatial weights matrices with row-standardised weights for each row.[8]

[8] We identified neighbours within a 1km radius using the "dnearneigh" function in the spdep package. It was necessary to write a simple function to identify neighbours within meshblocks – code available on request. Spatial weights matrices were created using the "nb2listw" function in the spdep package. Row-standardisation means that if a data point has *n* neighbours, each will be assigned a weight of *1/n* for analysis. Therefore, a point with five neighbours would have weights of 0.2, while a point with two neighbours would have weights of 0.5. Points with no neighbours were dropped from the analysis.

2.1.2 Using Akaike's Information Criterion to identify a preferred model

We used Akaike's Information Criterion in order to identify a preferred model that optimised the trade-off between goodness of fit and degrees of freedom in the model. This statistic identifies the degree to which a model explains variation in the dependent variable without introducing excessive complexity from a large number of independent variables. Formally, it is calculated as:

Equation 4: Akaike's Information Criterion

$$AIC = 2k - 2\ln(L)$$

where k is the number of independent variables and L is the maximum value for the likelihood function of the model (a measure of goodness of fit).

Lower AIC scores (including negative values) indicate a greater level of explanation of the dependent variable within a parsimonious model. Consequently, we use it as a means of choosing between alternative model specifications that include different combinations of explanatory variables and explain a different share of variation in the dependent variable. This method of model selection can be applied to both OLS and spatial regression models – e.g. to choose between different types of spatial regression models.

2.2 Dataset preparation

In order to estimate our hedonic model, we employed Auckland Council's property sales audit file, which includes information on all property transactions in Auckland. We used GIS analysis to create additional variables, including measures of properties' location and proximity to various amenities and other spatial data published by Statistics New Zealand and other organisations.

Here, we briefly describe the property sales data, additional variables that we joined to property sales records, and our approach to cleaning and filtering the data to obtain a final datasets for analysis covering sales of standalone houses, residential flats, and apartments in Auckland between 2011 and 2015 (inclusive).

2.2.1 Overview of sales audit file

We used the property sales audit file maintained by Auckland Council as the basis for hedonic analysis of recent property sales. This file, which is compiled to assist in rating valuations, contains data on every property transaction in Auckland. Coverage is more limited prior to the amalgamation of Auckland Council in 2011, as some predecessor councils outsourced the collection of this data.

Land Information New Zealand (2010) defines the data and metadata that must be recorded when properties are bought or sold. This includes, but is not limited to:

- The location of the property – defined by both the corresponding Auckland Council rates valuation reference and the property's street address
- The date when the property was sold
- The gross sale price including chattels (e.g. furniture and appliances) and the net sale price
- Information on the property title and type of sale, such as whether the sale is of a single rating unit, part of a rating unit, or multiple units and whether the property is sold freehold or leasehold
- Land use data, including zoning, property type (e.g. type of residential or commercial property), and number of rateable units (e.g. flats in a multi-unit building)
- Data on the estimated decade of construction (used to identify pre-1940 status[9]) and condition of the primary buildings on the property (which we split out into two separate measure of the condition of walls and roof)
- Land area (in hectares), building size (gross floor area) and site coverage
- Mass appraisal data, including the total living area (our preferred measure of dwelling size), presence of decks, workshops, garages under the main roof or freestanding garages, and the assumed view from the building.

2.2.2 Additional variables created for use in analysis

In order to enable spatial analysis of this dataset, we associated each sales record with the longitude and latitude coordinates of the relevant rating unit from Auckland Council's rating valuation roll (as of January 2015).[10] Because data on rating units is continuously updated, with titles regularly being created and destroyed, it was not possible to match a small number of sales. After geocoding the sales data, we used GIS analysis to calculate distance to various amenities and disamenities and to identify other characteristics of the property's location:

- Straight-line distance from the property parcel centroid to the city centre and nearest coastline

[9] 1940 was used as the cutoff for heritage status for two reasons. First, it aligns with Auckland Council's built heritage policies, which aim to control the demolition of pre-1944 buildings. Second, previous research into the influence of vintage on Auckland property values has found evidence of a price premium for buildings constructed prior to the 1940s, but not after (Rehm, Filippova and Stone, 2006).

[10] The coordinate reference system for these points is the New Zealand Transverse Mercator 2000 projection (EPSG:2193). This is standard practice for the majority of data published by New Zealand governments or about New Zealand.

- Straight-line distance from the property parcel centroid to the edge of the nearest park or open space and the size of that park. We measured proximity to three types of open spaces:
    - Parks or open spaces that were either regionally significant or significant across multiple local boards. We defined regional parks as parks with a significance score of four or five on at least one open space measure (see below for further detail on these measures).
    - Parks or open spaces that were less significant – e.g. local and neighbourhood parks. We defined local / neighbourhood parks as parks with a significance score of three or less on all open space measures.
    - Golf courses, both publicly owned and privately owned.
- The total area, in hectares, of parks or open spaces within a 500 metre radius of the property parcel centroid. This is a measure of the density of parks in the immediate vicinity of property sales. As above, we measured proximity to three types of open space:
    - Regional parks within a 500m radius
    - Local / neighbourhood parks within a 500m radius
    - Golf courses within a 500m radius
- Similar measures of proximity to industrial zoned land identified based on the location of the Light Industry and Heavy Industry zones in the notified version of the Auckland Unitary Plan (Auckland Council, 2013a):
    - Straight line distance to the nearest contiguous industrial area and size of that industrial area
    - Total area, in hectares, of industrial land within a 500 metre radius of the property parcel centroid
- Census data on meshblock-level demographic characteristics – population density and median household income from the 2013 Census[11]
- Number of pre-1940 (heritage) properties within the meshblock, based on an Auckland Council dataset

[11] Meshblocks provide a reasonable representation of the neighbourhood around each property as they generally include around 20-80 residences that are bounded by roads, parks, or natural barriers (Torshizian, 2016).

- Number of burglaries within the meshblock over the period July 2014 to December 2015, based on NZ Police data obtained and published by the New Zealand Herald[12]
- Estimated local air quality within (2006) Census area units, measured in terms of annual average concentrations of fine particulates and sourced from the Health and Air Pollution in New Zealand model (Kuschel et al, 2012).

In addition, during data cleaning (see Section 2.2.4 below) we found that a significant number of properties were recorded as being sold with no land. Following Gaudry and Quinet's (2009) recommendations about methods to address such cases, we created two additional variables to allow us to include these sales in our analysis:

- An edited measure of land area, which is equal to land area in square metres, plus one square metre. This enabled us to apply a logarithmic transformation to normalise this variable.[13]
- A dummy variable that is equal to 1 if a property sale had zero recorded land area, and 0 otherwise. This enabled us to identify the impact of properties sold with zero recorded land area (e.g. cross-leased properties).

2.2.3 Measuring park significance and park proximity

There are several challenges to estimating the value of proximity to parks (or other land uses). The first is that the quality of parks may be extremely heterogeneous, that is, some parks are more attractive than others. The second is that, as discussed in the literature review, there are several ways to measure proximity to parks.

In order to address these issues, we employed the region wide open space dataset maintained by Council to identify the location, size, and significance of parks. This dataset includes a total of 5,226 individual parks (or distinct areas of parks) with a total area of 93,900 hectares. The median park is 0.6 hectares, while the mean park area is 18 hectares – the latter figure reflecting the presence of some large regional parks and offshore islands.

We supplemented the regional open space dataset with further information on public and private golf courses, which are private open spaces accessible to members or paying users. We identified 41 golf courses with a total area of 1650 hectares (median 41 ha; mean 40 ha). As of December 2015, one of these courses had been closed for commercial development, while an additional three had announced development intentions.

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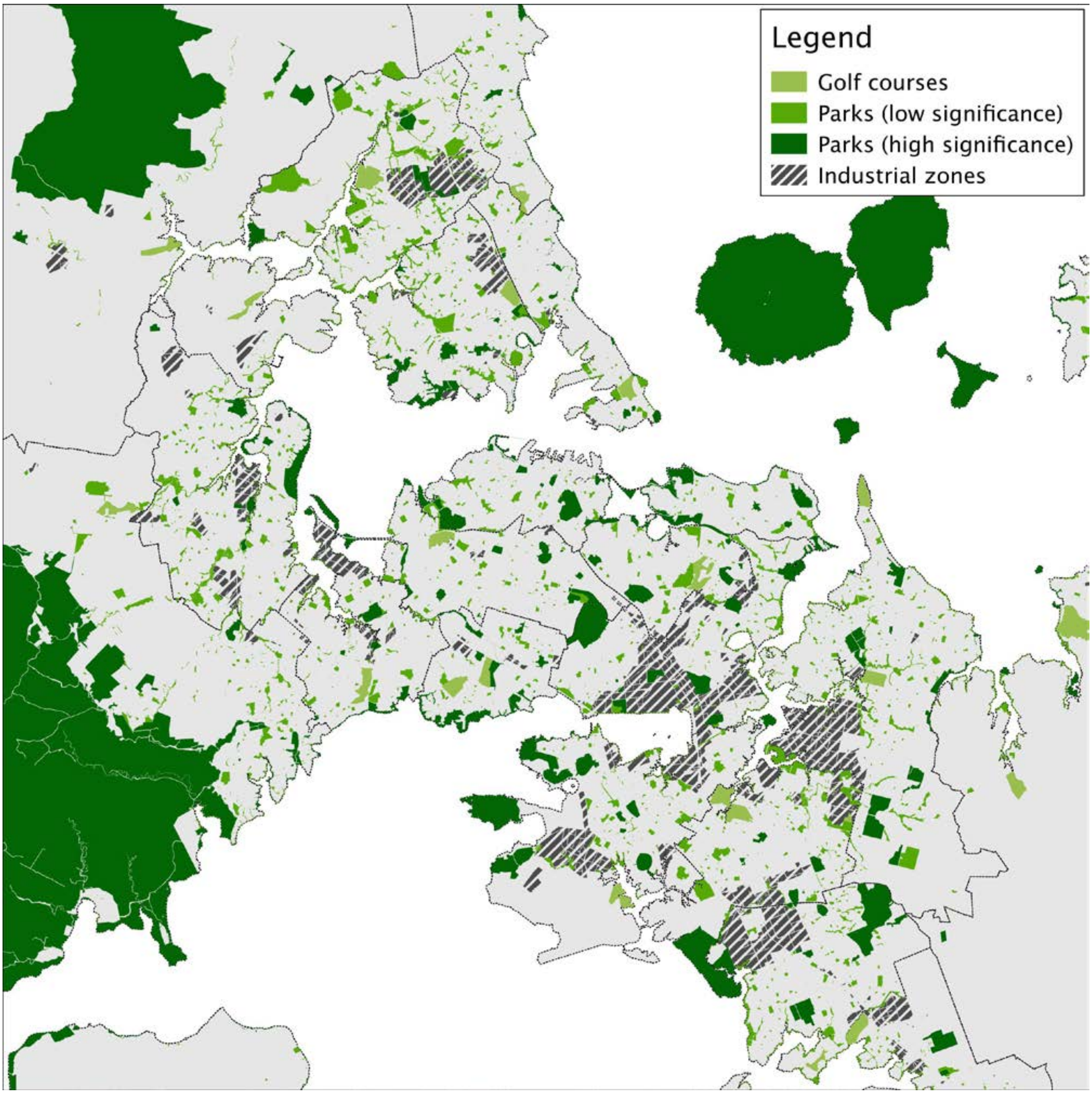
[12] We thank New Zealand Herald data editor Harkanwal Singh for providing this data, which can be viewed at http://insights.nzherald.co.nz/article/new-zealand-burglary-map.

[13] The logarithm of zero is undefined.

We also measured the location and size of industrial zones using the zoning map from the proposed Auckland Unitary Plan (publicly notified on 30 September 2013). We grouped together the Light Industry and Heavy Industry zones, noting that the zones enable a different mix of activities and that Heavy Industry zones tend to be separated from residential areas, e.g. by a “buffer” Light Industry area.

Figure 5 summarises our land use dataset. It distinguishes between golf courses, parks with low significance scores (indicating local or neighbourhood parks), parks with high significance scores (indicating regional parks), and industrial zones.

Figure 5: Our land use dataset



We defined parks as having regional or local / neighbourhood significance based on draft guidelines for categorising the significance of parks for various functions and uses developed as an input into Auckland Council's (2013b) *Parks and Open Spaces Strategic Action Plan* (Auckland Council, 2012). The categorisation guidelines account for the fact that parks differ in significance – i.e. some parks are more regionally significant, while others serve a local or neighbourhood function – and also the fact that parks may have multiple functions or uses. Consequently, parks have been assigned significance scores on ten distinct function / use categories.

Within each function / use category, significance scores vary from 0 to 5, with higher numbers indicating more regionally significant parks (as shown in Table 2). Higher scores do not necessarily indicate higher quality parks, as it is possible to have a high-quality neighbourhood park that attracts visitors primarily from a local catchment. However, regionally significant parks tend to be larger, with unique or iconic characteristics, and cater for visitors from across Auckland.

Table 2: Significance scores for parks

Score	Meaning
5	Auckland-wide (regional) park
4	Park serving multiple local boards
3	Local park
2	Neighbourhood park
1	Serves function / use but is of low quality
0	Does not serve function / use

Parks were scored against ten function / use categories that reflect different aspects of parks and open spaces. These categories are summarised in Table 3, along with a measure of the number of parks that have a score of 2-5 on each measure (indicating that is serves the function / use to a decent standard).

Table 3: Function / use categories for parks

Function / use category	Purpose	Number of parks with score 2-5
Historic heritage	The protection and conservation of historic heritage values (e.g. in archaeological sites or heritage places)	N/A – many parks not scored
Ecological	The restoration, conservation and enhancement of ecological and biodiversity values (e.g. riparian margins, regenerating bush)	1,527
Landscape and amenity	The protection, enhancement and access to natural, amenity and physical landscape values (e.g. viewpoints, landscape features)	4,343
Informal recreation	Provides for informal leisure and social opportunities (e.g. playgrounds, picnic areas)	1,746
Sport and organised recreation	Provides for organised sporting and active recreational opportunities (e.g. sports fields, stadiums)	687
Outdoor adventure	Provides for recreational opportunities requiring a large scale non-urban setting (e.g. camp grounds, mountain biking)	518
Greenways	Provides for recreational, commuting, pedestrian and cycling opportunities (e.g. coastal walkways, cycleways)	113
Civic space	High quality urban public spaces suitable for a variety of community uses (e.g. public squares, shared spaces)	103
Community buildings[14]	Provides for community uses (e.g. libraries, community halls)	495
Utility[15]	Provides for infrastructure and service facilities (e.g. stormwater ponds, service areas)	496

Park significance measures are often correlated. For example, the Auckland Domain has an informal recreation score of five, reflecting its high value for a range of leisure activities. But it also has a landscape score of five and a sport and organised recreation score of four. Consequently, while the park significance measures provide a great deal of nuance about the function and use of parks, it is difficult to use them to differentiate between parks that were significant for different reasons. We therefore constructed a summary indicator of park significance, defining a park as regionally significant if it had a significance score of four or five in at least one category. Other parks (i.e. parks with significance of three or less on all categories) were defined as local / neighbourhood parks.

