Encouraging reuse in rural Italy:
A case study implementing new frameworks to collect local data and understand feasible reprogramming strategies in Guadagnolo

by

Annabel Consilvio
B.S. Engineering
Olin College of Engineering, 2018

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Authored by: Annabel Consilvio
Department of Urban Studies and Planning
May 14, 2024

Certified by: Eric Robsky-Huntley
Lecturer in Urban Science and Planning
Department of Urban Studies and Planning
Thesis Supervisor

Accepted by: J. Phillip Thompson
Professor of Political Science and Urban Planning
MCP Committee Chair
Department of Urban Studies and Planning

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Abstract

This thesis presents a new survey methodology for collecting data on occupancy, building typologies, and building conditions in small, depopulating towns in rural Italy. The survey methodology is split into two phases: one in which granular data is gathered through a series of visual surveys and a second in which this data is analyzed through a series of assessments aimed at identifying the most strategic buildings for reuse to support economic development. With one in three Italian municipalities losing population since 1951, this new framework aims to equip municipalities with critical data that can inform strategic reprogramming efforts and strengthen funding applications (Serico Gruppo Cresme, 2008). The research is built on the prior efforts and knowledge of Liminal, the thesis client and an organization in Italy working to build capacity within these rural communities. By providing tools like this framework, Liminal empowers residents to envision new futures and supports municipalities to realize these visions.

This approach was tested in Guadagnolo, a rapidly depopulating town in the Monti Prenestini region of Lazio, which witnessed a 50% population decline in just two decades (*Progetto - Campo Base Guadagnolo*, 2022). Through this methodology, a robust and granular spatial database model of Guadagnolo's built fabric was constructed, permitting analysis of possible sites of reuse to support a university satellite campus and develop a long-term tourism destination. The assessment methodology provided several key buildings for the town to consider adapting to support these two reuse scenarios, while also generating extensive data that the town can utilize in a variety of future initiatives and funding applications. Ultimately, this thesis endeavors to support rural Italian communities by providing a data-driven framework that can unlock funding opportunities and initiate strategic planning efforts, providing a path forward that protects the cultural and ecological richness of these small towns.

Keywords: rural development, strategic reuse, economic revitalization, survey methodology

Thesis Supervisor: Eric Robsky-Huntley
Title: Lecturer in Urban Science and Planning, Department of Urban Studies and Planning
Thesis Reader: Ginevra D'Agostino
Title: President and Co-Founder of Liminal

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in collaboration with Liminal

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Table of Contents

Abstract **2**
Acknowledgments **4**
List of Figures **6**
List of Tables **7**
Chapter 1: Introduction & Background **8**
Introduction: Envisioning Rural Futures 8
Background on Rural Italy & Rural Challenges 10
Encouraging Economic Regeneration & Addressing Depopulation in Italy 14
Liminal & Their Impact in Rural Italy 19
Chapter 2: Monti Prenestini & Guadagnolo **22**
Monti Prenestini in a (Chest)nut Shell 22
Contextualizing Guadagnolo 28
Chapter 3: Survey Framework & Data Methodology **35**
Potential Impacts of the Proposed Framework 35
Proposing a Multi-Phase Framework 36
Data Collection Processes 46
Importance of the Case Study Approach 52
Chapter 4: Analyzing Guadagnolo's Strategic Reuse Opportunities **54**
Survey Results: Understanding the Town 54
Assessment Results: Reprogramming the Town 67
Proposing a Strategic Reuse Plan for Guadagnolo 76
Chapter 5: Conclusions & Next Steps **81**
Process Insights from Testing in Guadagnolo 81
Next Steps 91
Review of Key Contributions 96
Bibliography **98**
Appendices **102**
Appendix A: Survey Indicator Development 102
Appendix B: Hand-Drawn Maps, Field Notes, Municipal Resources 104
Appendix C: Elevation Data Processes & Results 112
Appendix D: Data Schema 115

