The Effect of Landscape Regeneration on Housing Prices

The Effect of Proximity to Landscape Regeneration projects on Housing Prices in the Altiplano Estepario Region

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Abstract

Land degradation is one of the most pressing environmental and socio-economic challenges in Mediterranean dryland regions. This research explores the non-market value of landscape regeneration by estimating the effect of proximity to restored areas on residential property prices in the Altiplano Estepario (southeast Spain). The hedonic pricing method is applied to determine whether the benefits of ecosystem restoration are reflected in local housing prices. The analysis employs a flexible spline regression to capture potential non-linear distance effects, supplemented by robustness checks and alternative specifications analyses. The results indicate that properties located within 15 km have a significant negative relationship with distance to the regeneration zones. This suggests that the visual and amenity value of restored landscapes is a determinant in housing demand. At greater distances, the influence of regeneration diminishes, highlighting the importance of spatial targeting in restoration planning. The alternative specifications incorporate key indicators of landscape regeneration. Land degradation, measured through erosion levels, is consistently associated with lower property values. This finding underscores the economic relevance of preserving and enhancing existing natural areas. The composition of surrounding land cover also matters. Agricultural landscapes, particularly those linked to sustainable practices, are positively valued by the housing market. This research contributes to the existing literature on the socio-economic impacts of ecosystem restoration in rural contexts. By showing that landscape regeneration can deliver market-recognized benefits, the findings strengthen the case for integrating ecological and economic objectives in regional development strategies. In addition, the results highlight the potential for housing markets to serve as indicators of public preferences for environmental quality in Mediterranean drylands.

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1. Introduction

Land degradation has emerged as a critical global challenge. The depletion of the earth by consistently extracting from the soil over a longer period of time, while not taking care of it, is threatening biodiversity, food security, and climate stability (UNEP & FAO, 2021). In response to this immense challenge, the United Nations initiated the Decade on Ecosystem Restoration (2021–2030). This program aims at promoting coordinated efforts that are needed to rehabilitate damaged ecosystems (UNEP & FAO, 2021). Research by the UNCCD (2022) found that 20% to 40% of the Earth's land surface is degraded, placing nearly half of the global population and approximately USD 44 trillion in economic output at risk. If current trends persist, an area the size of South America, 1.6 billion hectares, could become further degraded by 2050.

Although the scale of the problem is immense, the financial investment required to restore degraded ecosystems is relatively modest. The cost of restoring 1 billion hectares by 2030 is estimated at USD 1.6 trillion, significantly less than the USD 700 billion spent annually on environmentally harmful subsidies, including those for fossil fuels and unsustainable agriculture (UNCCD et al., 2022). To ensure long-term effectiveness, restoration strategies must be integrated with economic development (IPBES, 2019). Especially rural areas are under pressure from land abandonment, intensive agriculture, and climate change. As shown in research by Newton et al. (2021), ecological restoration of agricultural land at a landscape scale can increase the provision of ecosystem services while enhancing economic development and employment.

Landscape regeneration has proven to be a viable strategy to mitigate land degradation. These nature-based practices rebuild soil health, support biodiversity recovery, and restore natural water cycles in degraded environments. It can also be applied in agricultural environments while maintaining or enhancing agricultural productivity. Sustainable land management practices such as agroforestry, reforestation, and crop diversification have proven effective in improving soil fertility, increasing water retention, and boosting yields (Giger et al., 2015; van der Esch et al., 2022). Such practices contribute to international objectives on biodiversity, climate mitigation, and sustainable land use (IPBES, 2018). However, uptake remains limited due to institutional, financial, and informational barriers, as well as exposure to environmental shocks like drought and flooding (Knowler & Bradshaw, 2006; Ding et al., 2017; Zeweld et al., 2018).

A specific example of a regenerative landscape project is found in Altiplano Estepario, a semi-arid region in southeastern Spain overlapping parts of the provinces of Almería, Granada, and Murcia. Besides social challenges such as poverty, population aging and high unemployment, the Altiplano Estepario faces significant environmental challenges, including soil degradation, biodiversity loss, desertification, and erosion (Crowter Lab, 2023). These issues are exacerbated by unsustainable agricultural practices, such as intensive tilling, limited organic matter return to the soil, and reliance on chemical inputs. These methods, while offering short-term yield benefits, have contributed to long-term landscape degradation (Nuñez, 2023).

In response, the international non-profit organisation Commonland, in collaboration with the local association AlVelAl, has launched a large-scale regeneration initiative using the 4 Returns Framework in 2014. This model focuses on four types of returns over a 20-year period: natural capital (soil, water, and biodiversity), social capital (community cohesion), inspiration (sense of purpose), and financial capital (viable rural business models) (Ferwerda, 2015). Through regenerative farming, reforestation, and multi-stakeholder engagement, this initiative seeks to transform degraded areas into economically and ecologically resilient landscapes (Commonland, 2025).

Expressing the outcomes of landscape regeneration in numbers is essential to evaluate its ecological and socio-economic impacts on the local environment and attract long-term investment. As restoration gains attention in international environmental policy, stakeholders increasingly look for measurable indicators to compare progress across time and regions (Cimon-Morin et al., 2013). Demonstrating tangible returns such as improved soil health, higher agricultural productivity, or rising property values, not only helps in decision-making but also builds the case for public and private investment in restoration. This is particularly important in addressing the restoration investment gap, as public funding still dominates over private investment in ecosystem restoration (Ding et al., 2017).

A well-established method for valuing environmental benefits in housing markets is the hedonic pricing model, which estimates how non-market goods such as clean air, green space, or scenic views are reflected in property values (Rosen, 1974; Anderson & West, 2006; Ma & Swinton, 2011). The underlying assumption is that households are willing to pay a premium for environmental amenities, and that this willingness is observable through market behavior. This framework has been widely used in urban settings to evaluate the monetary value of parks, vegetation, and open space. In contrast, the use of hedonic pricing to evaluate the effects in rural areas, especially of landscape restoration, remains limited. While some studies show that rural properties benefit from proximity to natural features or higher ecological quality (Ma & Swinton, 2011; Oleagordía Montaña et al., 2015), few have examined whether targeted restoration interventions are perceived and valued by the housing market.

Restoration efforts are targeted at generating a range of ecosystem services such as erosion control, improved vegetation, enhanced landscape aesthetics, and opportunities for recreation. These may increase the attractiveness of nearby properties. Benefits are especially salient to local residents and are most likely to be capitalized into housing prices when they are visible, accessible, or experienced regularly. This expectation is consistent with previous research on green space and environmental amenities (e.g., Bin & Polasky, 2005; Sander & Haight, 2012), which finds that the value of environmental benefits tends to decline with distance.