[14] This was constructed as a dummy variable with a value of 1 if the park has community buildings and 0 if not.

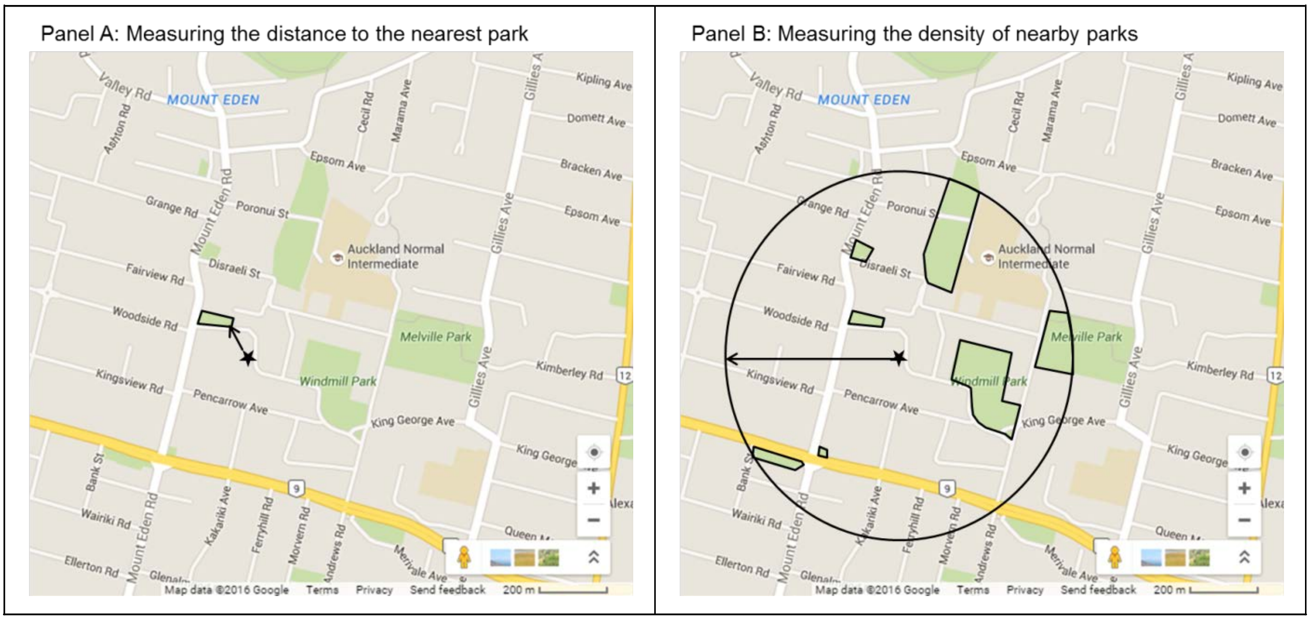
[15] This was constructed as a dummy variable with a value of 1 if the park has utility value and 0 if not.

This approach does not necessarily capture all of the nuances between different types of parks – e.g. between sports parks and ecological parks. This is acknowledged as a potential area for further research using more targeted methodologies.

We tested two approaches to measuring proximity to parks for use in hedonic analysis: straight-line distance from each dwelling to the nearest park, and the density of parks within a defined radius around each dwelling. This represents an extension to the previous literature, which has generally focused on a single measure rather than comparing multiple measures.

Figure 6 illustrates these measures. Panel A shows a measurement of the distance from an individual house to the nearest park. Note that this measure only considers the closest park and may not account for other parks in the same neighbourhood. Panel B shows a measurement of the density of parks within a defined radius – in this case, an approximate walkable catchment of 500m. This measure accounts for all parks in the neighbourhood, even if they are not necessarily the closest.

Figure 6: Two alternative measures of proximity to parks



2.2.4 Missing or incorrectly entered values

It was necessary to clean the data to exclude property sales that were not residential sales, which had missing variables, or potential data entry errors. We began with a dataset of 308,596 property sales, primarily from the 2000s onwards but with some records from the 1990s or earlier. The property sales file only covered the former Auckland City Council area prior to Auckland Council amalgamation in 2011. Consequently, we excluded sales prior to 2011 to ensure regional coverage. Then, we excluded non-residential property sales, which we identified based on the “property category” code defined by LINZ (2010).[16] We then excluded sales of non-dwellings – i.e. any sale of a property that was not a standalone house (defined as property type = RD), residential flat (property type = RF) or apartment (property type = RA).[17]

We then applied the following filters to the data:

- Exclude sales of leasehold properties or sales of multiple rating units
- Exclude all sales records with missing or non-complying data in the key variables tested for inclusion in the regression model – e.g. distance to the city centre or coast, median household income, and meshblock population density
- Exclude properties that are likely to be outliers or data entry errors on key variables, i.e.:
    - The top 1 per cent and bottom 1 per cent of measured ratios of sale prices to ratings valuation.[18] Properties with abnormally high or low ratios are likely to reflect data entry errors (e.g. sales of multiple properties recorded as a sale of a single title or incorrectly entered sale prices).
    - The top 1 per cent and bottom 1 per cent of floor area.[19] This included some properties with zero floor area that were likely to be data entry errors (e.g. sales of car parks incorrectly recorded as sales of dwellings).
    - The top 1 per cent of land area.[20] This included some residential properties recorded as being sold with hundreds of hectares of land. Close inspection of selected cases suggests that this was a data entry error – i.e. land area incorrectly being entered in square metres rather than hectares.

After cleaning the data, we were left with a final dataset consisting of 128,868 residential property sales.

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[16] LINZ also requires councils to collect data on the actual property use – i.e. the activity actually occurring on the site, rather than the activity for which the property is intended. As expected, these two measures were highly correlated.

[17] Among all three residential property types, we found a significant number of properties that were apparently sold with a land area of zero. This makes a certain amount of sense for apartment sales, many of which are high-rise apartments in the city centre, but does not make sense for houses and flats. Further investigation suggests that this was the result of cross-lease arrangements that make it difficult to determine land area. Cross-leases were common in the 1980s and 1990s as a way to undertake infill development on a site without obtaining a subdivision consent.

[18] Properties with a sale price to CV ratio of less than 0.567 or more than 1.81.

[19] Properties with a floor area of less than $31m^2$ or more than $309m^2$.

[20] Properties with more than $2263m^2$ of land.

3.0 Results

In this section, we present descriptive statistics on our dataset, and then summarise key findings from our hedonic analysis. Full model outputs, including a side-by-side comparison of OLS and spatial regression models estimated on two models that incorporate alternative measures of proximity to parks, are provided in Appendix A.

3.1 Descriptive statistics

Figure 7 maps the residential dwelling sales in our dataset, focusing on the Auckland urban area. The dataset also included dwelling sales in outlying towns, such as Orewa, Warkworth, Pukekohe, and Waiuku. Panel A shows dwelling sale prices, grouped by decile. Lighter (yellow) colours indicate lower prices, while darker (blue) colours indicate higher prices. This shows that prices are generally higher close to the Auckland city centre and along eastern coastlines. Panel B shows dwelling types – red dots indicate standalone houses, yellow dots indicate residential flats, and green dots indicate apartments. While houses and flats are widely distributed throughout the city, apartments are concentrated in and around the city centre.

Figure 7: Observed sale prices and dwelling types, 2011-2015

Panel A: Sale prices | Panel B: Dwelling type

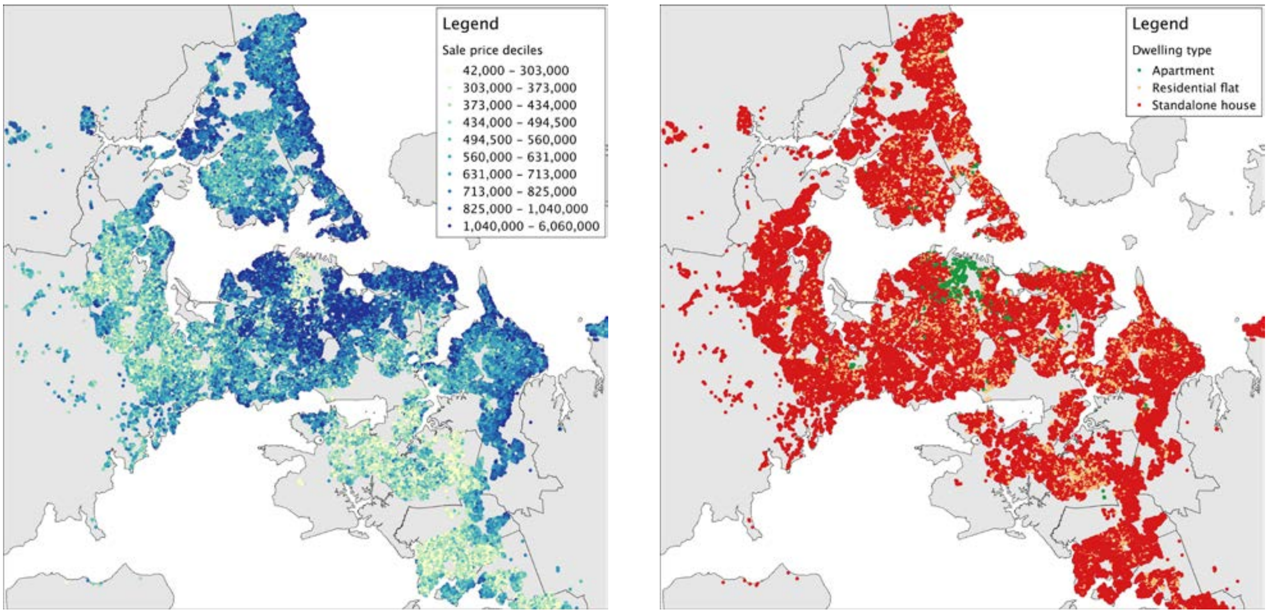


Table 4 provides descriptive statistics for this dataset. This table summarises the average value of each metric – for example, the average sale price for dwellings was just under \$640,000, while the average dwelling size was 123.9m^2 – as well as the range of minimum and maximum values. It also summarises the data on dummy variables – for instance, the share of dwelling sales that were of standalone houses (75.0%) versus flats (16.3%) or apartments (8.7%).

Table 4: Descriptive statistics on property sales dataset

Continuous variables					
Variable	Unit	Mean	St. Dev.	Min	Max
Net sale price	Nominal NZD	$639,830	$373,567	$42,000	$6,060,000
Ratio of sale price to rateable value	Ratio	1.18	0.20	0.57	1.81
Straight-line distance to CBD	Metres	13,632	9,886	129	61,414
Straight-line distance to coast	Metres	1,223	1,340	6	12,659
Land area	Square metres	417.3	390.2	0.0	2263.0
Floor area	Square metres	123.9	53.4	31.0	309.0
Number of garages under main roof	Number	0.78	0.86	0	39
Number of freestanding garages	Number	0.48	0.72	0	21
Number of pre-1940 buildings in meshblock	Number	4.05	7.13	0	70
Number of reported burglaries in meshblock	Number	4.55	6.74	0	69
Modelled annual average PM10 concentration	µg/m3	15.2	1.9	9.2	24.4
Meshblock population density	people/ha	57.285	137.058	0.028	1,961.54
Median household income in meshblock	$/year	$80,998	$28,614	$2,500	$150,000
Regional parks within 500m radius	Hectares	2.576	5.42	0	62.59
Local/n'hood parks within 500m radius	Hectares	4.656	4.285	0	40.01
Golf courses within 500m radius	Hectares	0.61	3.133	0	42.18
Industrial zones within 500m radius	Hectares	1.723	4.89	0	62.17
Distance to nearest regional park	Metres	766	772	2	9,964
Size of nearest regional park	Hectares	34.4	307.5	0.0	7,583.9
Distance to nearest local/n'hood park	Metres	171	144	1	3,661
Size of nearest local/n'hood park	Hectares	2.2	4.1	0.0	48.3
Distance to nearest golf course	Metres	2,527	1,475	1	9,868
Distance to nearest industrial zone	Metres	1,379	1,741	1	18,568
Size of nearest industrial zone	Hectares	166.8	293.9	0.0	1,169.8

Dummy variables	
Variable	Share
Dwelling type	
Standalone house (RD)	75.0%
Residential flat (RF)	16.3%
Apartment (RA)	8.7%
Dwelling sold with no land	35.3%
Deck or balcony	53.4%
Pre-1940 status	8.1%
View	
View of water	10.8%
Other view (land)	22.6%
No view	66.6%
Condition of roof	
Good (G)	68.7%
Average (A)	29.2%
Fair (F), Poor (P), or Mixed (X)	2.1%
Condition of walls	
Good (G)	69.4%
Average (A)	28.3%
Fair (F), Poor (P), or Mixed (X)	2.2%
Sale year	
2011	10.3%
2012	23.7%
2013	25.3%
2014	22.0%
2015	18.6%
No regional parks within 500m	58.2%
No local/n'hood parks within 500m	2.1%
No golf courses within 500m	93.3%
No industrial zones within 500m	74.1%

There are three types of dwellings included in the dataset:

- Standalone houses, which are detached or semi-detached houses on their own plot of land (75.0% of sales records)
- Residential flats, which are low-rise units that do not resemble houses, predominantly on cross-leased sites (16.3%)
- Apartments, which are units in multi-storey buildings on strata title (8.7%).

Table 5 summarises the mean value of selected variables for sales of houses, flats, and apartments. On average, houses sold for higher prices than flats and apartments. Houses also tended to be larger (in terms of floor area), and less likely to be sold with no land area. Apartments tended to be located closer to the city centre than either houses or flats.