List of Figures

Figure 1: The Inner Areas of Italy....10
Figure 2: Image depicting the narrow staircased streets of Guadagnolo....13
Figure 3: Monti Prenestini & its proximity to Rome....22
Figure 4: The three municipalities of Monti Prenestini....23
Figure 5: Elevations of Monti Prenestini compared to Rome....24
Figure 6: An image showing cattle blocking the road from inside a Cotral regional bus....25
Figure 7: An image of Castel San Pietro Romano....26
Figure 8: An image of Rocca di Cave from the valley....27
Figure 9: An image of a collapsed structure turned into a garden in Capranica Prenestina....27
Figure 10: An image of Guadagnolo....28
Figure 11: Building use in Guadagnolo....29
Figure 12: The landscapes around Guadagnolo....30
Figure 13: An image of the Santuario della Mentorella....31
Figure 14: An image of one of the public squares in Guadagnolo....31
Figure 15: Diagram visualizing high-level framework methodology....36
Figure 16: Cascading survey data structure....38
Figure 17: Orthophoto taken of Guadagnolo by Liminal....47
Figure 18: Recorded elevation map of Guadagnolo....50
Figure 19: Guadagnolo's building and street network according to the municipal map....52
Figure 20: Map depicting the perceived occupancy status of Guadagnolo....56
Figure 21: Maps of occupancy survey indicators....57
Figure 22: Building access levels in Guadagnolo....60
Figure 23: Pedestrian, truck, and car accessible buildings in Guadagnolo....61
Figure 24: The area, number of floors, and estimated volume of buildings in Guadagnolo....61
Figure 25: Maps of building amenities in Guadagnolo....62
Figure 26: Perceived building condition in Guadagnolo....65
Figure 27: Maps of facade and window/door condition in Guadagnolo....65
Figure 28: Map of eligible housing units for Guadagnolo....72
Figure 29: Map of eligible meeting spaces for Guadagnolo....73
Figure 30: Map of eligible working spaces for Guadagnolo....73
Figure 31: Map of eligible housing units with suitability criteria....75
Figure 32: Map of eligible meeting spaces with suitability criteria....75
Figure 33: Map of eligible working spaces with suitability criteria....76
Figure 34: Proposed reprogramming plan of Guadagnolo....78
Figure 35: Proposed reprogramming plan of Guadagnolo with existing building uses....78
Figure 36: Buildings in Guadagnolo made available for reprogramming through Base Camp Guadagnolo....85
Figure 37: Comparison of algorithm-generated occupancy status and grant-specified likely unoccupied buildings....86
Figure 38: An alternate visualization of eligible potential working spaces....89
Figure 39: Potential working spaces visualized by the number of eligibility criteria they meet....90

List of Tables

Table 1: Survey methodology driving questions..... 37
Table 2: Occupancy survey indicators and data schema..... 39
Table 3: Typology survey indicators and data schema..... 42
Table 4: Condition survey indicators and data schema..... 44
Table 5: Explanation of the occupancy algorithm..... 55
Table 6: Visual results of the occupancy algorithm..... 58
Table 7: Visual illustrations of damage scale within condition survey..... 63
Table 8: Explanation of condition algorithm..... 64
Table 9: Visual results of condition survey..... 66
Table 10: Explanation of two reuse scenarios for Guadagnolo and their needed building typologies..... 69
Table 11: Explanation of what drove the selection of each eligibility criteria..... 70
Table 12: Explanation of the eligibility criteria of the three different needed building typologies..... 71
Table 13: Lists of facade-level indicators to be moved to building-level indicators in future surveys..... 92

Chapter 1: Introduction & Background

Introduction: Envisioning Rural Futures

The Importance of Rural Futures & Italy as an Area of Study

In 2018, data from the United Nations estimated that two-thirds of the world's population will live in urban centers by 2050, creating challenges not only for cities needing to scale up, but also for rural areas rapidly losing population (World Urbanization Prospects 2018: Highlights, 2019). The future of rural areas is in question as a result of this massive trend in urbanization, and across the globe jurisdictions are struggling to save towns in rural areas from complete abandonment. These rural areas are critical in promoting methods of sustainable living, encouraging community cohesion, building social capital, and preserving cultural heritage. Recognizing the potential value that rural areas can have on both countries and their residents will be critical to ensuring that these spaces remain active beyond the next several decades. Lessons from rural living have the potential to shape how countries approach sustainable living practices, plan their "15-minute" cities, and ensure the continuation of historic cultural practices (Poorthuis & Zook, 2023).