Building on these insights, this study applies a hedonic pricing model to assess whether proximity to landscape restoration projects in the Altiplano Estepario, a rural dryland region in southeastern Spain, is reflected in housing prices. By doing so, it provides empirical evidence on the extent to which ecosystem service improvements, such as erosion control and visual landscape quality, are recognized and valued by local housing markets. This analysis contributes to the broader literature on environmental valuation by extending the application of hedonic pricing to rural restoration contexts, which remain underexplored compared to urban green space settings.

Specifically, this research focuses on answering the following question:
"What is the effect of proximity to regenerated landscape projects on housing prices in the Altiplano Estepario?"

The effect of proximity to regenerated areas is hypothesized to be associated with higher housing prices. Improvements in environmental quality, landscape aesthetics, and ecological functioning are likely to enhance the desirability of residential locations and become reflected in property values. However, such effects are expected to be limited to relatively short distances, as the perceived environmental and aesthetic benefits tend to diminish with increasing distance.

This research is structured as follows. Chapter 2 reviews the relevant literature, with a focus on applications of hedonic pricing in rural contexts and how environmental improvements are valued in housing prices. After that, the methodological approach is discussed in Chapter 3, while Chapter 4 presents the data, including sources and processing steps. Chapter 5 reports the main empirical results of the main model and alternative specifications. Chapter 6 discusses these findings in relation to existing literature and policy implications. Finally, Chapter 7 concludes the research, reveals its limitations and offers recommendations for future research.

2. Literature review

2.1 Rural hedonic pricing method

The Hedonic Pricing Method (HPM), formalized by Rosen (1974), is a widely applied econometric tool for valuing non-market attributes embedded in market goods, especially real estate. The core idea is that a property's price reflects the bundle of characteristics it offers, including structural features, location, and environmental amenities. The HPM has been widely applied in the literature to estimate the value of public and environmental goods, such as urban open space and parks (e.g., Anderson & West, 2006), air quality (e.g., Bajari et al., 2012) and noise reduction (Cohen & Coughlin, 2008). However, most of these applications are in urban areas. The use of HPM in rural contexts, especially to value environmental quality or ecosystem restoration, is less common but growing.

2.2 Valuation of ecological restoration

Ecological restoration, defined as the process of assisting the recovery of degraded ecosystems, is increasingly recognized as a public good with both ecological and socio-economic value (IPBES, 2019). These values must be considered when assessing the societal costs and benefits of land-use interventions (de Groot et al., 2013). As ecological restoration becomes a central tool in addressing climate change, biodiversity loss, and land degradation, there is a growing need for robust economic valuation methods that capture the full range of benefits it provides (Cimon-Morin et al., 2013).

There are multiple approaches for valuing ecological restoration. Stated preference methods, such as contingent valuation and choice experiments, estimate willingness to pay based on hypothetical scenarios. These are useful for capturing non-market benefits but often face criticism for hypothetical bias. Cost-based methods, including avoided damage costs and replacement costs, are sometimes used but can underestimate value by ignoring user preferences. Production function approaches link restoration to changes in ecosystem services that directly support economic activities, such as increased agricultural productivity or water regulation. In the Altiplano Estepario research has been done by de Groot et al. (2021). They made use of integrated cost-benefit analysis to compare different agricultural methods for almond production. The results show strong net benefits for sustainable land management once externalities were included.

Among revealed preference methods, the hedonic pricing method stands out as particularly suitable for quantifying the value of environmental improvements reflected in housing markets. This method is widely used in environmental economics because it relies on actual market behavior rather than stated intentions, offering strong policy relevance (Freeman et al., 2014). However, a key limitation is that HPM can only capture the value of environmental attributes that are both observable and understood by market participants, meaning it may underestimate the value of less visible or poorly perceived ecological benefits (Paterson & Boyle, 2002).

2.3 Capitalization of ecological improvements into housing markets

Existing HPM literature demonstrates that the presence of nearby environmental and cultural amenities are capitalized into property values. Ma and Swinton (2011) examined agricultural land markets in rural Michigan to explore how ecosystem services are incorporated into land prices. They found that land situated near forests, lakes, and conservation areas commanded higher prices. Similar evidence is found in Switzerland where Schläpfer et al. (2015) observed that rental prices tend to rise in areas offering access to natural features such as lakes, wetlands, and undisturbed landscapes, as well as culturally significant sites.

In light of this evidence, it is reasonable to expect that landscape restoration initiatives, such as reforestation, erosion control, and biodiversity enhancement, may also influence property values through similar mechanisms. These interventions do more than restore ecosystem functioning; they often enhance the visual character and perceived livability of a landscape (Oleagordía Montaña et al., 2015). When urban forest cover is present either on a parcel, in the surrounding neighborhood, or as large nearby forest blocks, these landscape features can contribute to housing value, depending on their visibility and spatial configuration (Mansfield et al., 2005).

Studies have shown that restoration outcomes such as improved soil quality, reduced erosion, and increased biodiversity can improve land productivity and ecological resilience, contributing to perceived property value (Ma & Swinton, 2011). Flood risk mitigation, particularly in areas exposed to extreme weather, represents another valued benefit (Bin & Polasky, 2005). In many contexts, improvements in scenic quality that is achieved through reforestation or the restoration of degraded landscapes have been linked to housing price premiums. Additionally, enhanced recreational potential, wildlife habitat restoration, and pollination services are often valued implicitly by homebuyers, especially in semi-rural contexts (Mäler et al., 2008).

The extent to which these improvements are reflected into housing values varies across several dimensions. Cavailhès et al. (2009) prove that proximity and outlook are critical. Properties that are closer to or have direct views of restored landscapes tend to exhibit stronger price effects (Dai, Felsenstein, & Grinberger, 2023). Market awareness and policy credibility also matter; buyers are more likely to pay premiums when restoration efforts are perceived as permanent and backed by long-term management (Klaiber & Smith, 2010). Clayton et al. (2024) finds evidence for significant differences across land value quantiles for biodiversity valuation. Additionally, the baseline environmental condition plays a role: improvements in degraded landscapes tend to generate higher marginal gains than enhancements in already pristine areas (Mäler et al., 2008). Time lags are also common. It takes nature time to restore, as well as housing markets may take years to fully reflect those new environmental amenities (Irwin & Bockstael, 2001).

3. Methodology

3.1 Model framework and identification strategy

This research makes use of the hedonic pricing method (HPM) to measure the effects of landscape restoration projects on residential housing values.

The functional form of the model looks like this:

$$\ln(Price_i) = f(Distance_i) + \mathbf{X}_i'\beta + \mathbf{N}_i'\delta + \gamma_{r(i)} + \varepsilon_i \quad (1)$$

Where $\ln(\text{Price}_i)$ denotes the natural logarithm of the asking price of property i, $f(\text{Distance}_i)$ is a flexible function of the Euclidean distance to the nearest landscape regeneration site, $\mathbf{X}_i$ represents a vector of structural house characteristics as well as property fixed effect. $\mathbf{N}_i$ represents neighborhood characteristics. Lastly, $\gamma_{r(i)}$ represents town fixed effects and ε_i is the error term.