Table 5: Some observed differences between sales of houses, flats, and apartments

Variable	Standalone houses (RD)	Residential flats (RF)	Apartments (RA)
Mean net sale price ($)	$701,364	$467,910	$432,906
Mean straight-line distance to CBD (m)	15,310	11,502	3,221
Mean straight-line distance to coast (m)	1,263	1,184	956
Mean floor area (m^2)	137.2	91.3	70.5
Share of dwellings sold with no recorded land	19.0%	76.3%	97.9%

Table 6 summarises our alternative measures of proximity to parks (straight-line distance and density of parks) at the level of individual property sales. We summarise the minimum and maximum value of each measure, as well as the 5th, 25th, 50th (median), 75th, and 95th percentiles of the measures. This analysis shows that:

- First, virtually every residential property in the dataset is within a 1 kilometre straight-line distance from the nearest local / neighbourhood park. The median distance to the nearest local / neighbourhood park was only 139 metres, and only 306 property sales were further than 1 kilometre from the nearest park. This reflects the widespread availability of parks throughout the urbanised area.
- Second, there was greater variation in proximity to regional parks (defined as parks with a value of four or five on one or more function and use categories). The median distance to the nearest regional park was 607 metres. Approximately 25 per cent of property sales were more than 1 kilometre from the nearest regional park. However, given the fact that these parks are expected to serve people travelling from multiple parts of the city, this represents a relatively high degree of accessibility to regional parks.
- Third, almost all property sales had a local or neighbourhood park (defined as parks with a value of three or less on all function and use categories) within a 500 metre radius, with the median property sale having 3.44 hectares of local / neighbourhood park within 500 metres. As the area of a 500m circle is 78.5 hectares, this suggests that roughly 4 per cent of the area around the median property consists of local / neighbourhood park. On the other hand, less than half of property sales had a regional park within a 500 metre radius.

Table 6: Summary of alternative measures of proximity to parks

Measure type	**Straight-line distance to nearest park (metres)**		**Area of parks within a 500m radius (hectares)**	
Percentile	**Regional parks**	**Local / n'hood parks**	**Regional parks**	**Local / n'hood parks**
Min	2	1	0	0
5%	73	20	0	0.21
25%	294	72	0	1.54
50%	607	139	0	3.44
75%	1,037	236	2.56	6.57
95%	1,780	414	14.08	13.02
Max	9,964	3,661	62.59	40.01

3.2 Preferred spatial regression model

We tested two hedonic regression models that incorporated alternative measures of proximity to parks:

- Model 1 measures the distance from each property sale to the nearest regional park, local / neighbourhood park, and golf course, as well as the size of those parks
- Model 2 measures the total area of regional parks, local / neighbourhood parks, and golf courses within a 500 metre radius around each property sale, and also includes a dummy variable identifying property sales with no parks within 500 metres.

Moran's I revealed spatial dependence in OLS model residuals. Consequently, we estimated spatial error and spatial lag models, using two alternative definitions of neighbourhoods, to address the resulting bias. Table 7 summarises AIC scores for the ten models we estimated on a randomly selected subset of the data. The model that performed best on this measure is a spatial error model with a 1km radius neighbourhood, estimated on Model 1 (highlighted in bold). We draw two conclusions from this analysis.

First, our findings about the preferred approach to spatial regression modelling are consistent with earlier research on property prices in Auckland (Grimes and Liang, 2007) and overseas cities (Rouwendal and Van Der Straaten, 2008) that also investigated the performance of alternative spatial regression models. This suggests that spatial processes influencing property sale prices can be treated as a "nuisance" to be controlled for in analysis. Furthermore, as our discussion of the differences between OLS and spatial regression models below shows, failing to account for spatial dependence can lead to biased estimates of key relationships.

Second, consistent with the results from OLS models estimated on the full dataset, we find that Model 1, which measures the distance to the nearest park (and the size of that park), outperforms Model 2, which measures of the quantity of open space within a 500m radius around property sales. However, the difference between AIC scores for spatial error models estimated with a 1km radius neighbourhood is not especially large, suggesting that there may not be an overly strong reason to prefer one approach over another.

This is an interesting finding given the fact that previous studies had employed different measures of park proximity but not tested alternative measures against each other. While our results may be specific to the Auckland context, they suggest that measures of distance to the nearest park are potentially more valid.

Table 7: Akaike's Information Criterion scores for OLS and spatial regression models estimated on a subset of the data

Model type	Functional form	
	Model 1 (distance to nearest park)	Model 2 (area of parks within 500m radius)
OLS model	-1193.815	-941.5907
Spatial error model; 1km radius neighbourhood	**-4533.061**	-4481.0872
Spatial error model; meshblock neighbourhood	-2184.776	-1972.3714
Spatial lag model; 1km radius neighbourhood	-1559.509	-1350.8411
Spatial lag model; meshblock neighbourhood	-1201.615	-950.7991

3.3 The impact of proximity to parks on Auckland property prices

We use the results from our preferred regression model – Model 1 estimated using a spatial error model with a 1km radius neighbourhood – to estimate the impact of proximity to parks on sale prices for different types of dwellings in Auckland. In Appendix A, we also report similar estimates from Model 2 for completeness. A qualitative comparison between model results suggests that our key results are not greatly affected by choices about how to measure proximity to parks. Full regression outputs for both Model 1 and Model 2 are also reported in Appendix A.

Following Angrist and Pischke (2009), we estimate the impact of proximity parks on the sale price of different types of dwellings by adding together the coefficients on interaction terms between dwelling type and park proximity measures. For instance, if γ_1 is the coefficient reflecting the impact of proximity to parks for the base type of dwelling (in this case, apartments), γ_2 is the coefficient on the interaction term between the park proximity variable and the second dwelling type (in this case, standalone houses), and γ_3 is the coefficient on the interaction term between the park proximity variable and the third dwelling type (in this case, residential flats), then can estimate the impact of proximity parks on the sale price of different types of dwellings by combining model parameters as follows:

Equation 5: Calculating impact of park proximity for separate dwelling types

$$Impact\ of\ park\ proximity\ on\ apartment\ price = \gamma_1$$

$$Impact\ of\ park\ proximity\ on\ standalone\ house\ price = \gamma_1 + \gamma_2$$

$$Impact\ of\ park\ proximity\ on\ residential\ flat\ price = \gamma_1 + \gamma_3$$

If proximity of parks has a similar impact on sale prices for all dwelling types, then we would expect the parameters γ_2 and γ_3 not to be statistically different from 0. Table 8 summarises the resulting estimates, showing the average impact of the distance to the nearest park on sale price for three types of dwellings. We report the impact of:

- Distance to the nearest regional park, local / neighbourhood park and golf course. A negative sign on this coefficient indicates that proximity to parks is valued – i.e. that sale prices tend to fall within increased distance to the nearest park.
- The area of the nearest regional park and local / neighbourhood park. A positive sign on this coefficient indicates that proximity to larger parks is associated with higher sale prices.

We also report similar estimates of the impact of proximity to industrial zones, which have been identified (see Appendix B) as a disamenity that will tend to reduce adjacent property values.

Statistically significant coefficients are highlighted in bold. Most coefficients are not statistically significant, even at a 10 per cent level, which suggests that they have neither a positive or negative impact on prices. However, some coefficients are statistically significant, displaying the expected sign:

- Proximity to both regional and local / neighbourhood parks has a positive effect on apartment sale prices. These effects are statistically significant at the 1 per cent level.
- The equivalent coefficients for residential flats and standalone houses are smaller and statistically different from the apartment coefficients. This suggests that, holding other dwelling characteristics constant, increased distance to the nearest regional park or local / neighbourhood park does not decrease the value of flats and houses.
- As expected, proximity to industrial zones has a negative effect on prices for apartments, flats, and houses. This is as expected, increasing confidence in the overall findings.

Because we included a large number of control variables, including dwelling characteristics and neighbourhood characteristics including median household income from the 2013 Census and reported burglaries (a proxy for local crime rates, which may affect the value that people derive from parks), these estimates are likely to reflect the underlying relationships between park proximity and property values.

Table 8: The impact of distance to the nearest park (based on model 6 employing a spatial error model with 1km radius neighbourhood)

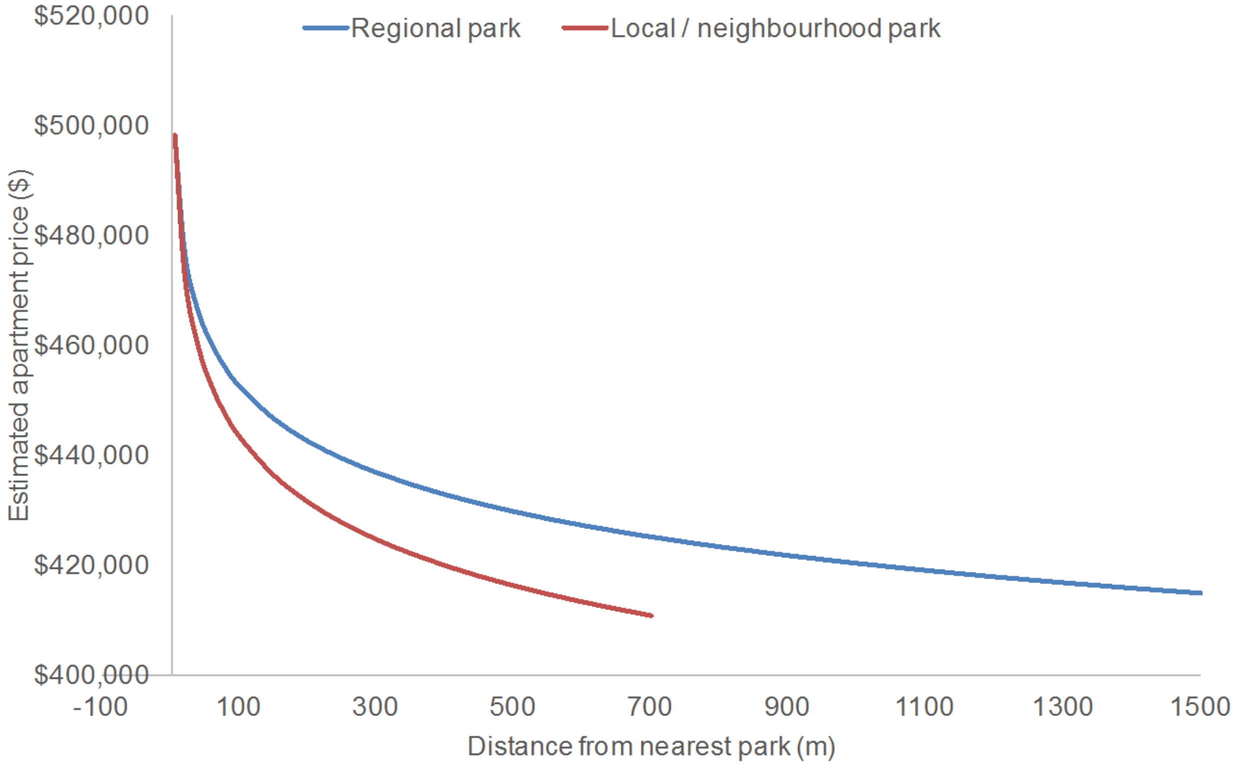
Park type	Coefficient	Dwelling type		
		Apartment	Residential flat	Standalone house
Regional park	Distance to nearest park	**-0.032** (1)	-0.004 (3)	-0.004 (4)
	Area of nearest park	-0.005	-0.003	0.000
Local / n'hood park	Distance to nearest park	**-0.039** (1)	0.005 (3)	0.005 (3)
	Area of nearest park	0.000	-0.003	-0.003
Golf course	Distance to nearest golf course	**0.049** (2)	-0.005 (4)	-0.001 (3)
	Area of nearest golf course	N/A – not estimated		
Industrial zone	Distance to nearest industry	**0.019** (2)	**0.018**	**0.025**
	Area of nearest industry	**0.030** (1)	-0.004 (3)	0.000 (3)

Notes: (1) Statistically significantly different from zero at the 1% level; (2) statistically significantly different from zero at the 5% level; (3) statistically significantly different from apartment coefficient (but not necessarily from zero) at the 1% level; (4) statistically significantly different from apartment coefficient (but not necessarily from zero) at the 5% level.

We used the model coefficients in the above table to estimate how prices for an average apartment (70.5 square metres floorspace; sale price of around $433,000; roughly 3.2km from town hall) would vary with increasing distance to the nearest regional or local / neighbourhood park if we held all other attributes constant. Figure 8 illustrates this relationship for both types of parks. It shows that average sale prices are expected to fall with increased distance from the nearest park. An average apartment immediately adjacent to the nearest regional or local / neighbourhood is expected to sell for roughly $500,000. By contrast, an average apartment 500 metres away from the nearest regional park is expected to be 13.7 per cent less valuable, while an average apartment 500 metres away from the nearest local / neighbourhood park is expected to be 16.4 per cent less valuable.

Note that although this chart suggests that apartment prices decline more slowly with increasing distance to the nearest regional park than with distance to the nearest local / neighbourhood park, the difference between the coefficients for these two types of parks is not statistically significant.

Figure 8: Estimated apartment sale prices as a function of distance from the nearest regional or local / neighbourhood park



3.4 Other determinants of property values

Our hedonic analysis also provides information on the other determinants of property values, including cases where dwelling attributes (e.g. floorspace or presence of a deck) have different impacts on sale prices for different types of dwellings. Table 9 provides a qualitative summary of other determinants of property values, based on Model 1 estimated using a spatial error model with a 1km radius neighbourhood. The sign and statistical significance of these coefficients was generally the same in Model 2 estimated using the same approach. This indicates that findings about the impact of other dwelling, neighbourhood, and location attributes are not affected by choice of park proximity measure.

Table 9: Other determinants of residential property sale prices

Variable	Impact on residential property sale prices
Distance to city centre	Increased distance has a negative impact on sale prices for all types of dwellings. This effect is statistically significant at the 1% level. This negative effect is stronger for both standalone houses (significant difference at the 1% level) and residential flats (significant difference at the 10% level), indicating that the value of these types of dwellings drops off more rapidly with distance.[21]
Distance to coast	Increased distance has a negative impact on sale prices for all types of dwellings. This effect is statistically significant at the 5% level. There was no statistically significant difference in the impact of distance to coast on prices for apartments, flats, and houses.
Land area	Increased land area has a positive impact on sale prices for all types of dwellings. This effect is statistically significant at the 5% level. There is no statistically significant difference between the impact of increased land area on prices for apartments, flats, and houses.
Floor area	Increased floor area has a positive impact on sale prices for all types of dwellings. This effect is statistically significant at the 1% level. This positive effect is weaker for flats and standalone dwellings, suggesting that their value is less influenced by size. This difference is statistically significant at the 1% level.
Presence of garage	Garages, either under the main roof or freestanding, have a negative impact on apartment sale prices. This effect was only significant for garages under the main roof (5% significance level). However, the effect of garages under the main roof was positive for houses and flats – a difference that was significant at the 1% level. Freestanding garages also had a positive effect on flats at the 1% level.

[21] This may simply reflect the fact that most apartments are concentrated in and around the city centre, meaning that we observe less variation in this variable for apartments.