Italy is one of the many countries experiencing rapid rural depopulation as a result of both urbanization and several localized challenges, such as a low birth rate, brain drain, and deteriorating infrastructure. Italy is also unique in its struggle with depopulation in comparison to some other countries, particularly due to its reliance on tourism as an economic driver for the country, much of which is owed to the picturesque rural landscapes. Estimates claim 70% of the country's land is covered by municipalities with less than 6,000 people, and many of these rural municipalities are at risk of disappearing or changing fundamentally as a result of depopulation (Berg, 2022). The potential loss of cultural identity of these rural areas presents a huge risk to the country, particularly due to the potential loss of cultural heritage and practices built up over centuries from ancient civilizations. Traditional landscape and agricultural practices are still used in many of these rural regions today, providing more sustainable and resilient methods to some of society's present challenges. Terraced landscapes to handle flooding and erosion and drying strategies for food preservation are still practiced today across the country, and these examples represent only a few of the many resilient landscaping and living practices that could be lost with total depopulation of rural places (Bertolino & Corrado, 2021; A. Mattogno, personal communication, March 5, 2024).

Missing Data on Rural Areas

Adding to the challenge of solving the depopulation trends in rural Italy is the lack of available data on many of these rural municipalities. Many of the towns in remote corners of the country do not exist on Google Maps or are mapped insufficiently, making them difficult to navigate, which prevents easy access to delivery services or other amenities and also leads to fewer tourists attempting to visit the area (A. Mattogno, personal communication, March 5, 2024).

Towns are so small that very few have a dedicated town planner or municipal office larger than one person, making it difficult to update census figures, track the condition of public and private infrastructure, or even know which buildings are for sale, in use, or abandoned within the town (Raney, 2022). Population estimates are often skewed due to the seasonal population fluctuations in these rural areas, making it even more difficult to understand a town's potential risk of total abandonment (A. Mattogno, personal communication, March 5, 2024).

Despite this, many government-funded reprogramming initiatives require both qualitative and quantitative data in order to qualify for grants or loans focused on rural reprogramming (Boyd, 2023). Residents of these towns currently have no clear way to contribute to data collection processes, despite being the most familiar with the built environment of their rural towns and having the easiest access to this information. In order to generate feasible, long term solutions to the depopulation issues facing rural Italy, a significant effort to collect various types of data on these towns needs to be made. In particular, understanding the potential risks related to depopulation and infrastructure decay will be key to both accessing government funding and completing successful, long lasting reprogramming initiatives. This thesis contributes a model for such a data collection process, and offers one implementation of this process in the town of Guadagnolo, a rural town in the Lazio region of Italy.

Structure and Methodology of the Thesis

This thesis explores the influences and role of typology, condition, and occupancy data in shaping rural futures. Specifically, it tests a framework to both collect and analyze data around these three themes to generate a data-driven, contextually-relevant strategic reuse plan for the town. The data collection process is driven by a visual survey method that documents information on key typology, condition, and occupancy indicators, which were developed with support from local residents. This information provides previously unavailable insights into the current workings of rural places and promises to provide municipalities with more robust local data that can be used in grant applications and planning proposals. Over time, spatial analysis of this data across hundreds of Italian towns can begin to reveal connections between the occupancy, condition, and typology data that can be used to inform national policy direction addressing rural development. More immediately, the data can highlight key areas of investment for individual municipalities and regions, providing new paths forward for municipal officials and local organizations. By understanding which buildings are logistically feasible for reprogramming within a given town, the survey can also help provide larger regions with information on all of their municipalities, allowing them to equitably distribute funds where they will be the most impactful for the regions as a whole.