To capture the potentially non-linear relationship between proximity to landscape regeneration areas and housing prices, distance is modeled using a natural cubic spline with three degrees of freedom. This flexible approach allows the data to determine the shape of the distance decay effect without imposing a fixed functional form. The rationale for this specification is that the ecological and aesthetic benefits of restoration, such as improved soil quality, flood mitigation, and enhanced landscape appeal, are expected to be most pronounced at shorter distances and taper off with distance. A spline transformation therefore enables a more realistic, data-driven estimation of how proximity influences property values.

In a spline model, the degrees of freedom refer to the number of basis functions used to flexibly approximate the shape of the relationship. Conceptually, this is similar to including polynomial terms in a regression, but splines offer better control over fit and smoothness across the entire domain of the variable (Harrell, 2015). Using three degrees of freedom provides a balance between flexibility, model simplicity, and interpretability. According to Harrell (2015), this degree of flexibility is often sufficient in smaller sample models to detect plausible non-linear relationships while avoiding overfitting.

To assess the robustness of the spline regression results, two alternative functional forms are estimated: a linear model, which assumes a constant marginal effect of distance, and a categorical model based on 2.5 km proximity bands up to 20 km. These specifications, presented in the results chapter, serve as useful benchmarks. Notably, the categorical model closely replicates the downward slope observed in the spline within the first 20 km, reinforcing the evidence of a distance-decay effect in housing prices. This approach is consistent with methods employed by Łaszkiewicz et al. (2022) and supports a more data-driven understanding of how landscape restoration is capitalized into rural property markets.

It is important to note that although this approach provides valuable insights into how environmental amenities are reflected in the housing market, it does not permit a causal interpretation in the strict econometric sense. This is primarily because the placement of restoration projects is non-random: such interventions often target highly degraded areas that may already have lower baseline property values. Due to the absence of pre-treatment housing data, this potential negative selection bias cannot be empirically verified. Though it suggests a likely negative selection bias that would attenuate the estimated effect. To mitigate this concern, the analysis includes a comprehensive set of control variables, employs a flexible functional form for distance, and includes alternative model specifications that use proxies for environmental quality. Taken together, these strategies aim to provide a robust and credible estimate of the extent to which landscape restoration efforts are reflected in local housing markets.

3.2 Main variables

ln(price) represents the dependent variable of the natural log of listed price of a certain individual house (i) within the Altiplano Estepario region. All prices are put in Euros and by using the natural log rather than the absolute price helps us with reducing skewness and the influence of outliers. It also provides us with the opportunity to interpret the results as a percentage change in price with respect to the rest of the included variables.

The key variable of interest is the distance to the nearest regenerated landscape site, measured in Euclidean distance (in kilometres). Due to the use of splines, the individual spline coefficients do not have a direct interpretation. Instead, the full spline function captures how the implicit price of proximity to restoration sites varies across different distances. This approach enables us to identify the distance ranges where landscape regeneration is most strongly capitalized into property values.

3.3 Control variables

3.3.1 House control variables

In a HPM model, it is important to control for a comprehensive set of housing-specific structural characteristics such as building size (measured in built square meters), number of bedrooms and bathrooms, presence of a garden, terrace, or swimming pool (e.g. Dai, X et al., 2023). These variables capture intrinsic differences in housing quality and desirability that are unrelated to the surrounding environment but can significantly influence market value.

In addition, property type fixed effects are included to control for systematic differences across property categories such as detached houses, village homes, rural estates, and luxury properties (Bajari et al., 2012). These may influence price independently of structural attributes or location. These fixed effects help isolate the environmental contribution to property values by absorbing unobserved variation related to the type of dwelling.

3.3.2 Neighborhood control variables

At the neighborhood level, the model includes variables that capture spatial accessibility and environmental context. One control variable measures the distance to the nearest city with more than 10,000 inhabitants, serving as a proxy for accessibility to employment, services, and infrastructure. The coefficient of this variable is expected to be negative, as properties located farther from urban centers generally experience reduced accessibility and lower demand. This relationship is well documented in the literature on rural housing markets and environmental valuation (e.g., Bilbao-Terol et al., 2017; Ma & Swinton, 2011). Including this control helps reduce potential omitted variable bias arising from differences in regional accessibility.

The model also includes a control for distance to the coastline, given that proximity to coastal areas is frequently associated with positive amenity values related to recreational opportunities, aesthetic quality, and climate moderation (Cavailhès et al., 2009). Similar to the urban accessibility variable, a negative coefficient is expected, indicating a price premium for houses located closer to the coast. These spatial accessibility controls account for variation in locational desirability that is independent of the landscape regeneration effort under investigation.

To further address unobserved spatial heterogeneity, town-level fixed effects are included. These fixed effects absorb all unobserved, time-invariant differences at the municipal level such as local unemployment rates, baseline environmental quality, or regional housing market conditions that might otherwise bias the estimated impact of restoration. As a result, the estimated coefficients reflect within-town variation, comparing properties located at different distances to restoration projects within the same municipality, rather than across municipalities.

By incorporating both property-level and neighborhood-level control variables, along with fixed effects, the model aims to normalize housing units in terms of their baseline market value. This approach helps ensure that the estimated coefficient on the landscape regeneration variable reflects the capitalized value of environmental improvements, rather than being confounded by variation in property characteristics or accessibility. Following previous research, this specification contributes to mitigating endogeneity concerns and strengthens the internal validity of the hedonic pricing model.

3.4 Alternative specifications

To strengthen the interpretation of the estimated effect of distance to landscape regeneration sites, a series of alternative specifications is conducted in which the main explanatory variable is replaced by alternative indicators that are theoretically and empirically linked to landscape regeneration processes. These proxies allow us to test whether the main findings are robust across different dimensions of environmental quality that are likely to be influenced by restoration activities. In all models, the same set of control variables is retained to ensure comparability across specifications.

The first alternative specification replaces proximity by erosion level. Literature shows that soil erosion is a core driver of land degradation in Mediterranean dryland regions such as the

Altiplano Estepario. Erosion level is therefore a central target of landscape regeneration effort and can serve a direct indicator of the need for, and an inverse indicator of restoration benefits (Lal, 2001; García-Ruiz et al., 2013). A negative correlation between erosion intensity and housing prices would suggest that degraded land conditions are valued negatively in the housing market. This could be due to erosion leading to reduced visual appeal, diminished agricultural productivity, and heightened exposure to environmental risks. Confirming this relationship would provide evidence that restoration projects aimed at reducing erosion could yield tangible economic benefits for nearby properties. This makes erosion a suitable inverse proxy for landscape health and restoration success. The erosion level at each property location is therefore included as an explanatory variable. In the main model, the analysis is restricted to properties located on land surfaces (erosion classes 1–7), where erosion is a meaningful indicator of environmental quality. In the robustness model, all properties are included, with additional dummy variables for water bodies (erosion class 8) and artificial surfaces (class 9) to account for distinct value dynamics in these settings and to verify that the main results are not driven by sample composition.