Presence of deck or balcony	The presence of a deck or balcony has a positive impact on sale prices for apartments. This effect is statistically significant at the 1% level. However, the impact of decks/balconies on sale prices is lower for houses and flats than for apartments. This difference is statistically significant at the 1% level. The coefficient estimates imply that decks and balconies potentially have zero impact on house and flat prices.
Pre-1940 status	Pre-1940 status has a positive impact on sale prices for all types of dwellings. This effect is statistically significant at the 5% level. There is no statistically significant difference between the impact of pre-1940 status on prices for apartments, flats, and houses.
Views	Views of water had a positive impact on sale prices for all types of dwellings. This effect is statistically significant at the 5% level. Views of land had a positive, statistically significant (10% level) impact on sale prices for apartments, but not for houses or flats.
Number of pre-1940 buildings in meshblock	Additional pre-1940 buildings within meshblocks have a positive impact on sale prices for apartments. This effect is statistically significant at the 1% level. There was a statistically significant difference between the impact of neighbouring pre-1940 dwellings on prices for flats and houses. The impact on these dwellings was less positive and potentially no different from zero.

4.0 Discussion and conclusions

Following our analysis of the impact of proximity to parks on dwelling sale prices in Auckland, we briefly reflect upon the implications of this study for policy analysis and future research.

4.1 Implications for policy analysis

We began this study with three research questions:

1. Does proximity to parks have a positive effect on sale prices for residential properties?
2. Does the impact of proximity to parks vary by park size or park type – e.g. is there evidence that regional parks have different effects than smaller local parks?
3. Does the impact of proximity to parks vary between different types of dwellings – e.g. are apartment prices more affected than standalone house prices?

We find that proximity to parks and public open spaces has a positive impact on apartment prices. That is, if we compare two apartments that were equivalent in all respects except distance to the nearest park, we would expect the apartment that was closer to the park to command a higher price. Higher prices in turn reflect the higher level of amenity that apartment owners (or occupants) receive from proximity to a park. Proximity to both regional parks and to local / neighbourhood parks has a positive impact, which suggests that parks of varying significance and size are valued by apartment-buyers.

These results are intuitively sensible. Apartments tend to have less private open space, in the form of yards or large balconies, and as a result their occupants may place greater value on the availability of public open space.[22] This may help to explain development outcomes around inner-city parks such as the Domain and Basque Park – as shown in Figure 9.

[22] Apartment prices are also more responsive to the size of living areas and presence of a deck or balcony than either house or flat prices – suggesting that private living space is more important for apartments.

Figure 9: Apartment development around Basque Park (Source: ParkView Residences[23])

However, there is no statistically significant relationship between distance to the nearest park and sale prices for standalone houses and flats. In other words, if we compare two houses (or flats) that were equivalent in all respects except distance to the nearest park, we would expect them to sell for the same price.

Our findings about the impact of proximity to parks on property sale prices control for the influence of factors such as crime rates or other amenities such as proximity to the coast. To the extent possible with the available data, we have also controlled for differences in the significance of parks, by distinguishing between regionally significant parks and parks with local / neighbourhood significance. However, it has not been possible to control for all characteristics of parks, such as age and level of development.

4.1.1 Optimal park provision in a growing city

Hedonic analysis has been used to estimate and compare the value of competing goods, such as the availability of urban parks versus the availability of land for housing, in Reading, UK (Cheshire and Sheppard, 2002) and three Dutch cities (Rouwendal and van der Straaten, 2008). In some cases, these results have been interpreted as implying that specific cities are over-supplied with parks relative to land for housing. But in our view, there are several other interpretations of the data that must be considered.

First, our analysis suggests that almost all residential property sales in Auckland are close to parks. Over 95 per cent of property sales are within 500 metres of at least one local or neighbourhood park, and there are only 306 property sales were further than one kilometre from the nearest park. Similarly, approximately 75 per cent of properties were within one kilometre of the nearest regional park. This reflects the widespread availability of parks throughout the urbanised area. This is supported by evidence from surveys showing that

[23] http://www.parkview.co.nz/.

Aucklanders are highly aware of parks and green spaces as an aspect of the Auckland environment (see Section 1.1).

Consequently, our results for houses and flats may simply reflect the relative equality of proximity to parks throughout the Auckland urban area. Compared to other cities, Auckland may have few places that aren't close to parks. In this context, we may be unable to observe enough variation in access to parks to obtain meaningful estimates of the degree to which park proximity affects property values. This does not necessarily mean that parks are not valued in Auckland, but that their value accrues broadly to most Auckland houses and flats, regardless of whether they are immediately next to a park.

Second, our findings have implications for future urban growth and change. Because proximity to parks has a more positive impact on apartment prices than it does on prices for either standalone houses or flats, the social value of the city's parks will tend to rise if apartments are developed near them. Consequently, Auckland has an opportunity to gain additional value from its existing urban parks as it continues to develop and change.

In this context, we may think of Auckland's network of open spaces as a case of successful "future proofing" for the needs of a growing city. Even if parks are oversupplied relative to the needs of a city where most people live in standalone houses and hence have access to abundant private open spaces (i.e. backyards), the value of parks is likely to rise as apartments make up an increasing share of the housing stock throughout the city.

4.1.2 Industrial zones and property values

Our findings on the impact of industrial zoned land on residential property values are also likely to be relevant for policy analysis, including analysis of zoning policies that seek to separate residential and industrial activities. Auckland's residential property prices tend to rise with increased distance to the nearest industrial zone. In contrast to parks, industrial zones appear to be a disamenity for home-buyers. This may reflect localised nuisances associated with industrial activities, such as noise, emissions, heavy vehicle movements, or poor urban environments.[24]

Even though the nature of Auckland's industrial economy has changed significantly in recent decades, with warehousing, distribution, and light manufacturing replacing polluting "smokestack" industries, these results suggest there may be an ongoing rationale to use zoning to separate out industrial and residential activities and to provide buffer zones between activities. This can provide benefits both to residents – who are less exposed to

[24] We controlled for local air quality through the inclusion of modelled estimates of PM_{10} concentrations at a suburb level from Kuschel et al (2012). This suggests that factors other than air quality are driving this result.

nuisances – and to industrial activities that may otherwise experience "reverse sensitivities", or complaints about their operations from nearby sensitive residential uses.

4.2 Implications for researchers

This study offers several lessons for researchers, as well as suggesting some areas for further research. We summarise some key considerations below.

4.2.1 Comparing measures of park proximity

The first lesson relates to the choice of park proximity measures. We calculate and compare two separate proximity measures: distance to the nearest park, and density of parks within a 500m radius. We find that the first measure – distance to the nearest park – results in a model that better optimises the trade-off between the model's explanatory power and parsimoniousness, as measured by Akaike's Information Criterion.

However, after addressing spatial dependence, the difference in AIC scores is not large. Furthermore, the results from the two models are qualitatively similar. This suggests that results from studies of the impact of parks on residential property values may not be affected by choice of park proximity variables.

In this context, it may be valid for researchers to choose park proximity measures based on:

- Information about the underlying economic relationships – i.e. how home-buyers perceive proximity to parks in different contexts
- The purpose of the study and the intended use of hedonic estimates of the value of park proximity – for example, measures of park density may be more useful for determining the optimal level of park provision in cities (cf. Cheshire and Sheppard, 2002; Rouwendal and van Der Straaten, 2008)
- The ease of calculating different park proximity measures – we found that it was significantly more challenging to calculate park density measures, which may pose a barrier for researchers.[25]

[25] To calculate this measure, we converted a GIS polygon map of parks (and other land uses) into a set of discrete points, each representing a 10m by 10m square, and calculated the number of points within a 500m distance of each property sale. This proved to be less computationally intensive than calculating the intersection between park polygons and 500m "buffers" around a large number of property sales, without resulting in a significant decrease in accuracy.

4.2.2 Designing regression models to incorporate different dwelling types and land ownership arrangements

The second lesson relates to the design of regression models to address differences between dwelling types and quirks in property sales datasets. We found that there was value in including different dwelling types in our regression model, as it provided more nuanced information on how parks affected different dwelling types.

However, in order to do so it was necessary to extend our regression model beyond the approach taken in Nunns, Hitchins and Balderston (2015), which analysed freehold house sales only. We included a large number of interaction terms between dwelling type and a range of dwelling and neighbourhood characteristics. This resulted in a considerable improvement in model quality.

It was also necessary to address the issue of property sales recorded with no land area – an issue that affected almost all apartment sales, three-quarters of residential flat sales, and one-fifth of standalone houses. In order to do so, we modified the land area variable following the approach set out by Gaudry and Quinet (2009) by creating a continuous variable equal to land area (measured in square metres and normalised by means of a logarithmic transformation) and a dummy variable to capture the impact of properties sold with zero land area (equals to one if a property sale had zero land area, and zero otherwise).

4.2.3 Avenues for further hedonic analysis

There are several areas for further empirical research into the determinants of property values in New Zealand. One implication of this study is that results from studies in other cities – such as a positive relationship between park proximity and house prices– may not necessarily occur in the New Zealand context, possibly due to differences in urban form or other social and economic factors. Consequently, there is a case to exercise caution when attempting to apply results from overseas studies for policy analysis in New Zealand, and potentially to conduct primary research to understand the relationships that apply locally.

Areas for future investigation may include analysing the impact of other urban amenities and disamenities, including public facilities, jobs and retail. In Appendix B, we identify several areas where the New Zealand-specific empirical literature could be extended. De Groot et al (2015) undertake an especially comprehensive analysis that also addresses accessibility to employment, retail, and cultural facilities and events, as well as exploring the role of transport networks in shaping accessibility. Their analysis and methods present opportunities for further work in the New Zealand context.

In addition, it would be desirable to improve our measures of proximity to amenities to incorporate accessibility via transport networks rather than simply straight-line distances.

In some parts of the city, amenities that are physically close may be difficult to access due to convoluted road networks or geographic barriers like harbours and hills. As highlighted in Torshizian (2016), measuring accessibility on transport networks can be preferable to measuring straight-line distances. Network analysis tools are available to model accessibility within road and public transport networks (Adli and Donovan, 2016). Future work should seek to integrate these tools into hedonic analysis.

4.2.4 The need for stated preference research on Aucklanders' preferences for and perceptions of parks

A second area for further research is in the application of stated preference techniques, such as contingent valuation or choice experiments conducted using data from surveys or focus groups, to further explore nuances in Aucklanders' perceptions of the value of proximity to parks. For example:

- How do people account for proximity to parks when choosing where to live? Do they consider distance to the nearest park, the simple availability of a park in the neighbourhood, the density of open spaces in the area, or some other metric?
- How do people value individual parks (e.g. the Domain or Cornwall Park)? How do they value particular characteristics of parks?
- How do people view the tradeoff between private open spaces (e.g. backyards and balconies) and public open spaces? Are parks substitutes for private open space, as implied by our results showing that park proximity had a positive impact on apartment sale prices but not on sale prices for standalone houses and flats?
- Do different groups of Aucklanders respond differently to proximity to parks?
- Is Auckland perceived as having abundant parks relative to other cities? If so, does this translate into a higher city-wide level of amenity for residents?

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Appendix A Additional data and analysis

In this Appendix, we provide detailed outputs from Model 1, which uses a measure of distance to the nearest park, and Model 2, which uses a measure of density of parks around property sales.

To enable an analysis of model outputs, we report:

- OLS models estimated on the full dataset of 128,868 property sales
- OLS models estimated on a randomly-selected subset of 10,000 property sales
- Spatial error models estimated on the subset, using two different definitions of “neighbourhoods” around property sales
- Spatial lag models estimated on the subset, using two different definitions of “neighbourhoods” around property sales.

As discussed in the body of the report, Model 1 estimated using a spatial error model with a 1 kilometre radius neighbourhood was our preferred model.

Model 1 output statistics (OLS and spatial regression models)

The following table reports full model outputs for Model 1, estimated using OLS and spatial regression models. Outputs for separate models are reported in columns, with each row representing the coefficient on a particular variable. Levels of statistical significance for individual variables are summarised with asterisks, and standard errors for model coefficients are reported in parentheses below coefficients.

Table 10: Full OLS and spatial regression model outputs for Model 1 (park distance measure)

Dependent variable	log(sale_price_net)					
	OLS models		*Spatial error models*		*Spatial lag models*	
	Full dataset	*Subset*	*Subset, 1km n'hood*	*Subset, MB n'hood*	*Subset, 1km n'hood*	*Subset, MB n'hood*
dwelling_typeRD	4.325***	4.390***	4.031***	3.744***	4.386***	4.420***
	(0.133)	(0.525)	(0.466)	(0.571)	(0.514)	(0.523)
dwelling_typeRF	2.696***	2.857***	2.283***	2.272***	2.796***	2.900***
	(0.154)	(0.597)	(0.517)	(0.633)	(0.584)	(0.594)
sale_year2012	0.055***	0.049***	0.065***	0.055***	0.049***	0.049***
	(0.002)	(0.009)	(0.007)	(0.008)	(0.008)	(0.009)
sale_year2013	0.177***	0.173***	0.192***	0.179***	0.173***	0.174***
	(0.002)	(0.008)	(0.007)	(0.008)	(0.008)	(0.008)
sale_year2014	0.283***	0.276***	0.299***	0.280***	0.275***	0.276***
	(0.002)	(0.009)	(0.007)	(0.008)	(0.008)	(0.009)
sale_year2015	0.454***	0.444***	0.468***	0.453***	0.444***	0.444***
	(0.002)	(0.009)	(0.007)	(0.008)	(0.009)	(0.009)
log(DCBD)	-0.098***	-0.092***	-0.124***	-0.108***	-0.098***	-0.091***
	(0.005)	(0.018)	(0.020)	(0.020)	(0.017)	(0.018)
log(DCOAST)	-0.035***	-0.038***	-0.030**	-0.046***	-0.036***	-0.038***
	(0.003)	(0.012)	(0.012)	(0.014)	(0.011)	(0.012)
log(land_area_m2_edited)	0.042**	0.116*	0.112**	0.075	0.129*	0.119*
	(0.017)	(0.068)	(0.056)	(0.064)	(0.067)	(0.068)
no_land_area	0.175**	0.529	0.544**	0.323	0.603*	0.542
	(0.083)	(0.332)	(0.273)	(0.315)	(0.324)	(0.330)
log(mass_total_floor_area)	0.942***	0.919***	0.897***	0.908***	0.910***	0.921***
	(0.006)	(0.022)	(0.018)	(0.022)	(0.021)	(0.022)
mass_garage_under_main_roof	0.003	-0.028	-0.036**	-0.024	-0.031	-0.028
	(0.005)	(0.019)	(0.016)	(0.021)	(0.019)	(0.019)
mass_garage_freestanding	-0.015	0.031	-0.023	0.036	0.018	0.030
	(0.012)	(0.046)	(0.038)	(0.047)	(0.045)	(0.046)
mass_deck_fixedY	0.129***	0.106***	0.087***	0.108***	0.101***	0.106***
	(0.005)	(0.017)	(0.014)	(0.018)	(0.016)	(0.017)
building_condition_wallsF	-0.042***	-0.049**	-0.037*	-0.040*	-0.040*	-0.047**
	(0.006)	(0.023)	(0.019)	(0.021)	(0.023)	(0.023)
building_condition_wallsG	0.041***	0.057***	0.040***	0.045***	0.054***	0.057***
	(0.003)	(0.012)	(0.010)	(0.011)	(0.011)	(0.012)
building_condition_wallsP	-0.172***	-0.189***	-0.153***	-0.128***	-0.184***	-0.188***
	(0.011)	(0.042)	(0.034)	(0.040)	(0.041)	(0.042)
building_condition_wallsX	-0.005	-0.009	-0.014	-0.073	-0.008	-0.006
	(0.018)	(0.078)	(0.064)	(0.071)	(0.076)	(0.078)