To test this new methodology and framework, this thesis uses Guadagnolo as a case study, a rural town in the central Italian region of Lazio. The case study builds upon extensive past work and a network of data and relationships first cultivated by Liminal, the thesis partner organization and a nonprofit working in Italy to re-envision the future of rural areas. Over the course of several weeks, data collection was conducted on-site in Guadagnolo and then analyzed to build a digital, spatial data model of the town. The results of the assessment

methodology reveal several buildings that Guadagnolo could consider prioritizing in their reprogramming plans to encourage economic revitalization of the town. The structures support the needs of the community's two desired reuse scenarios, a university satellite campus or a long-term tourist destination.

Background on Rural Italy & Rural Challenges

Rural Italy & the "Inner Areas"

Italy is known for its beautiful landscapes, charming villages, and slow pace of life, and many of these attributes are most visible in the rural areas of the country. Although much global focus is typically placed on the major metropolitan centers of the country (Rome, Milan, Venice, etc), it is estimated that about 70% of Italy's land is made up of towns with populations below 6,000 (Berg, 2022). These rural geographies are present across all 20 regions of Italy, and despite their differences in climate, architecture, and history, many share similar advantages and challenges. About a third of the country is occupied by mountains over 700 meters, and many historic lookouts that became villages, typically called hamlets, are built atop these peaks (Swamy & Brivio, 1996). These outposts provide a cooler climate than the larger cities during Italy's increasingly hot summer months and typically provide residents with panoramic views of the mountains and countryside.

Figure 1: The Inner Areas of Italy.
The highlighted areas indicate the designated regions in Italy eligible for funding through "Inner Area" initiatives. (Dezio et al., 2021)

In 2014, the national government of Italy defined a set of rural territories as "Inner Areas" in order to facilitate policy changes and provide incentives to address the growing number of challenges specific to these rural areas. The National Strategy for Inner Areas (SNAI) defines these regions as "territories substantially far from centers offering essential services and thus characterized by depopulation and degradation" (Casavola, 2015). Within Lazio, a region in central Italy, a total of 4 Inner Areas have been selected and are eligible for funding and incentives provided by SNAI (Torriani et al., 2023). The Inner Areas do not cover all places in Italy experiencing depopulation and abandonment, however the framework is an important step in defining the general problem area and identifying key attributes leading to depopulation and abandonment.

Birth Rates, Brain Drain, and Depopulation

In the past decade, Italy has seen a significant decline in population across the country, dropping from 60.3 million in 2013 to below 59 million people in 2023 (Caltabiano, 2023). Multiple factors are contributing to this decline, with several often working against each other to amplify the speed of depopulation. A low birth rate, an aging population, and an economy that encourages young people to leave the country for better economic opportunities are all working in tandem to drive the population down at increasing speeds nationwide.

Italy has one of the world lowest birth rates in the world, with the 2023 rate estimate being just 7 children born per 1000 people (*The World Factbook 2023 - Birth Rate*, 2024). In comparison, the US birth rate estimate for 2023 is 12.2 births per 1000 people (*The World Factbook 2023 - Birth Rate*, 2024). There are many contributing factors to this low fertility rate in Italy, but a large one still remains the lack of economic security among young people, particularly women. Many people are choosing not to have children due to births often having a negative impact on their future economic opportunities or present financial status, while the quantity of programs supporting new parents have simultaneously become limited over the years, making it even more difficult to justify the choice (Carbonaro, 2024). These challenges are widely recognized in the country as having both immediate and long term consequences. Schools are closing due to a lack of students and putting teachers out of jobs, all the while economists are concerned about the future of the country's workforce, and therefore economy, nationwide. In 2023, the Prime Minister of Italy dedicated 1 billion euro specifically to develop strategies to remediate the birth rate in the country (Cinelli, 2023).

Adding on to the low birth rate, Italy also has one of the oldest populations in Europe. In Italy, 24% of people are over the age of 65, meaning about one in every four people in the country is approaching or over Italy's standard retirement age of 67 (Carbonaro, 2024; OECD, 2023). As more and more people age out of working and live longer, additional infrastructure and jobs are needed to support them. However, with the birth rate dropping so consistently over the past decades, there is concern that the workforce will not exist to take over these positions.