Secondly, land cover composition within a 1 km radius of each property is included. Land cover serves as a key proxy for the outcomes of landscape regeneration, as restoration projects aim to transform degraded land (bare soil, abandoned cropland) into more ecologically functional landscapes. Changes in land cover reflect improvements in vegetation cover, biodiversity, and aesthetic value (Crouzeilles et al., 2016). Moreover, land cover in the surrounding landscape is highly relevant for residents' perceptions and property values (Ma & Swinton, 2011; Sander & Haight, 2012). By incorporating shares of six aggregated land cover categories, the model captures landscape-level effects of restoration beyond formal project proximity and allows for a more comprehensive assessment of how environmental conditions are capitalized into housing markets.

Together, these alternative specifications serve as robustness checks for our main results and contribute to a more comprehensive understanding of how various aspects of landscape regeneration are capitalized into housing markets. Moreover, they allow us to distinguish whether observed valuation effects are driven by formal project proximity, by improvements in underlying land conditions or by changes in the broader landscape context. The outcomes of these analyses therefore provide additional insight into the spatial and functional mechanisms through which landscape restoration influences economic outcomes in rural housing markets.

4. Data

4.1 Landscape regeneration areas

Spatial data on the outline of the boundary area of Altiplano Estepario were provided by CommonLand. Data on the landscape regeneration areas are received from the AlVelAl organisation. However, it is important to note that from the three zones (natural, combined and economic), only the spatial data for the natural regeneration zones were available and shared for this research.

4.2 Housing data and controls

For the housing market data, Idealista is used as the primary source. Idealista is the largest online real estate marketplace in Spain. A custom geographic search area is defined on the website that globally corresponds to the Altiplano Estepario region (Appendix 1). To ensure relevance to the research topic, this study excluded flats, penthouses, duplexes, and terraced houses, focusing only on rural houses as these are most likely to be directly affected by the landscape regeneration projects. The data collection was performed on 15 April 2025, capturing all listings available within the defined area on that day.

To collect the data, this research used a web automation tool to extract publicly available information from Idealista (www.idealista.com). The data collection was carried out exclusively for academic purposes within the framework of this master's thesis. No personal or sensitive data was gathered, and all analyses were conducted on anonymized records. The data will not be used for any commercial or public purposes.

Of the 2,350 houses initially collected, 1,880 fall within the boundaries of the Altiplano Estepario and were retained for analysis. In the dataset, each house consists of 52 housing characteristics as variables, however not all present. From this data listed prices are used as the dependent variable in the model. In this research some additional variables are selected as these variables also influence the house prices. Used variables contain built area, bedrooms, bathrooms, terrace, swimming pool and garden. Property type and town were also used from the Idealista dataset to include as fixed effects.

Although additional variables such as building year, energy certificate, and overall condition would provide valuable information on the state of each property, these details were not consistently available across all listings. Including them would have substantially reduced the sample size, thereby compromising statistical power and the generalizability of the model. As such, they were excluded from the final specification in favor of broader coverage.

4.3 Neighborhood characteristics

To account for urban accessibility, the distance to the nearest city with a population greater than 10,000 inhabitants was included as a control variable. Population data for Spanish municipalities (2019) were used to identify relevant urban centers, after which the shortest distance from each property to the nearest qualifying city was calculated in kilometers.

Proximity to the coast was captured in a similar manner. A shapefile of the European coastline was obtained and cropped to the study area. The shortest Euclidean distance from each property to the coastline was computed and included as a variable in the model.

Table 1: Descriptives table housing & neighborhood characteristics

	Unique	Missing Pct.	Mean	SD	Min	Median	Max
Listed Price (€)	471	1	150.9	129.8	9.0	110.0	975.0
Built Area (sqm)	448	0	222.6	151.9	1.0	180.0	974.0
Bedrooms	25	1	4.6	3.1	1.0	4.0	57.0
Bathrooms	15	3	2.0	1.4	1.0	2.0	17.0
Distance to City (km)	1214	0	5.7	7.0	0.0	3.2	29.1
Distance to Coast (km)	1821	0	72.4	30.4	21.3	74.9	145.8
		N	%				
Terrace (yes/no)	FALSE	942	49.9				
	TRUE	946	50.1				
Swimming Pool (yes/no)	FALSE	1550	82.1				
	TRUE	338	17.9				
Garden (yes/no)	FALSE	1322	70.0				
	TRUE	566	30.0				

An overview map of the study area, including the regeneration zone, housing observations, and nearby cities, is provided in Appendix 2. This visual helps contextualize the geographic distribution of observations and the spatial boundaries of the analysis.

4.4 Alternative specifications

To validate the robustness of our findings, some alternative specifications are performed using alternative indicators that proxy the intended outcomes of landscape regeneration. The first proxy variable is soil erosion level, which relies on data sourced from the Soil and Water Conservation Research Group, part of the Centre for Applied Soil Science and Biology of the Segura (CEBAS) under the Spanish National Research Council (CSIC). Erosion is measured in tonnes per hectare per year ($t \cdot ha^{-1} \cdot yr^{-1}$). According to MITECO (2022), the Spanish Ministry for the Ecological Transition and the Demographic Challenge, soil losses exceeding 5 $t/ha \cdot yr^{-1}$ (from class 2 onward) are considered high, while losses above 25 $t/ha \cdot yr^{-1}$ (class 4 and above) are cause for concern due to their contribution to desertification risk (Appendix 2). In the analysis, each house was linked to its corresponding erosion level. Erosion values were not available for locations that are predominantly urban or covered by water. As a result, these observations were excluded from the main model of this alternative specification. This effectively omits transactions located near water bodies or within urban areas, which are likely to exhibit systematically different price levels. To assess the impact of this exclusion, a separate model specification was estimated that includes these observations by assigning an erosion value of zero. Dummy variables were introduced to capture the distinct price effects associated with proximity to water and location within urban areas.

In the second alternative specification, surrounding land cover was evaluated to examine how broader landscape composition influences housing prices. For this purpose, data from the CORINE Land Cover (CLC) 2018 raster, provided by Copernicus EU (the European land monitoring programme), were used. The CLC dataset offers high-resolution land use classification based on satellite imagery. Landscape types were reclassified into six aggregated land cover categories: urban, conventional agriculture, sustainable agriculture, natural green areas, bare natural areas, and water bodies (see Appendix 3). For each category, a binary raster layer was generated and processed using a focal mean operation with a 1 km circular neighbourhood to calculate the share of each land cover type within a 1 km radius around each residential property. These land cover shares were then extracted for each property location and merged with the housing dataset for subsequent analysis.

5. Results

5.1. Baseline regression

Table 2 presents results from three model specifications assessing the relationship between distance to regenerated landscapes and housing prices. Across all models, controls are significant with the exception of "Distance to coast (km)".