building_condition_roofF	0.0003	0.001	-0.009	-0.009	-0.002	-0.001
	(0.006)	(0.023)	(0.019)	(0.021)	(0.022)	(0.023)
building_condition_roofG	-0.004	-0.015	0.003	0.002	-0.013	-0.017
	(0.003)	(0.012)	(0.009)	(0.011)	(0.011)	(0.011)
building_condition_roofP	-0.034**	0.011	-0.019	0.008	0.019	0.011
	(0.013)	(0.049)	(0.040)	(0.046)	(0.048)	(0.048)
building_condition_roofX	-0.029	-0.010	0.022	0.064	-0.008	-0.014
	(0.018)	(0.083)	(0.068)	(0.075)	(0.081)	(0.083)
pre_1940_status	-0.014	0.049	0.097**	0.077	0.057	0.050
	(0.013)	(0.048)	(0.039)	(0.049)	(0.047)	(0.047)
mass_viewO	0.018**	0.043*	0.046**	0.047*	0.046*	0.044*
	(0.007)	(0.024)	(0.020)	(0.026)	(0.024)	(0.024)
mass_viewW	0.100***	0.112***	0.050*	0.097***	0.106***	0.112***
	(0.009)	(0.036)	(0.030)	(0.036)	(0.035)	(0.036)
pre1940_in_mb	0.008***	0.008***	0.007***	0.008***	0.007***	0.008***
	(0.0004)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
PM10_annual_average	-0.017***	-0.014***	-0.006	-0.014**	-0.011**	-0.015***
	(0.001)	(0.005)	(0.004)	(0.006)	(0.005)	(0.005)
MB_burglaries	0.001	0.001	-0.001	-0.0004	0.0005	0.001
	(0.0004)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
log(X2013_median_HH_income)	0.179***	0.166***	0.100***	0.149***	0.153***	0.165***
	(0.006)	(0.022)	(0.019)	(0.025)	(0.021)	(0.022)
log(pop_density_2013)	-0.013***	-0.020**	-0.026***	-0.033***	-0.022**	-0.021**
	(0.002)	(0.009)	(0.007)	(0.011)	(0.009)	(0.009)
log(X_distance_AnyparkNOTGOLFgteql_4)	-0.045***	-0.038***	-0.032***	-0.037***	-0.041***	-0.037***
	(0.003)	(0.012)	(0.010)	(0.014)	(0.012)	(0.012)
log(park_area_gteql_4)	-0.002	-0.008	-0.005	-0.005	-0.008*	-0.008*
	(0.001)	(0.005)	(0.004)	(0.006)	(0.005)	(0.005)
log(X_distance_AnyparkNOTGOLF_LT4)	-0.017***	-0.028***	-0.039***	-0.022*	-0.028***	-0.027***
	(0.003)	(0.010)	(0.009)	(0.012)	(0.010)	(0.010)
log(park_area_less_4)	0.011***	0.003	0.0004	-0.00004	0.002	0.003
	(0.002)	(0.006)	(0.005)	(0.007)	(0.005)	(0.006)
log(X_distance_AnyGolf)	0.054***	0.040*	0.049**	0.039	0.045**	0.041*
	(0.006)	(0.022)	(0.021)	(0.025)	(0.022)	(0.022)
log(near_ind_dist)	0.023***	0.027***	0.019**	0.019*	0.026***	0.028***
	(0.002)	(0.010)	(0.008)	(0.011)	(0.009)	(0.010)
log(Ind_Area)	0.024***	0.027***	0.030***	0.028***	0.027***	0.026***
	(0.002)	(0.006)	(0.006)	(0.008)	(0.006)	(0.006)
dwelling_typeRD:log(DCBD)	-0.225***	-0.236***	-0.162***	-0.227***	-0.218***	-0.237***
	(0.005)	(0.019)	(0.019)	(0.021)	(0.018)	(0.019)
dwelling_typeRF:log(DCBD)	-0.106***	-0.137***	-0.036*	-0.131***	-0.115***	-0.138***
	(0.006)	(0.022)	(0.021)	(0.024)	(0.021)	(0.022)
dwelling_typeRD:log(DCOAST)	0.038***	0.046***	0.007	0.050***	0.043***	0.046***
	(0.003)	(0.012)	(0.012)	(0.014)	(0.012)	(0.012)
dwelling_typeRF:log(DCOAST)	0.020***	0.025*	-0.003	0.034**	0.022*	0.024*
	(0.004)	(0.013)	(0.013)	(0.015)	(0.013)	(0.013)
dwelling_typeRD:log(land_area_m2_edited)	0.085***	0.017	0.066	0.076	0.009	0.014
	(0.017)	(0.069)	(0.056)	(0.065)	(0.067)	(0.068)
dwelling_typeRF:log(land_area_m2_edited)	0.095***	0.058	0.042	0.086	0.038	0.055
	(0.018)	(0.074)	(0.061)	(0.070)	(0.072)	(0.073)

dwelling_typeRD:no_land_area	0.550***	0.233	0.466*	0.547*	0.187	0.227
	(0.085)	(0.336)	(0.277)	(0.320)	(0.329)	(0.335)
dwelling_typeRF:no_land_area	0.540***	0.385	0.294	0.551	0.275	0.371
	(0.091)	(0.365)	(0.300)	(0.346)	(0.357)	(0.363)
dwelling_typeRD:log(mass_total_floor_area)	-0.430***	-0.384***	-0.474***	-0.424***	-0.395***	-0.386***
	(0.006)	(0.024)	(0.020)	(0.023)	(0.023)	(0.023)
dwelling_typeRF:log(mass_total_floor_area)	-0.454***	-0.425***	-0.406***	-0.436***	-0.420***	-0.427***
	(0.008)	(0.029)	(0.024)	(0.028)	(0.028)	(0.029)
dwelling_typeRD:mass_garage_under_main_roof	0.041***	0.061***	0.066***	0.058***	0.063***	0.061***
	(0.005)	(0.020)	(0.017)	(0.021)	(0.019)	(0.020)
dwelling_typeRF:mass_garage_under_main_roof	0.069***	0.148***	0.128***	0.135***	0.143***	0.148***
	(0.006)	(0.024)	(0.020)	(0.025)	(0.023)	(0.024)
dwelling_typeRD:mass_garage_freestanding	0.014	-0.030	0.033	-0.033	-0.015	-0.029
	(0.012)	(0.046)	(0.038)	(0.047)	(0.045)	(0.046)
dwelling_typeRF:mass_garage_freestanding	0.054***	0.071	0.119***	0.069	0.078*	0.072
	(0.013)	(0.048)	(0.040)	(0.048)	(0.047)	(0.048)
dwelling_typeRD:mass_deck_fixedY	-0.117***	-0.096***	-0.094***	-0.101***	-0.095***	-0.097***
	(0.005)	(0.018)	(0.015)	(0.019)	(0.017)	(0.018)
dwelling_typeRF:mass_deck_fixedY	-0.122***	-0.109***	-0.093***	-0.106***	-0.103***	-0.110***
	(0.006)	(0.022)	(0.018)	(0.022)	(0.021)	(0.022)
dwelling_typeRD:pre_1940_status	0.149***	0.082*	0.013	0.045	0.074	0.082*
	(0.013)	(0.049)	(0.040)	(0.050)	(0.048)	(0.049)
dwelling_typeRF:pre_1940_status	0.146***	0.042	0.008	0.028	0.035	0.041
	(0.019)	(0.071)	(0.059)	(0.071)	(0.070)	(0.071)
dwelling_typeRD:mass_viewO	-0.019***	-0.045*	-0.053***	-0.052*	-0.046*	-0.045*
	(0.007)	(0.025)	(0.020)	(0.027)	(0.025)	(0.025)
dwelling_typeRF:mass_viewO	-0.014*	-0.046	-0.050**	-0.040	-0.051*	-0.047
	(0.008)	(0.029)	(0.024)	(0.030)	(0.029)	(0.029)
dwelling_typeRD:mass_viewW	0.005	-0.005	0.026	0.001	-0.004	-0.005
	(0.010)	(0.037)	(0.031)	(0.038)	(0.036)	(0.037)
dwelling_typeRF:mass_viewW	0.001	0.008	-0.006	-0.006	0.014	0.006
	(0.012)	(0.044)	(0.036)	(0.043)	(0.043)	(0.043)
dwelling_typeRD:pre1940_in_mb	-0.005***	-0.005***	-0.004***	-0.004**	-0.004**	-0.005***
	(0.0005)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
dwelling_typeRF:pre1940_in_mb	-0.009***	-0.010***	-0.008***	-0.010***	-0.009***	-0.010***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
dwelling_typeRD:PM10_annual_average	0.002	-0.005	0.0001	-0.005	-0.006	-0.004
	(0.001)	(0.006)	(0.005)	(0.007)	(0.005)	(0.006)
dwelling_typeRF:PM10_annual_average	0.006***	-0.0002	0.008	0.002	-0.002	-0.0001
	(0.002)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)
dwelling_typeRD:MB_burglaries	-0.003***	-0.003*	0.002	-0.002	-0.003**	-0.003*
	(0.0004)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
dwelling_typeRF:MB_burglaries	-0.004***	-0.005***	-0.0003	-0.003	-0.004**	-0.005***
	(0.0005)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
dwelling_typeRD:log(X2013_median_HH_income)	-0.045***	-0.037	-0.043**	-0.005	-0.037	-0.037
	(0.006)	(0.023)	(0.020)	(0.027)	(0.023)	(0.023)
dwelling_typeRF:log(X2013_median_HH_income)	0.006	0.018	-0.008	0.045	0.018	0.018
	(0.008)	(0.029)	(0.024)	(0.031)	(0.028)	(0.029)
dwelling_typeRD:log(pop_density_2013)	-0.027***	-0.018*	0.013	-0.001	-0.030***	-0.018*
	(0.003)	(0.010)	(0.008)	(0.012)	(0.009)	(0.010)

dwelling_typeRF:log(pop_density_2013)	-0.041***	-0.041***	-0.0002	-0.022	-0.039***	-0.041***
	(0.004)	(0.014)	(0.011)	(0.015)	(0.013)	(0.014)
dwelling_typeRD:log(X_distance_AnyparkNOTGOLFgteql_4)	0.022***	0.017	0.028***	0.013	0.024**	0.016
	(0.003)	(0.012)	(0.011)	(0.014)	(0.012)	(0.012)
dwelling_typeRF:log(X_distance_AnyparkNOTGOLFgteql_4)	0.025***	0.011	0.028**	0.008	0.018	0.011
	(0.004)	(0.013)	(0.011)	(0.015)	(0.013)	(0.013)
dwelling_typeRD:log(park_area_gteql_4)	-0.009***	-0.002	0.005	-0.005	-0.001	-0.002
	(0.001)	(0.005)	(0.004)	(0.006)	(0.005)	(0.005)
dwelling_typeRF:log(park_area_gteql_4)	-0.008***	-0.0002	0.002	-0.004	0.001	-0.00003
	(0.002)	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)
dwelling_typeRD:log(X_distance_AnyparkNOTGOLF_LT4)	0.027***	0.037***	0.044***	0.029**	0.038***	0.036***
	(0.003)	(0.011)	(0.009)	(0.013)	(0.010)	(0.011)
dwelling_typeRF:log(X_distance_AnyparkNOTGOLF_LT4)	0.032***	0.050***	0.044***	0.038***	0.049***	0.050***
	(0.003)	(0.012)	(0.010)	(0.014)	(0.012)	(0.012)
dwelling_typeRD:log(park_area_less_4)	-0.011***	-0.005	-0.003	-0.001	-0.005	-0.005
	(0.002)	(0.006)	(0.005)	(0.007)	(0.006)	(0.006)
dwelling_typeRF:log(park_area_less_4)	-0.013***	-0.013*	-0.003	-0.002	-0.012*	-0.012*
	(0.002)	(0.007)	(0.006)	(0.008)	(0.007)	(0.007)
dwelling_typeRD:log(X_distance_AnyGolf)	-0.068***	-0.056**	-0.050**	-0.053**	-0.058***	-0.056**
	(0.006)	(0.023)	(0.020)	(0.025)	(0.022)	(0.023)
dwelling_typeRF:log(X_distance_AnyGolf)	-0.066***	-0.048**	-0.054***	-0.046*	-0.051**	-0.048**
	(0.006)	(0.024)	(0.021)	(0.026)	(0.023)	(0.023)
dwelling_typeRD:log(near_ind_dist)	0.019***	0.018*	0.006	0.029**	0.016	0.018*
	(0.002)	(0.010)	(0.009)	(0.011)	(0.010)	(0.010)
dwelling_typeRF:log(near_ind_dist)	0.026***	0.015	-0.001	0.023*	0.013	0.014
	(0.003)	(0.011)	(0.009)	(0.012)	(0.011)	(0.011)
dwelling_typeRD:log(Ind_Area)	-0.024***	-0.029***	-0.030***	-0.030***	-0.028***	-0.028***
	(0.002)	(0.007)	(0.006)	(0.008)	(0.006)	(0.007)
dwelling_typeRF:log(Ind_Area)	-0.025***	-0.032***	-0.034***	-0.032***	-0.032***	-0.032***
	(0.002)	(0.007)	(0.006)	(0.008)	(0.007)	(0.007)
Constant	7.254***	7.175***	8.000***	7.823***	6.368***	7.145***
	(0.127)	(0.505)	(0.441)	(0.550)	(0.496)	(0.503)
Observations	128,868	10,000	10,000	10,000	10,000	10,000
R^2	0.800	0.804				
Adjusted R^2	0.800	0.802				
Log Likelihood			2,352.531	1,178.388	865.754	686.807
$sigma^2$			0.035	0.044	0.049	0.051
Akaike Inf. Crit.	-19,759.92	-1,193.815	-4,533.061	-2,184.776	-1,559.509	-1,201.615
Residual Std. Error	0.224 (df = 128784)	0.227 (df = 9916)				
F Statistic	6,193.750*** (df = 83; 128784)	488.723*** (df = 83; 9916)				
Wald Test (df = 1)			10,281.830***	1,248.087***	361.524***	9.810***
LR Test (df = 1)			3,341.246***	992.961***	367.694***	9.800***
Note:	*p<0.1; **p<0.05; ***p<0.01					

Model 2 output statistics (OLS and spatial regression models)

The following table reports full model outputs for Model 2. Outputs for separate models are reported in columns, with each row representing the coefficient on a particular variable. Levels of statistical significance for individual variables are summarised with asterisks, and standard errors for model coefficients are reported in parentheses below coefficients.

Table 11: Full OLS and spatial regression model outputs for Model 2 (park density measure)

Dependent variable	log(sale_price_net)					
	OLS models		*Spatial error models*		*Spatial lag models*	
	Full dataset	*Subset*	*Subset, 1km n'hood*	*Subset, MB n'hood*	*Subset, 1km n'hood*	*Subset, MB n'hood*
dwelling_typeRD	4.025***	4.114***	3.831***	3.527***	4.089***	4.133***
	(0.133)	(0.517)	(0.449)	(0.550)	(0.505)	(0.515)
dwelling_typeRF	2.275***	2.440***	2.016***	1.911***	2.355***	2.479***
	(0.153)	(0.591)	(0.501)	(0.613)	(0.576)	(0.588)
sale_year2012	0.052***	0.045***	0.064***	0.053***	0.045***	0.045***
	(0.002)	(0.009)	(0.007)	(0.008)	(0.008)	(0.009)
sale_year2013	0.173***	0.170***	0.192***	0.178***	0.170***	0.170***
	(0.002)	(0.009)	(0.007)	(0.008)	(0.008)	(0.009)
sale_year2014	0.279***	0.271***	0.297***	0.277***	0.270***	0.271***
	(0.002)	(0.009)	(0.007)	(0.008)	(0.009)	(0.009)
sale_year2015	0.450***	0.438***	0.467***	0.449***	0.438***	0.438***
	(0.002)	(0.009)	(0.007)	(0.008)	(0.009)	(0.009)
log(DCBD)	-0.063***	-0.044***	-0.076***	-0.059***	-0.051***	-0.044***
	(0.003)	(0.013)	(0.016)	(0.016)	(0.013)	(0.013)
log(DCOAST)	-0.039***	-0.048***	-0.040***	-0.054***	-0.046***	-0.048***
	(0.003)	(0.012)	(0.012)	(0.014)	(0.012)	(0.012)
log(land_area_m2_edited)	0.043**	0.095	0.083	0.053	0.107	0.099
	(0.017)	(0.069)	(0.056)	(0.066)	(0.068)	(0.069)
no_land_area	0.167**	0.412	0.398	0.187	0.479	0.427
	(0.085)	(0.340)	(0.276)	(0.323)	(0.331)	(0.338)
log(mass_total_floor_area)	0.949***	0.923***	0.904***	0.910***	0.913***	0.924***
	(0.006)	(0.022)	(0.018)	(0.022)	(0.022)	(0.022)
mass_garage_under_main_roof	0.004	-0.028	-0.033**	-0.017	-0.030	-0.028
	(0.005)	(0.019)	(0.016)	(0.021)	(0.018)	(0.019)
mass_garage_freestanding	-0.005	0.045	-0.011	0.044	0.030	0.045
	(0.012)	(0.046)	(0.038)	(0.046)	(0.045)	(0.045)
mass_deck_fixedY	0.125***	0.109***	0.093***	0.109***	0.104***	0.109***
	(0.005)	(0.017)	(0.014)	(0.018)	(0.017)	(0.017)
building_condition_wallsF	-0.045***	-0.056**	-0.038**	-0.045**	-0.045**	-0.054**
	(0.006)	(0.023)	(0.019)	(0.021)	(0.023)	(0.023)
building_condition_wallsG	0.042***	0.058***	0.041***	0.046***	0.056***	0.059***
	(0.003)	(0.012)	(0.010)	(0.011)	(0.011)	(0.012)
building_condition_wallsP	-0.182***	-0.214***	-0.167***	-0.144***	-0.209***	-0.213***
	(0.012)	(0.043)	(0.034)	(0.041)	(0.042)	(0.042)
building_condition_wallsX	-0.002	-0.006	-0.011	-0.072	-0.002	-0.002
	(0.018)	(0.079)	(0.064)	(0.071)	(0.077)	(0.079)
building_condition_roofF	0.0003	0.003	-0.010	-0.010	-0.001	0.001

	(0.006)	(0.023)	(0.019)	(0.021)	(0.023)	(0.023)
building_condition_roofG	-0.005	-0.017	0.002	0.002	-0.014	-0.018
	(0.003)	(0.012)	(0.010)	(0.011)	(0.011)	(0.012)
building_condition_roofP	-0.035***	0.034	-0.007	0.029	0.041	0.034
	(0.013)	(0.049)	(0.040)	(0.046)	(0.048)	(0.049)
building_condition_roofX	-0.030	-0.006	0.020	0.071	-0.007	-0.011
	(0.019)	(0.084)	(0.068)	(0.076)	(0.082)	(0.084)
pre_1940_status	0.018	0.081*	0.123***	0.099**	0.093**	0.082*
	(0.013)	(0.047)	(0.039)	(0.050)	(0.046)	(0.047)
mass_viewO	0.035***	0.071***	0.076***	0.072***	0.076***	0.071***
	(0.007)	(0.025)	(0.020)	(0.027)	(0.024)	(0.024)
mass_viewW	0.117***	0.140***	0.072**	0.126***	0.134***	0.140***
	(0.010)	(0.036)	(0.030)	(0.037)	(0.035)	(0.036)
pre1940_in_mb	0.007***	0.008***	0.006***	0.008***	0.008***	0.008***
	(0.0004)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
PM10_annual_average	-0.016***	-0.012**	-0.005	-0.012*	-0.009*	-0.012**
	(0.001)	(0.005)	(0.004)	(0.006)	(0.005)	(0.005)
MB_burglaries	0.001***	0.002	0.001	0.002	0.002	0.002
	(0.0004)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
log(X2013_median_HH_income)	0.160***	0.156***	0.099***	0.151***	0.144***	0.156***
	(0.006)	(0.022)	(0.018)	(0.025)	(0.021)	(0.022)
log(pop_density_2013)	-0.016***	-0.022**	-0.028***	-0.034***	-0.024***	-0.023**
	(0.002)	(0.009)	(0.007)	(0.011)	(0.009)	(0.009)
Parks_High	0.004***	-0.0003	-0.001	-0.002	-0.0003	-0.0002
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Parks_Low	-0.007***	-0.008***	-0.006***	-0.009***	-0.009***	-0.008***
	(0.001)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)
Golf_Cours	-0.048***	-0.077**	-0.036	-0.087***	-0.073**	-0.077**
	(0.008)	(0.033)	(0.027)	(0.031)	(0.032)	(0.033)
PAUP_Indus	-0.005***	-0.008	-0.005	-0.004	-0.008	-0.008*
	(0.001)	(0.005)	(0.004)	(0.006)	(0.005)	(0.005)
Parks_High_None	-0.049***	-0.084***	-0.060**	-0.090***	-0.091***	-0.083***
	(0.008)	(0.030)	(0.026)	(0.035)	(0.029)	(0.029)
Parks_Low_None	-0.215***	-0.252*	-0.258**	-0.331**	-0.260*	-0.255*
	(0.032)	(0.137)	(0.112)	(0.158)	(0.134)	(0.137)
Golf_Cours_None	0.034	-0.103	-0.013	-0.140	-0.098	-0.101
	(0.033)	(0.143)	(0.114)	(0.141)	(0.140)	(0.142)
PAUP_Indus_None	0.011*	-0.040*	-0.045**	-0.044	-0.044*	-0.040*
	(0.006)	(0.024)	(0.020)	(0.029)	(0.023)	(0.024)
dwelling_typeRD:log(DCBD)	-0.262***	-0.287***	-0.203***	-0.278***	-0.266***	-0.287***
	(0.004)	(0.014)	(0.016)	(0.017)	(0.014)	(0.014)
dwelling_typeRF:log(DCBD)	-0.131***	-0.181***	-0.082***	-0.178***	-0.158***	-0.182***
	(0.005)	(0.018)	(0.017)	(0.020)	(0.017)	(0.018)
dwelling_typeRD:log(DCOAST)	0.036***	0.049***	0.016	0.052***	0.048***	0.049***
	(0.003)	(0.013)	(0.012)	(0.015)	(0.012)	(0.013)
dwelling_typeRF:log(DCOAST)	0.020***	0.031**	0.004	0.039**	0.030**	0.031**
	(0.004)	(0.014)	(0.013)	(0.016)	(0.014)	(0.014)
dwelling_typeRD:log(land_area_m2_edited)	0.083***	0.034	0.094*	0.096	0.027	0.031
	(0.017)	(0.070)	(0.057)	(0.066)	(0.068)	(0.070)
dwelling_typeRF:log(land_area_m2_edited)	0.097***	0.077	0.071	0.113	0.058	0.073

	(0.019)	(0.075)	(0.061)	(0.071)	(0.073)	(0.075)
dwelling_typeRD:no_land_area	0.549***	0.326	0.611**	0.665**	0.287	0.317
	(0.086)	(0.344)	(0.279)	(0.327)	(0.336)	(0.342)
dwelling_typeRF:no_land_area	0.558***	0.488	0.445	0.706**	0.383	0.470
	(0.093)	(0.373)	(0.303)	(0.354)	(0.364)	(0.371)
dwelling_typeRD:log(mass_total_floor_area)	-0.433***	-0.384***	-0.480***	-0.423***	-0.396***	-0.386***
	(0.007)	(0.024)	(0.020)	(0.024)	(0.023)	(0.024)
dwelling_typeRF:log(mass_total_floor_area)	-0.457***	-0.432***	-0.415***	-0.438***	-0.427***	-0.434***
	(0.008)	(0.029)	(0.024)	(0.028)	(0.028)	(0.029)
dwelling_typeRD:mass_garage_under_main_roof	0.037***	0.057***	0.062***	0.048**	0.059***	0.058***
	(0.005)	(0.019)	(0.016)	(0.021)	(0.019)	(0.019)
dwelling_typeRF:mass_garage_under_main_roof	0.066***	0.146***	0.123***	0.124***	0.141***	0.147***
	(0.006)	(0.024)	(0.020)	(0.025)	(0.023)	(0.024)
dwelling_typeRD:mass_garage_freestanding	-0.001	-0.049	0.020	-0.045	-0.031	-0.048
	(0.012)	(0.046)	(0.038)	(0.046)	(0.045)	(0.046)
dwelling_typeRF:mass_garage_freestanding	0.042***	0.058	0.108***	0.060	0.067	0.059
	(0.013)	(0.048)	(0.039)	(0.048)	(0.047)	(0.048)
dwelling_typeRD:mass_deck_fixedY	-0.108***	-0.096***	-0.101***	-0.099***	-0.096***	-0.097***
	(0.005)	(0.018)	(0.015)	(0.019)	(0.018)	(0.018)
dwelling_typeRF:mass_deck_fixedY	-0.112***	-0.100***	-0.099***	-0.100***	-0.094***	-0.101***
	(0.006)	(0.022)	(0.018)	(0.023)	(0.022)	(0.022)
dwelling_typeRD:pre_1940_status	0.114***	0.047	-0.013	0.021	0.035	0.047
	(0.013)	(0.049)	(0.040)	(0.051)	(0.047)	(0.048)
dwelling_typeRF:pre_1940_status	0.118***	0.023	-0.025	0.019	0.012	0.022
	(0.019)	(0.072)	(0.059)	(0.072)	(0.070)	(0.071)
dwelling_typeRD:mass_viewO	-0.033***	-0.068***	-0.083***	-0.074***	-0.072***	-0.068***
	(0.007)	(0.025)	(0.020)	(0.028)	(0.025)	(0.025)
dwelling_typeRF:mass_viewO	-0.028***	-0.070**	-0.078***	-0.062**	-0.077***	-0.071**
	(0.008)	(0.029)	(0.024)	(0.031)	(0.029)	(0.029)
dwelling_typeRD:mass_viewW	0.005	-0.015	0.005	-0.013	-0.017	-0.015
	(0.010)	(0.038)	(0.031)	(0.038)	(0.037)	(0.037)
dwelling_typeRF:mass_viewW	-0.005	-0.026	-0.026	-0.030	-0.021	-0.027
	(0.012)	(0.044)	(0.036)	(0.044)	(0.043)	(0.044)
dwelling_typeRD:pre1940_in_mb	-0.003***	-0.004**	-0.004***	-0.004*	-0.004**	-0.004**
	(0.0005)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
dwelling_typeRF:pre1940_in_mb	-0.008***	-0.010***	-0.007***	-0.010***	-0.010***	-0.010***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
dwelling_typeRD:PM10_annual_average	-0.002*	-0.012**	-0.002	-0.011*	-0.013**	-0.011**
	(0.001)	(0.006)	(0.005)	(0.007)	(0.005)	(0.006)
dwelling_typeRF:PM10_annual_average	0.005**	-0.005	0.006	-0.003	-0.006	-0.005
	(0.002)	(0.007)	(0.006)	(0.008)	(0.007)	(0.007)
dwelling_typeRD:MB_burglaries	-0.004***	-0.005***	0.0003	-0.005**	-0.006***	-0.006***
	(0.0004)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
dwelling_typeRF:MB_burglaries	-0.006***	-0.008***	-0.002*	-0.006***	-0.007***	-0.008***
	(0.0005)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
dwelling_typeRD:log(X2013_median_HH_income)	-0.015**	-0.019	-0.040**	0.003	-0.020	-0.019
	(0.007)	(0.024)	(0.020)	(0.027)	(0.023)	(0.024)
dwelling_typeRF:log(X2013_median_HH_income)	0.037***	0.045	-0.003	0.056*	0.043	0.045
	(0.008)	(0.029)	(0.024)	(0.031)	(0.028)	(0.029)
dwelling_typeRD:log(pop_density_2013)	-0.030***	-0.023**	0.013	-0.008	-0.034***	-0.023**