Table 2: Effect of Distance to Regeneration on Log(House Price)

	Spline Distance	**Linear Distance**	**Distance Bands (2.5km)**
(Intercept)	3.820 (0.120)***	3.852 (0.100)***	3.710 (0.108)***
Log(Built Area)	0.084 (0.016)***	0.084 (0.016)***	0.083 (0.016)***
Bedrooms	0.014 (0.005)***	0.014 (0.005)***	0.014 (0.005)***
Bathrooms	0.231 (0.014)***	0.230 (0.014)***	0.231 (0.014)***
Terrace	0.170 (0.030)***	0.167 (0.030)***	0.168 (0.030)***
Swimming Pool	0.540 (0.043)***	0.547 (0.043)***	0.541 (0.043)***
Garden	0.263 (0.035)***	0.264 (0.035)***	0.264 (0.035)***
Distance to City (km)	-0.015 (0.003)***	-0.016 (0.003)***	-0.015 (0.003)***
Distance to Coast (km)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)
Spline 1	-0.289 (0.100)***		
Spline 2	-0.029 (0.159)		
Spline 3	0.091 (0.154)		
Distance to Restoration (km)		-0.003 (0.002)*	
Dist. cat. 1: 0–2.5km			0.125 (0.084)
Dist. cat. 2: 2.5–5km			0.088 (0.076)
Dist. cat. 3: 5–7.5km			0.064 (0.091)
Dist. cat. 4: 7.5–10km			0.228 (0.090)**
Dist. cat. 5: 10–12.5km			0.222 (0.071)***
Dist. cat. 6: 12.5–15km			0.090 (0.064)
Dist. cat. 7: 15–17.5km			0.116 (0.068)*
Dist. cat. 8: 17.5–20km			0.136 (0.060)**
Num.Obs.	1817	1817	1817
R2	0.513	0.511	0.514
R2 Adj.	0.496	0.496	0.497
Log.Lik.	-1573.134	-1575.944	-1569.999
RMSE	0.58	0.58	0.57

Standard errors in parentheses.

- * p<0.1, ** p<0.05, *** p<0.01.

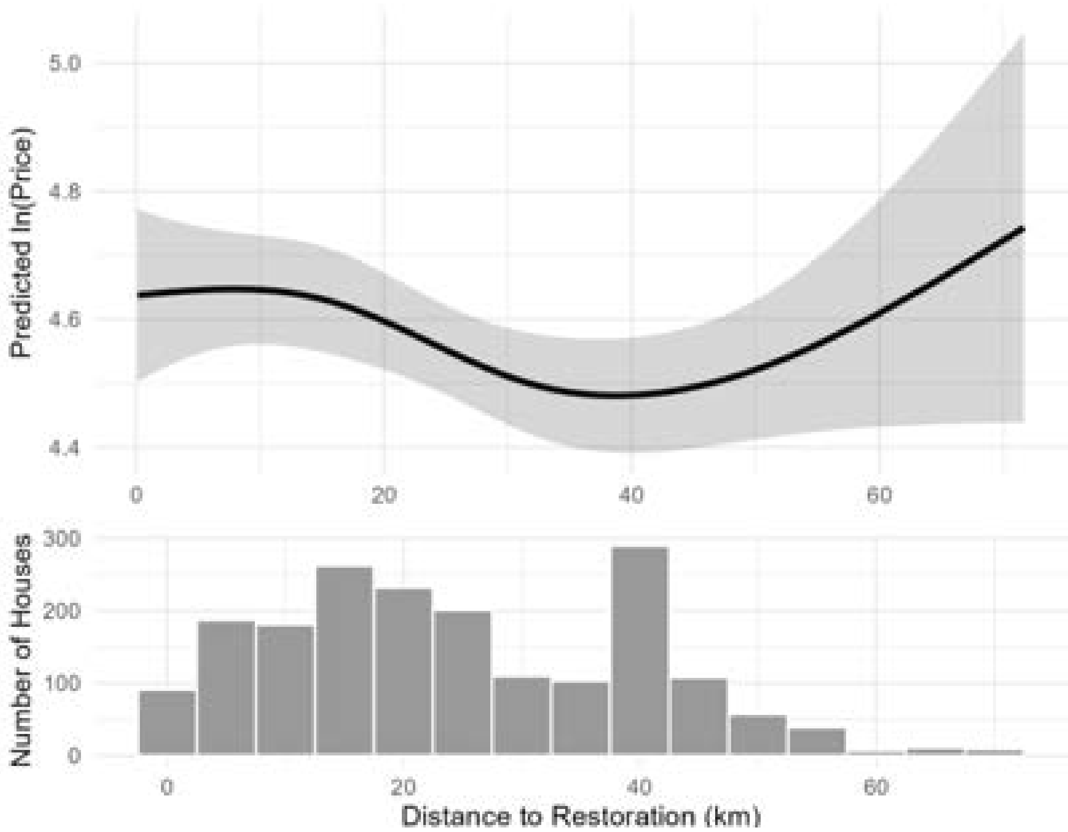
Town and property type fixed effects are included but not shown.

Reference category for distance bands: >20km.

The first column of Table 2 presents the results from a spline regression model with three degrees of freedom. Internal knots were placed at approximately 15.2 km and 31.8 km, based on quantiles of the distance distribution. This flexible specification allows the relationship between proximity to regeneration and house prices to vary non-linearly across space, without imposing a fixed functional form. The first spline component is statistically significant ($p < 0.05$), suggesting a negative price effect within roughly the first 15 km. The second and third spline terms are not statistically significant, indicating that the price-distance relationship becomes flatter and more uncertain beyond this threshold. The spline model explains approximately 51% of the variation in log house prices ($R^2 = 0.513$), which is consistent with hedonic pricing studies in rural or semi-rural settings (e.g., Bin & Polasky, 2005; Cho et al., 2006), and supports the robustness of the findings.

While individual spline coefficients are not directly interpretable in economic terms, their combined effect is visualized in Figure 1. The upper panel displays the predicted values of the natural logarithm of house prices (ln(Price)) across the full range of distances to the nearest restoration site. The black line represents the predicted ln(Price), while the shaded grey area shows the 95% confidence interval. The lower panel shows a histogram of the number of observations per distance band, indicating where the model estimates are most data-driven and reliable. The figure shows a non-linear relationship: predicted house prices decline steadily as distance to a restoration site increases from 0 to around 40 km. Beyond that point, prices appear to rise again, although this upward trend is accompanied by wide confidence intervals indicated by the grey area. The greater statistical uncertainty is due to fewer observations at those distances as indicated in the lower panel.