	(0.003)	(0.010)	(0.008)	(0.012)	(0.010)	(0.010)
dwelling_typeRF:log(pop_density_2013)	-0.041***	-0.044***	-0.00004	-0.028*	-0.042***	-0.044***
	(0.004)	(0.014)	(0.011)	(0.015)	(0.014)	(0.014)
dwelling_typeRD:Parks_High	-0.007***	-0.002	0.001	-0.00003	-0.002	-0.002
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
dwelling_typeRF:Parks_High	-0.006***	-0.002	0.002	-0.00004	-0.002	-0.002
	(0.001)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)
dwelling_typeRD:Parks_Low	0.004***	0.004	0.004	0.005	0.004	0.004
	(0.001)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)
dwelling_typeRF:Parks_Low	0.005***	0.002	0.004	0.005	0.003	0.002
	(0.001)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
dwelling_typeRD:Golf_Cours	0.047***	0.075**	0.036	0.086***	0.071**	0.075**
	(0.008)	(0.033)	(0.027)	(0.031)	(0.032)	(0.033)
dwelling_typeRF:Golf_Cours	0.042***	0.071**	0.033	0.083***	0.067**	0.071**
	(0.008)	(0.033)	(0.027)	(0.031)	(0.032)	(0.033)
dwelling_typeRD:PAUP_Indus	0.003***	0.006	0.002	0.001	0.006	0.006
	(0.001)	(0.005)	(0.004)	(0.006)	(0.005)	(0.005)
dwelling_typeRF:PAUP_Indus	0.001	0.004	0.0005	-0.001	0.004	0.004
	(0.001)	(0.005)	(0.004)	(0.006)	(0.005)	(0.005)
dwelling_typeRD:Parks_High_None	-0.003	0.037	0.057**	0.044	0.053*	0.035
	(0.008)	(0.030)	(0.026)	(0.035)	(0.030)	(0.030)
dwelling_typeRF:Parks_High_None	-0.011	0.002	0.053*	0.019	0.016	0.001
	(0.009)	(0.033)	(0.028)	(0.037)	(0.032)	(0.033)
dwelling_typeRD:Parks_Low_None	0.244***	0.258*	0.207*	0.323**	0.285**	0.261*
	(0.033)	(0.139)	(0.113)	(0.160)	(0.135)	(0.138)
dwelling_typeRF:Parks_Low_None	0.305***	0.320**	0.294**	0.389**	0.331**	0.326**
	(0.034)	(0.143)	(0.116)	(0.163)	(0.139)	(0.142)
dwelling_typeRD:Golf_Cours_None	-0.064*	0.073	0.007	0.117	0.070	0.071
	(0.033)	(0.144)	(0.115)	(0.141)	(0.140)	(0.143)
dwelling_typeRF:Golf_Cours_None	-0.077**	0.075	-0.007	0.128	0.070	0.072
	(0.034)	(0.147)	(0.117)	(0.142)	(0.143)	(0.146)
dwelling_typeRD:PAUP_Indus_None	0.036***	0.087***	0.054**	0.092***	0.086***	0.087***
	(0.007)	(0.025)	(0.021)	(0.030)	(0.024)	(0.025)
dwelling_typeRF:PAUP_Indus_None	0.050***	0.095***	0.031	0.083**	0.090***	0.096***
	(0.008)	(0.028)	(0.024)	(0.032)	(0.028)	(0.028)
Constant	7.652***	7.632***	8.343***	8.211***	6.807***	7.613***
	(0.126)	(0.496)	(0.419)	(0.527)	(0.486)	(0.494)
Observations	128,868	10,000	10,000	10,000	10,000	10,000
R^2	0.794	0.799				
Adjusted R^2	0.794	0.797				
Log Likelihood			2,329.544	1,075.186	764.421	564.400
$sigma^2$			0.035	0.045	0.050	0.052
Akaike Inf. Crit.	-16,170.61	-941.5907	-4,481.087	-1,972.371	-1,350.841	-950.799
Residual Std. Error	0.227 (df = 128781)	0.230 (df = 9913)				
F Statistic	5,772.563*** (df = 86; 128781)	457.260*** (df = 86; 9913)				
Wald Test (df = 1)			10,966.470***	1,311.324***	403.408***	11.221***
LR Test (df = 1)			3,541.496***	1,032.781***	411.250***	11.208***
Note:	*p<0.1; **p<0.05; ***p<0.01					

Key results from Model 2 (measuring area of parks within a 500m radius)

To enable a qualitative comparison with the results of Model 1, which were reported in Section 3.3, we have summarised the results of Model 2 (estimated using a spatial error model with a 1km radius neighbourhood) in a similar way.

Table 12 summarises the average impact of parks and industrial zones within 500m of a property on sale price for three types of dwellings. We report the impact of:

- Having *at least one* regional park, local / neighbourhood park, golf course, or industrial zone (i.e. a non-zero area of this land use) within a 500 metre radius. A **positive** sign on this coefficient indicates that the presence of at least one park within 500m is associated with increased sale prices, relative to not having any parks in the area.
- Having an increased area of regional parks, local / neighbourhood parks, golf courses, or industrial zones within a 500 metre radius. A **positive** sign on this coefficient indicates that increased density of parks around dwellings is associated with higher sale prices.

A key finding of this analysis is that after controlling for spatial dependence, few model coefficients are statistically significant. The implication of this is that the quantity of parks, golf courses, or industrial zones within a 500 metre radius appears to have little or no impact on property sale prices.

However, the presence of at least one local / neighbourhood park *or* one regional park within a 500 metre radius is associated with a higher sale price for apartments – as shown in the bolded coefficient. These coefficients are statistically significant at the 5 per cent level. However, an increased quantity of local / neighbourhood parks within a 500m radius does not appear to have an additional effect and may in fact have a slight negative effect.

Moreover, we find evidence that the effect of presence of a local / neighbourhood park differs between dwelling types. The coefficients on the interaction terms between this variable and dwelling types RF and RD are statistically significant and of the opposite sign to the coefficient for apartments (RA). This suggests that the impact of having a local / neighbourhood park or a regional park within a 500m radius is weaker (and potentially not different from zero) for flats and houses.

Table 12: The impact of park density within a 500m radius (based on Model 2 estimated using a spatial error model with 1km radius neighbourhood)

Park type	**Coefficient**	**Dwelling type**		
		Apartment	**Residential flat**	**Standalone house**
Regional park	Impact of having >0 park area	**0.060** (2)	0.007 (4)	0.003 (3)
	Impact of an added 1 ha of park	-0.0010	0.0010	0.000
Local / n'hood park	Impact of having >0 park area	**0.258** (2)	-0.036 (3)	0.051 (4)
	Impact of an added 1 ha of park	**-0.006** (1)	-0.002	-0.002
Golf course	Impact of having >0 park area	0.013	0.020	0.006
	Impact of an added 1 ha of park	-0.036	-0.003	0.000
Industrial zone	Impact of having >0 industrial area	**0.045** (2)	**0.014**	-0.009 (3)
	Impact of an added 1 ha of industry	-0.005	-0.0045	-0.005

Notes: (1) Statistically significantly different from zero at the 1% level; (2) statistically significantly different from zero at the 5% level; (3) statistically significantly different from apartment coefficient (but not necessarily from zero) at the 5% level; (4) statistically significantly different from apartment coefficient (but not necessarily from zero) at the 10% level.

Appendix B A review of the broader hedonic literature

The prices that people pay for housing implicitly reflect the value that they place on various attributes of the dwelling, neighbourhood, and city. However, these attributes are “bundled” together in any individual dwelling, which can make it difficult to identify the individual value that people place on different attributes, such as:

- Dwelling characteristics – e.g. size, views, age, and condition
- Location – e.g. their proximity to employment centres, public goods, and natural amenities such as coastlines
- Neighbourhood characteristics – e.g. the presence of parks, historic buildings, or popular schools.

Hedonic analysis “disentangles” the implicit prices for different attributes using regression techniques (Rosen, 1974). Following this insight, a large empirical literature has emerged on the determinants of property prices.

In this Appendix, we briefly review the available evidence on the impact of a range of public amenities and disamenities, including proximity to public infrastructure and facilities and environmental nuisances, on property prices. This review is primarily focused on the New Zealand-specific literature, but we also consider the international literature where there is little or no local evidence.

Table 13 summarises the types of public amenities and disamenities that are covered in the hedonic pricing literature. These encompass both public investments and various public or mixed goods that are required or protected by regulations. We have also indicated some areas where there is, to the best of our knowledge, no empirical evidence.

Amenities and disamenities that are accounted for in our analysis are highlighted in bold.

Table 13: Types of public amenities and disamenities covered by the hedonic pricing literature

Amenity / disamenity	NZ evidence?	Int'l evidence?
Public parks and green spaces	**No**	Yes
Transport infrastructure (rapid transit, roads)	Yes	Yes
Sports stadiums	No	Yes
Libraries, museums and other cultural facilities	No	Some
School zones	Yes	Yes
Noise (e.g. airport flight paths)	No	Yes
Air quality	**No**	Yes
Undesirable / incompatible land uses	**No**	Yes
Neighbourhood aesthetics (e.g. landscaping, street trees)	Yes	Yes
Old / heritage buildings	**Yes**	Yes
Views	**Yes**	Yes
Overshadowing / access to daylight	No	No

Public parks and green spaces

To date, there has been no New Zealand-specific research into the hedonic value of parks and open spaces, but there is a sizeable international literature on this topic. Crompton (2001) and Brander and Koetse (2011) review and summarise this literature. Table 14 summarises some recent research into the value of proximity to parks.[26]

Crompton (2001) undertook a literature review of 30 hedonic pricing studies on open space, finding that all but five reported that increased proximity had a positive impact on property values. However, these impacts appeared to vary considerably depending upon park attributes.

More recently, Brander and Koetse (2011) undertook a meta-analysis of contingent valuation and hedonic analysis of the value of urban open space. Based on an analysis of 12 studies that reported explicit estimates of the effect of proximity to parks, they conclude that proximity to parks is associated with higher property values. Moreover, their meta-analysis suggests that proximity to parks is more highly valued in densely populated areas.

[26] Studies were identified by searching for combinations of the phrases {hedonic analysis, property value} and {parks, open spaces} in Google Scholar.

Some studies also considered the “interaction” between proximity to parks and other variables, such as distance to the city centre or local crime rates (Anderson and West, 2006; Troy and Grove, 2008). One insight from these studies is that the value of proximity parks may depend upon other location or neighbourhood attributes – e.g. proximity to parks may have a negative value in high-crime areas as they are perceived as being unsafe.

Table 14: Some recent studies on the value of proximity to parks

Study	Area / time period	Open space variables	Key findings
Anderson and West (2006)	Minneapolis-St Paul 1997	Straight-line distance to several types of open space (neighbourhood parks, special parks, golf courses, cemeteries) Size of nearest open space Distance and size are interacted in model. Distance is also interacted with other variables (e.g. distance to CBD, neighbourhood serious crime rates)	The value of proximity to open space depends upon a home's location and neighbourhood characteristics. Proximity to parks has a stronger positive impact in dense neighbourhoods near the CBD
Cheshire and Sheppard (2002)	Reading, UK 1984/85	Total open space in surrounding area, including public and private open space	Increased open space is associated with higher property values. The authors use the results of hedonic analysis to model the welfare implications of relaxing greenbelt regulations, finding that this would result in net gains.
Cho, Bowker and Park (2006)	Knox County, TN 1998-2002	Straight-line distance to park Size of nearest park	Across the entire study area, proximity to parks is positively associated with sale price. However, there is evidence of spatial variation in this value – proximity is negatively valued in some areas and considerably more highly valued in others.

Geoghegan (2002)	Howard County, MD 1993-1996	Percentage of land area within a 1600m radius that is developable open space (e.g. farms) or permanent open space (e.g. parks)	Increased density of permanent open space is positively associated with sale prices, as is increased density of developable open space. However, the relationship between developable open space and property values is weaker and not statistically significant.
Jim and Chen (2007)	Guangzhou 2004	Straight line distance to nearest park Also measures green space as a percentage of land area in the residential precinct	Proximity to parks is positively associated with sale price, as is the share of green space in the residential precinct.
Morancho (2003)	Castellon, Spain Unknown years	Straight-line distance to green area Size of nearest green area Variables are not interacted and collinearity is found between size of green area and other variables	Proximity to green urban areas is positively associated with dwelling sale price.
Nicholls and Crompton (2005)	Austin, TX	Straight-line distance to the nearest entrance to the greenbelt Properties adjacent to the greenbelt and properties with a view of the greenbelt were also identified	Proximity to the nearest entrance to the greenbelt is positively associated with sale price in one of three study areas; there was no statistically significant association in the other two areas.

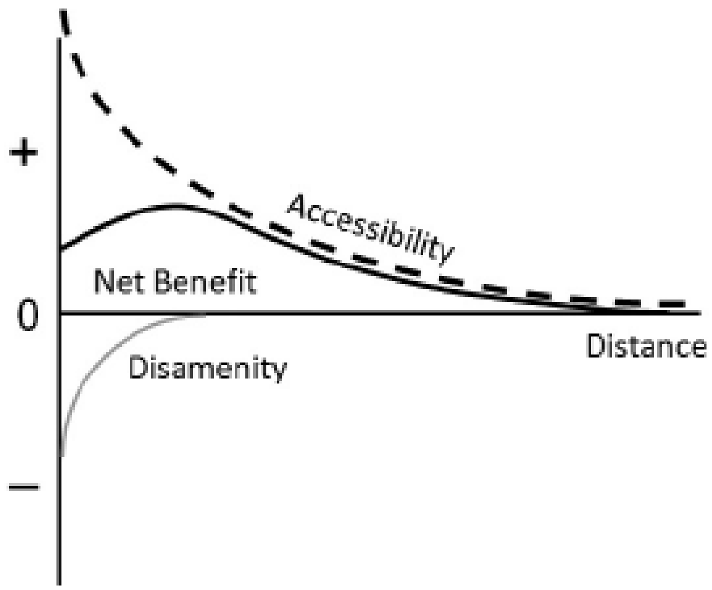
Rouwendal and van der Straaten (2008)	Amsterdam, The Hague and Rotterdam 2000	Percentage of land area within a 100-1000m radius that is parks and public gardens	Increased density of parks is positively associated with sale prices in the Hague and Rotterdam; only proximity to the Vondelpark positively affects sale prices in Amsterdam. The authors use these results to test the optimality of park provision (versus increased housing provision) in each city.
Sander and Polasky (2009)	Ramsey County, MN 2005	Road distance to closest park Straight-line distance to closest trail, lake, and stream	Proximity to parks is positively associated with home sale price
Troy and Grove (2008)	Baltimore 2001-2004	Straight-line distance to nearest park Distance is interacted with measures of violent crimes in the area of the park	Proximity to parks is positively associated with property value where the neighbourhood's combined robbery and rape rates are below a certain threshold, and negatively valued in areas with crime rates above that threshold

Transport infrastructure

There is a significant literature on the impact of transport infrastructure, especially rapid transit infrastructure, on property values. This includes two Auckland-specific studies on the impact of the Northern Motorway extension and the Western Line upgrades (Grimes and Liang, 2008; Grimes and Young, 2010). This literature has focused on changes in property values following the announcement, construction, or opening of new transport facilities.

New transport facilities may result in both localised disamenities from vehicle use (e.g. noise, air pollution, crash risk) and benefits from improved accessibility, both of which will affect property values. This is illustrated in Figure 10. Close to a new highway interchange (or rapid transit station), the disamenities associated with transport operations will tend to reduce property values – as shown by the grey line. However, there is also a countervailing effect, as improved transport accessibility raises property values in surrounding areas that are now more accessible – as shown by the dotted black line. The net effect is shown by the solid black line, which indicates that the property value impact is likely to be largest a moderate distance away from the transport facility.

Figure 10: Expected impacts of transport facilities on property values (Source: Seo et al, 2014)



Several authors have conducted meta-analyses of empirical studies of the property value impacts of rail investments. Mohammad et al (2013) conducted a meta-analysis of 23 empirical studies on the property value impacts of rail infrastructure, including 102 observations. They observed a wide variation in estimated property value impacts from -45% to more than +100%, with a mean impact of +8.0% and a median of +5.4%.

Debrezion et al (2007) conducted a meta-analysis on studies of the property value impacts of new rail stations. They reported 57 observations that indicate a wide range of property impact values from -61% to +145%, with a mean uplift factor of +8.6%.

Baker and Nunns (2015) also surveyed this literature, with a focus on the relationship between measured uplifts in property values and the benefits measured in conventional transport cost-benefit analysis. They argued that property value uplifts following transport improvements reflect the capitalised value of improved accessibility and environmental amenity, *plus* the value of improved opportunities for property development or redevelopment.[27]

Two Auckland-specific studies suggest that residential property values can rise in response to both road and rail investments:

- Grimes and Liang (2008) analysed the impact of the extension of Auckland's Northern Motorway from Tristram Avenue to Orewa on adjacent land values. They estimated that the extensions raised land values in the area by at least $2.3 billion (2004 NZD), not accounting for decreases or increases elsewhere in the city.
- Grimes and Young (2010) estimated the impact of the announcement of upgrades to Auckland's Western Line in 2005 on property values in the former Waitakere City. They found evidence of a statistically significant "announcement effect" – property values adjacent to stations rose by 3.5% following the announcement (but prior to project completion), with diminishing impacts up to 9 kilometres from rail stations. In total, Waitakere land values rose by an estimated $217-$244 million (2004 NZD), not accounting for increases or decreases elsewhere in the city. Grimes and Young speculated that the effects after project completion may be higher.

Consistent with these findings, Maré et al (2011) find that land prices decline with increased distance to the nearest railway station and the nearest motorway onramp in Auckland. However, they also note that these relationships have weak explanatory power (i.e. low R^2 values).

Sports stadiums

There is no New Zealand-specific literature on the impact of new stadiums or sports facilities on property values. However, several studies have investigated the relationship in other jurisdictions.

Sports stadiums have been hypothesised to impose negative externalities on neighbouring properties and hence reduce their values. However, four recent studies contradict this expectation.[28] They found that the construction of new stadiums tends to raise, not lower, surrounding residential property values. In some cases, effects were observed after announcement of the projects as well as after construction.

[27] Which would be additional to the benefits estimated by conventional evaluation procedures.

[28] These studies addressed the following stadiums:

- Millennium Stadium, Cardiff and City of Manchester Stadium (Davies, 2005)
- Fedex Field, Washington DC (Tu, 2005)
- Three multifunctional sports arenas, Berlin (Ahlfeldt and Maennig, 2007)
- New Wembley and Emirates Stadium, London (Ahlfeldt and Kavetsos, 2014)

Libraries, museums, and other cultural facilities

Libraries, museums and other cultural facilities are often funded, provided, or otherwise supported by councils. These facilities are often provided free of charge to the public.

There is some international evidence linking the presence of these facilities to higher property prices. However, there is no New Zealand-specific literature on this topic.

Clark and Kahn (2006) analysed the impact of six cultural amenities – museums, zoos, dance companies, theatres, operas, and symphonies – on US cities (taking into account both median house prices and wage levels). They used this analysis to estimate willingness to pay for increased cultural facilities, finding a positive effect from all amenities at the city level.

De Groot et al (2015) measured the impact of accessibility to cultural facilities (concerts and theatre shows) within an acceptable travel time on land prices in Dutch cities. They found that being able to reach 100 concerts or theatre shows (per annum) from a location is associated with an increase in land value of 16 euro per square metre. However, we note that this measure may not reflect the direct role of council services, as concerts and theatre shows are private goods that are typically provided by the market, albeit sometimes with government support through grants or access to public facilities.

School zones

School zoning can also influence property prices, especially in countries like the US where schools are funded / provided by local governments. Rehm and Filippova (2008) undertake a review of the international literature, which generally shows that the (perceived or actual) quality of schools can make some areas significantly more or less desirable for households.

In New Zealand, several papers have explored the impact of specific school zones on property prices, following the reintroduction of geographically delimited school zones in 2000. McClay and Harrison (2003) and Gibson et al (2005) analysed the impact of individual school zones on property prices in Christchurch, finding evidence of varying price premium for individual school zones. The latter study estimated lower price premiums after controlling for spatial autocorrelation in the data (i.e. the tendency of higher-value homes to cluster together for reasons that are hard to measure).

In Auckland, Rehm and Filippova (2008) analysed the impacts of the reintroduction of geographic school zones on residential property prices in inner-city Auckland. They found evidence that prices within the Auckland Grammar and Epsom Girls Grammar zones diverged from prices in adjacent areas, while prices around the Auckland Girls Grammar and Mount Albert Grammar zones did not diverge to a comparable degree. Rohani (2012) also explored the impact of school deciles in Auckland’s North Shore, but does not find sufficient variations in decile ratings within the study area to enable a robust analysis.

In a separate analysis of the patterns of population location and land prices in Auckland, Maré et al (2011) find that land values tend to decline with increased distance to the nearest school. However, they do not attempt to classify schools by quality.[29]

Noise

There are a number of empirical studies on the impact of higher noise levels, especially from airport operation, on residential property values. However, there are no New Zealand-specific studies on this topic.

Nelson (2004) undertook a meta-analysis of twenty studies on the impact of airport noise exposure on residential property values in Canada and the United States. He found that a one decibel (dB) increase in noise levels is associated with a 0.8-0.9% reduction in property values in Canada, and a 0.5-0.6% reduction in property values in the United States. (Within the range of noise levels up to 75 dB. Note that decibels are reported on a logarithmic scale, meaning that the perception of noise doubles for every 10 dB increase.)

The NZ Transport Agency (2013) recommends using a higher value for valuing the negative noise impacts of road traffic in the context of transport appraisal. They suggest that a one decibel increase in all-day noise levels is associated with a 1.2% reduction in residential property values. This higher value reflects the fact that some negative effects of high noise may not be fully capitalised into residential property prices.

Air quality

In a similar vein, there are a number of empirical studies on the impact of poor air quality on property values. However, there are no New Zealand-specific studies on this topic.

Smith and Huang (1995) undertook a meta-analysis of 37 US studies of the impact of air quality on property values undertaken over the period 1967-1988. They found that the mean willingness to pay for a 1 microgram per cubic metre reduction in average particulate (PM10) concentrations across these studies is approximately $110 per house in 1982-84 USD. However, the median estimate was only $22, suggesting that results may vary considerably between studies.

Subsequent research has addressed various other issues, such as the impact of other pollutants (SO2 and NOx) on property values (Kim et al, 2003), the impacts of *changes* to air quality following new air quality legislation in the US (Chay and Greenstone, 2000), and the impact of migration (and cost barriers to moving away from areas of poor air quality) on estimates of willingness to pay for better air quality (Bayer et al, 2008). The last two studies, which attempted to address the issue of households moving or “sorting” themselves spatially in response to poor air quality, resulted in higher estimates of the value of air quality than conventional hedonic model designs.

[29] Decile ratings are a measure of socioeconomic status within school zones, rather than the quality of schools.

Incompatible land uses

The colocation of incompatible land uses may result in some negative externalities. While some nuisances are related to noise and air quality issues discussed above, others may be harder to measure, such as smells, dust, reverse sensitivities (i.e. noxious land uses receiving complaints from sensitive neighbours), and visual disamenities. These effects may arise between (for example) industrial and residential land uses or rural and residential activities.

Consequently, some studies have estimated the impact of proximity to incompatible land uses on residential property values. While there is no New Zealand-specific literature on this topic, several papers estimated these relationships in other cities. Farber (1998) undertook a literature review of 25 studies on the impact of undesirable land uses, such as power stations, refineries, landfills, incinerators, hazardous waste sites, heavily polluted (Superfund) sites, on property values. On the whole, these studies suggested that these land uses lower nearby residential property values.

Other studies focused on the impact of industrial zones or industrial activities on residential property values. McMillen and McDonald (2002) analysed the effect of Chicago’s first zoning code (1923) on land values. The aim of the zoning code was to separate commercial, industrial and residential activities. They found that applying exclusively residential zoning led to higher growth in land prices, even in neighbourhoods with a mix of existing uses that were “grandfathered in” by the zoning code. The authors interpreted this as evidence that zoning provides an “insurance policy” against future entry of incompatible land uses.

Other studies focused on the impact of proximity to incompatible land uses on residential property values at a single point in time. Rouwendal and van der Straaten (2008) found that the amount of industrial land within a 500 metre radius is negatively associated with house prices in three large Dutch cities. De Vor and De Groot (2011) investigated the impact of proximity to industrial sites on residential property values in the Randstad and North-Brabant areas of the Netherlands. They found that proximity to industry is associated with lower house prices, but that these effects are limited to a 750 metre distance in the North-Brabant area.

Neighbourhood aesthetics

Neighbourhood aesthetics, such as the presence of street trees and attractive landscaping, may act as local public goods that can be enjoyed by people in the immediate vicinity. There is some New Zealand-specific evidence that aesthetics positively affect neighbouring property values.

Bourassa et al (2005) investigated the impact of several aesthetic characteristics, including “attractive immediate surroundings” and “good landscaping”, on property values in Auckland, Wellington and Christchurch. While their results are based on subjective assessments of the built environment around house sales, they suggest that more aesthetically pleasing neighbourhoods have positive spillovers for neighbours. Bourassa et al estimated that the value of “attractive immediate surroundings” in Auckland rose from roughly $12,000 per house in 1986 to around $31,000 in 1996 (in 1996 NZD), while the value of “good landscaping” rose from around $7,000 to $12,000 over the same period.

In a similar vein, some overseas studies have analysed the value of street trees and tree cover. Donovan and Butry (2010) analysed the impact of street trees and neighbourhood tree cover on residential property values in Portland, Oregon. They found that the number of street trees fronting houses and the total crown area of trees within a 30.5m radius had a positive effect on prices. In a similar analysis of multifamily dwellings in Los Angeles, Li and Saphores (2012) found that an increase in tree canopy cover within a 200 metre distance of property boundaries was associated with higher prices. However, increases in grassy areas in the vicinity did not enhance property values.

Old / heritage buildings

There is a large empirical literature investigating the impact of building age on property prices. Hedonic pricing studies have often, although not always, found evidence of a price premium for older buildings. Auckland-specific studies of the value of older buildings include Bourassa et al (2005), Rehm et al (2006), and Nunns et al (2015). However, this literature relates to the *private* benefits of older buildings, rather than the public benefits that may be preserved by regulation.

In response to this, several papers have investigated positive spillovers from old or historic buildings. Lazrak et al (2014) found that scheduled heritage properties in Zaanstad, The Netherlands raise the value of houses within a 50-metre radius by 0.24-0.28%. Nunns et al (2015) employed a similar approach to study the value of pre-1940 buildings in Auckland. They found that each additional pre-1940 building in a neighbourhood is associated with 0.3% higher sale prices for surrounding houses. Similarly, de Groot et al (2015) found that increased density of scheduled historic buildings in Dutch cities was associated with higher land prices.

Other international studies have explored the relationship between heritage preservation policies and property values. Nijkamp (2012) surveyed the empirical literature on the effect of heritage scheduling (or “listing”) or heritage management regulation on house prices. He found that heritage preservation policies were associated higher property values in a range of cities.

However, a separate study by the Australian Productivity Commission (2006) found either mixed results or no significant positive price effect associated with heritage listing or regulation in two Australian cities.

Views

There is a large empirical literature on the value that people place on views. This literature suggests that there is a positive relationship between access to views and residential property values.

Table 15 summarises some Auckland-specific studies on the value of views. These studies indicate that the price premium for water views is potentially large, while views of land are less valued. These findings are generally consistent with international research – see Bourassa et al (2004) for a review of international studies of the value of views.

One caveat to this literature is that it is difficult to measure variations in the quality of views of land in Auckland. For example, a view out to an industrial park may be valued very differently to a view of the Waitakere Ranges. Consequently, it is possible that some views of land may be considerably more valued than average.

Table 15: Studies of the value of views in Auckland

Study	Summary
Bourassa et al (2004)	In Auckland, a view of land was associated with a 4-6% higher price for houses sold in 1996. Wide views were more valued than narrow views. Views of water had a higher value – views of water at the coast were associated with a 33-59% increase in sale price, depending upon whether the view was medium or wide in scope. The value of water views drops off sharply with distance – at 2000 metres from the coast, water views raised prices by 11-14%, depending upon scope of view.
Rohani (2012)	In Auckland's North Shore, a view of land was associated with a 6% higher property valuation in 2011. A view of the Hauraki Gulf, which is likely to include Rangitoto, was associated with a 15-50% higher property valuation, with wider views worth more.
Nunns et al (2015)	For residential properties sold in Auckland between 2011-2014, views of water had a strong positive association with sale prices (+8.3%), while views of land had a slight negative association with sale prices (-1.7%). (Based on the preferred spatial regression model; OLS models produced higher coefficients. Note that most previous research on Auckland is limited to OLS.) 13.2% of residential sales had views of water.
Filippova (2009)	For residential properties sold in Auckland between 2004 and 2006, water views were associated with an average price premium of 18%. However, the water view premium varies significantly between 17 sub-markets, ranging from a minimum of 5% in West Harbour to a maximum of 54% in Mission Bay.

Overshadowing and access to daylight

There are no published studies that identify the relationship between overshadowing and property values. This is surprising given that many cities, including Auckland, have many rules such as height limits, boundary setbacks, and height in relation to boundary controls that are intended to preserve access to daylight in built-up areas of the city.

Find out more: phone 09 301 0101
email rimu@aucklandcouncil.govt.nz or
visit www.aucklandcouncil.govt.nz

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