Figure 1: Effect of distance to regeneration site on ln(Price)



The black prediction line can be interpreted as the expected ln(Price) for a typical house located at a given distance, holding all other variables constant. For example, a home located 5 km from a restored landscape is predicted to have the highest ln(Price) of approximately 4.65, while a comparable home 35 km away is predicted at the lowest value which is around 4.45. Because the dependent variable is log-transformed, these differences can be translated into percentage price differences: a difference of 0.2 in ln(Price) corresponds to a 22% higher price (since $e^{0.2} \approx 1.22$) . This means that, all else equal, homes located near restored landscapes are estimated to be up to 20–25% more expensive than those located further away (30–40 km). However, this difference should be interpreted with great caution. While the first spline component is statistically significant ($p < 0.05$), indicating a decline in prices within the first 15 km, the second and third components are not statistically significant. This means that the shape of the curve beyond this range is estimated with greater imprecision, and specific predicted differences (such as the 22%) are not statistically robust but rather display how to interpret the figure. In short, the figure demonstrates that the economic benefits of landscape regeneration are highly localized. The proximity effect is strongest within the first 30–40 km, and beyond that, the relationship flattens and becomes less reliable.

The second column in table 2 shows results from the linear specification, which yields a negative coefficient on distance to restoration (–0.003), significant at the 10% level. This implies that each additional kilometer away from a regeneration site is associated with a 0.3% reduction in housing price, ceteris paribus. The model fit ($R^2 = 0.511$) is similar to the spline specification.

The third model uses distance categories consisting of 2.5 km intervals up to 20 km, with >20 km as the reference category. Several of these bands are statistically significant, notably the 7.5–10 km and 10–12.5 km ranges ($p < 0.05$), and to a lesser extent the 17.5–20 km band ($p < 0.1$). All estimated coefficients are positive, suggesting that proximity to restored landscapes is associated with price premiums relative to properties located more than 20 km away. However, there is no consistent effect over distance. This model achieves a slightly higher explanatory power ($R^2 = 0.514$). Alternative versions using different distance bands were also estimated as robustness checks. These yielded comparable patterns but generally produced lower significance levels. Similarly, spline models with higher degrees of freedom were tested but showed no improvement in explanatory power. The presented models were therefore selected for their balance of flexibility, interpretability, and statistical robustness.

5.2 Alternative specifications

Table 3 presents the results from the Erosion main regression model (land variables only), Erosion robustness model (full sample), and the specification including detailed land cover composition in a 1 km radius. Across all models, housing characteristics display strong and consistent effects.

Table 3: Alternative specifications

	Erosion, Main (land only)	Erosion, Robustness (full sample)	Landcover (1km)
(Intercept)	4.034 (0.139)***	3.938 (0.105)***	3.636 (0.171)***
Log(Built Area)	0.077 (0.022)***	0.092 (0.016)***	0.082 (0.016)***
Bedrooms	-0.006 (0.009)	0.015 (0.005)***	0.014 (0.005)***
Bathrooms	0.215 (0.019)***	0.227 (0.014)***	0.228 (0.014)***
Terrace	0.241 (0.046)***	0.169 (0.030)***	0.168 (0.030)***
Swimming Pool	0.467 (0.054)***	0.524 (0.043)***	0.541 (0.043)***
Garden	0.147 (0.051)***	0.248 (0.035)***	0.259 (0.035)***
Distance to City (km)	-0.020 (0.004)***	-0.016 (0.003)***	-0.014 (0.003)***
Distance to Coast (km)	0.001 (0.001)	-0.001 (0.001)	-0.002 (0.001)**
Erosion level	-0.048 (0.015)***	-0.045 (0.016)***	
Urban Dummy		0.185 (0.106)*	
Water Dummy		0.173 (0.133)	
Urban Share (1km)			0.122 (0.089)
Conventional Agriculture Share (1km)			0.266 (0.137)*
Sustainable Agriculture Share (1km)			0.386 (0.170)**
Natural Green Share (1km)			0.169 (0.175)
Natural Bare Share (1km)			-0.033 (0.165)
Water Share (1km)			0.947 (0.684)
R-squared	0.560	0.516	0.515
Adjusted R-squared	0.530	0.500	0.498
Number of Observations	733	1817	1817

Standard errors in parentheses.

- * p<0.1, ** p<0.05, *** p<0.01.

Town and Property Type fixed effects are included but not reported.

Across both erosion model specifications, the estimated coefficients are broadly consistent in both magnitude and direction, providing a stable basis for inference. In the main model, which restricts the sample to land-only transactions, erosion emerges as a statistically significant determinant of housing prices. The coefficient of -0.048 ($p < 0.01$) indicates that properties located in areas with higher average erosion levels are associated with notably lower prices, holding other factors constant. This negative association remains robust in the full-sample model, where the coefficient slightly reduces to -0.045 ($p < 0.01$). This suggests that the effect persists when excluded property-types are included.

Another alternative specification examines surrounding land cover. The results indicate that a greater proportion of sustainable agriculture within a 1 km radius is significantly associated with higher property values at the 5% level, while conventional agriculture shows a positive association at the 10% significance level. The share of urban land and natural green areas shows positive but not significant effects, while bare natural areas and water share have no robust influence. These results suggest that the type of surrounding land use matters for housing values, with agricultural landscapes, particularly those related to sustainable practices, being positively valued in the region.

6. Discussion

6.1 Economic interpretation

The results of the model show how proximity to landscape regeneration projects in the Altiplano Estepario influences residential property values. The baseline model reveals that housing prices tend to be higher near regeneration sites, with the most notable effects occurring within the first 15 kilometers. While spline coefficients themselves do not carry a direct marginal interpretation, the shape of the estimated spline function clearly suggests a distance decay effect: the value of proximity diminishes beyond the immediate vicinity of restored landscapes.

The spatially localized nature of the observed effect can be explained through several mechanisms. Many of the benefits provided by landscape restoration are experienced most directly by nearby residents. These amenities such as improved visual quality, enhanced recreational opportunities, and reduced soil erosion are typically non-excludable and tied to the immediate environment. Proximity therefore becomes a proxy for access. Buyers may be willing to pay a premium to live closer to these improved landscapes, anticipating both use and non-use benefits.

Beyond 15 kilometers, the model finds no statistically significant relationship. This suggests that the visibility, accessibility, or even awareness of these restored areas declines with distance. Buyers may simply be less informed or responsive to improvements that fall outside their immediate visual or experiential range. This finding underscores the importance of spatial targeting in restoration policies: to generate measurable economic co-benefits through the housing market, projects must be located within zones where environmental improvements are visible, accessible, and salient to potential buyers.

The effects of housing characteristics are consistent across models. Larger built area, more bedrooms and bathrooms, and outdoor amenities such as terraces and swimming pools are all associated with higher housing prices. The distance to the nearest city also shows a robust negative association with prices, likely reflecting access to employment and services. In contrast, distance to the coast is not significant, probably due to limited variability in the sample: all houses are located at similarly large distances from the sea.

However, when looking at all proximity models, the overall contribution of distance to regeneration remains limited. The signs across specifications generally point in the expected direction (i.e., closer proximity associated with higher prices), which supports the underlying hypothesis. However, the statistical significance is relatively low across all models. This is not entirely surprising, given the diffuse nature of landscape restoration impacts and the fact that many of these projects are still in progress. As such, their full effects may not yet be capitalized into housing prices. Moreover, the hedonic pricing of environmental amenities in rural settings presents additional challenges due to lower housing density and smaller transaction volumes, which reduce statistical power and make it harder to detect subtle effects.

6.2 Alternative specifications

To further explore the effect of landscape regeneration projects on housing prices, a range of alternative model specifications was tested. Those specifications focus not on proximity per se, but on the intended outcomes of restoration, such as improved erosion control and improved land cover. These specifications capture the underlying mechanism by which regeneration projects are hypothesized to influence property values, namely, by transforming degraded land into more ecologically stable and visually appealing landscapes. The outcomes of these models reinforce the interpretation that the observed price premium near restoration zones is likely driven by actual environmental improvements rather than mere spatial proximity. It also suggests that regeneration impacts may take time to materialize in economic terms, especially in areas where the projects are still in development.

The robust negative association between land erosion and property values suggests that environmental degradation translates into real economic costs for households. This underscores the importance of soil conservation and sustainable land management from both an ecological and economic perspective. The reversal of land degradation through restoration initiatives not only supports ecosystem resilience but can also contribute to wealth preservation for rural homeowners by stabilizing or enhancing property values.

Moreover, the analysis of surrounding land cover underscores the positive valuation of agricultural landscapes, especially those linked to sustainable agricultural practices. This points to the role of landscape character and perceived environmental quality in shaping housing preferences. In contrast, urban land shares and natural green areas appear to exert more modest and statistically insignificant effects. This may reflect the rural context of the Altiplano Estepario, where agricultural identity and cultural landscape features remain important attributes of place value.

Overall, the results suggest that investments in landscape regeneration and sustainable land use transitions can yield broader welfare gains by enhancing not only ecological outcomes but also the attractiveness and value of residential locations. This provides empirical support for landscape restoration initiatives that integrate environmental and economic objectives.

6.3 Alignment with prior research

The findings are consistent with the theoretical and empirical expectations from ecosystem service valuation. Restoration efforts enhance regulating services (e.g., erosion control, water retention), cultural services (e.g., landscape aesthetics), and supporting services (e.g., biodiversity), all of which contribute indirectly to property values. While previous hedonic pricing studies have typically focused on urban parks and wetlands (e.g., Anderson & West, 2006; Bin & Polasky, 2005), this research extends the scope of application to a rural Mediterranean dryland region, showing that even in relatively remote areas, improvements in ecosystem services are capitalized into market prices.

Importantly, the magnitude of the estimated price effects is similar to the range found in other hedonic pricing studies in rural areas that focused on natural amenities (Mäler et al., 2008; Ma & Swinton, 2011, Schläpfer et al., 2015). Even though the absence of formal public access or recreation infrastructure in most of the restoration zones. This suggests that visual and symbolic value alone may be sufficient to generate housing premiums. It highlights the role of aesthetic and identity-based ecosystem values in rural housing markets.

6.4 Policy implications

The findings of this research suggest that landscape restoration delivers economic as well as ecological value. The improvements of the restoration are reflected in higher housing prices due to increasing demand. This provides a clear market signal that such investments are valued by residents and buyers. Policymakers should therefore incorporate amenity benefits into cost-benefit assessments of restoration projects. Doing so would support more accurate valuations and stronger justification for public funding under instruments such as the EU Green Deal and Common Agricultural Policy.

This also strengthens the case for further investment in landscape restoration projects by private investors. The evidence that restored landscapes enhance property values creates potential for profitable investment in regeneration. It makes a business-case to regenerate the landscape or improve erosion levels around new housing projects as this would lead to return on investment as this would increase house prices. Public policy could further encourage private participation through incentives and partnerships such as blended financing.

The results also point to the importance of where restoration takes place. Price effects are most significant near the project area, where restored landscapes effects are visible and accessible. If certain areas are targeted to be improved by landscape restoration, it is now clear where to start. This way the local economic benefits of restoration can be maximised, in addition to environmental gains. In contrast, interventions in more remote locations may yield limited impacts on housing markets, even though they are ecologically valuable.

Finally, this study confirms that standard housing market and spatial data can provide a practical basis for monitoring and evaluating restoration impacts, even in rural areas. Standard valuation models are needed to communicate and compare effects. Ecosystem restoration gains prominence in climate and biodiversity agendas. Simple and transparent valuation methods like hedonic pricing analysis can help guide both public and private investment decisions.

7. Conclusion

This research set out to explore the non-market value of landscape regeneration by estimating the effect of proximity to regeneration projects on house prices, using a hedonic pricing approach. In a world increasingly affected by land degradation and its associated social, economic, and ecological challenges, it becomes more important to measure and understand the benefits of restoration efforts.

The empirical results reveal a positive association between proximity to natural regeneration zones and housing prices in the Altiplano Estepario within the first 15km. While several of these associations do not reach conventional levels of statistical significance, the direction of the effects remains consistent across model specifications. This pattern suggests that properties located closer to regeneration sites tend to command higher listing prices than those further away. It implies that landscape regeneration projects may generate not only ecological value but also potential economic benefits that are capitalized into local property markets. Especially as these projects mature and their environmental improvements become more visible.

The alternative specifications on erosion and land cover further reinforce this conclusion, and reveal an additional insight: land degradation significantly lowers housing prices in the region. The negative association between erosion levels and property values suggests that degraded landscapes are less attractive and provide fewer ecosystem services to residents. This underscores the economic importance of preserving and enhancing the quality of existing natural areas.

Several methodological limitations must be acknowledged. The analysis cannot determine what specific characteristics of the regenerated landscapes (e.g., improved visual quality, biodiversity, soil health) are responsible for the observed price premium. The alternative specification however suggests that erosion control is a main factor. Furthermore, the model omits potentially important control variables, such as energy label and building year. The reliance on cross-sectional listing data also limits the ability to assess before-and-after dynamics.

Future research could expand on this work in several directions. First, distinguishing between types of regeneration zones (natural, combined, and economic) would allow for a more nuanced understanding of how different restoration strategies influence housing markets. Combined or economic zones, which may integrate sustainable agriculture, tourism, or agroforestry, could produce a wider range of co-benefits that are more readily captured in property values. Second, survey-based methods could help uncover the specific attributes of regenerated landscapes that matter most to homebuyers. Third, using panel data or repeat sales would enable before–after comparisons and help isolate the causal effect of regeneration projects. A difference-in-differences framework or spatial lag model could account for confounding time trends and spatial spillovers, respectively. Finally, this research focuses on measurable effects rather than concrete numbers. It would be interesting for future research to compare the financial gain of the surrounding housing markets with the cost of the investment in landscape regeneration projects.

In conclusion, this study contributes to a growing body of evidence that landscape regeneration not only provides ecological value but also generates measurable economic benefits. By demonstrating that restored natural areas can enhance property values, the findings highlight the potential for market-based signals to support conservation and restoration investment. This research confirms the importance of integrating environmental valuation into land-use planning and policy design. As the pressures of land degradation intensify under climate and development challenges, linking ecological improvements with economic opportunities will be essential in guiding efficient, equitable, and sustainable investment in nature.

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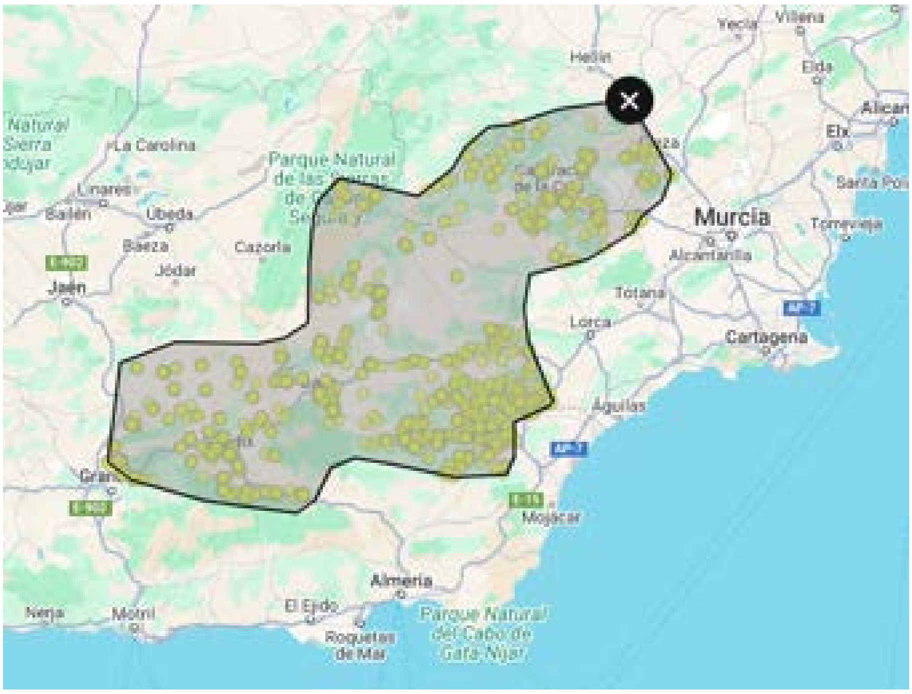
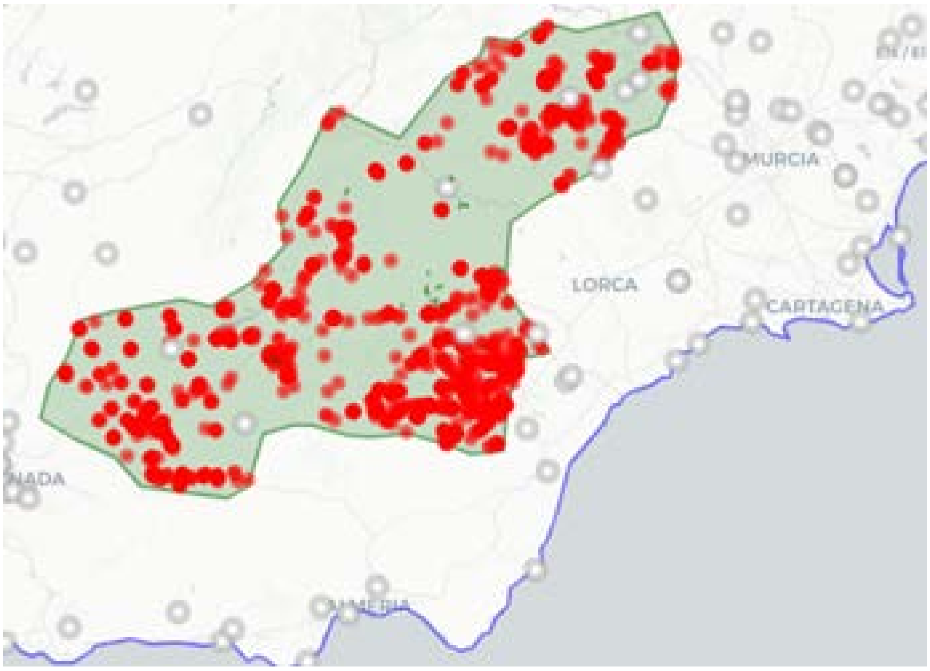
Appendix

<u>Appendix 1:</u>



<u>Appendix 2: Geographic overview of the study area</u>



Light green area: Altiplano Estepario (study region)
Dark green dots: Landscape regeneration sites
Red dots: Listed houses
Grey dots: Cities with >10,000 inhabitants
Blue line: Coastline

Appendix 3: Erosion level classification

Value	Erosion Level ($t \cdot ha^{-1} \cdot yr^{-1}$)	Description
1	≤ 5	Very low erosion
2	> 5 and ≤ 10	Low erosion
3	> 10 and ≤ 25	Moderate erosion
4	> 25 and ≤ 50	High erosion
5	> 50 and ≤ 100	Very high erosion
6	> 100 and ≤ 200	Severe erosion
7	> 200	Extreme erosion
8	—	Surface water bodies and wetlands
9	—	Artificial surfaces (e.g., urban areas, infrastructure)

Appendix 4: Aggregation land cover types

Aggregated Category	CLC Codes	Included Land Cover Classes
Urban	111	Continuous urban fabric
	112	Discontinuous urban fabric
	121	Industrial or commercial units
	122	Road and rail networks and associated land
	123	Port areas
	124	Airports
	131	Mineral extraction sites
	132	Dump sites
	133	Construction sites
	141	Green urban areas
	142	Sport and leisure facilities
Conventional Agriculture	211	Non-irrigated arable land
	212	Permanently irrigated land
	213	Rice fields
	221	Vineyards
	222	Fruit trees and berry plantations
	223	Olive groves
	231	Pastures
	241	Annual crops associated with permanent crops
Sustainable Agriculture	242	Complex cultivation patterns
	243	Land principally occupied by agriculture with significant areas of natural vegetation
	244	Agro-forestry areas
Natural Greenland	311	Broad-leaved forest
	312	Coniferous forest
	313	Mixed forest
	321	Natural grasslands
Natural Bare-Land	322	Moors and heathland
	323	Sclerophyllous vegetation
	324	Transitional woodland-shrub
	331	Beaches - dunes - sands
	332	Bare rocks
	333	Sparsely vegetated areas
	334	Burnt areas
	335	Glaciers and perpetual snow
Water	411	Inland marshes
	412	Peat bogs
	421	Salt marshes
	422	Salines
	423	Intertidal flats
	511	Water courses
	512	Water bodies
	521	Coastal lagoons
	522	Estuaries
	523	Sea and ocean