Furthermore, the economic climate in Italy has led many young people to move out of the country, thus decreasing the exact population most likely to both increase the birth rate and take jobs caring for the aging population. This phenomena, often referred to as "brain drain," has been occurring in Italy for decades, with many educated young people emigrating elsewhere in Europe in search of higher paying jobs or an improved quality of life. Since 2011, approximately 500,000 young people have emigrated out of Italy, further contributing to the concerns about nationwide workforce and the ability for parts of Italy to economically recover (Vagnoni, 2024). Like the low birth rate, young people emigrating out of the country is also contributing to the depopulation trends seen in Italy today.

At a rural scale, even more acute depopulation rates are observerved. Within Italy, movement patterns indicate that specific locations are more vulnerable to depopulation than others, with rural areas being particularly at risk. Many young workers who grow up outside the major cities

of Italy are moving into major metropolitan centers in search for higher paying jobs and an easier life, creating areas in the country only populated by an aging population, and therefore even more at risk of shrinking to the point of becoming ghost towns (Chiellino, 2023). At the same time, coastal, urban centers in the country have seen population increases over time as economic opportunities concentrate in these locations. For example, Rome has seen a population increase of 14% between 2001 and 2019, while the mountainous region of Madonie in Sicily has seen a 10% decrease in population between 2008 and 2018 (Dezio et al., 2021; *Italy*, 2021). Rural municipalities are facing the brunt of the impact of emigration and movement in the country, putting them at risk for total depopulation. Some statistics state that at least 6,000 of these smaller, rural villages have already been completely abandoned, but at least another 15,000 towns are at risk of total abandonment due to already having lost about 90% of their residents (Marchetti, 2015).

Challenges Facing Rural Redevelopment

The existing state of these municipalities makes it difficult to encourage repopulation and economic development efforts. One of the largest difficulties is the lack of economic opportunities within these locations. Due to their small size, few job opportunities often exist directly in the historic centers of towns, which is why so many residents move into larger economic centers. Agricultural jobs are more common in the area surrounding the villages, but many village residents still have to work elsewhere in larger municipalities. Given this dynamic, these small, rural villages are not often considered as places for people to relocate, making repopulation efforts difficult.

This challenge is further amplified by the seasonal nature of many of these places. Oftentimes, particularly in mountainous regions, these rural centers become a place of summer retreat, but are left empty during the other months of the year, making it difficult to justify full-time operations that could create more jobs in these towns. Some houses are occupied only for the same week or set of weeks each year during the traditional summer vacation for Italians in August (A. Mattogno, personal communication, March 5, 2024). As a result, outside of peak seasons, many local restaurants, cafes, and bars close or only operate with limited hours and staff.

In addition to the lack of economic and job opportunities for prospective new residents, historic buildings are not always weather appropriate for year-round usage, which again creates limitations to repopulation, at least until renovations are made to make them habitable year-round. Because so many towns are used as a summer retreat location, the necessary updates to have heating or insulate the buildings have not always been made. The standards that modern homebuyers have has also grown over time, and many historic, medieval structures naturally do not meet these requirements without renovations. Homes do not have air conditioning and are typically much smaller than modern accommodations, at face value making them undesirable to newcomers. The medieval town plan of these places can also be an issue. Many homes are built adjoining each other, creating large aggregates of buildings with only one or two facades that have access to windows, meaning many have limited natural light

or consistent air circulation (G. D'Agostino & N. Delgado Alcega, personal communication, January 15, 2024).

Accessibility of buildings can also make repopulation and reprogramming difficult. Historic streets are narrow, uneven, and extremely steep, particularly in mountain towns. Many towns are still paved using traditional cobblestones, which are extremely slippery and irregular, and many pedestrian paths to access buildings are full of stairways that can make wheelchairs, strollers, or most other mobility aids unusable. Houses do not always have direct access to a car or truck loading zone, forcing residents to carry deliveries and purchases home by foot from the center of town, oftentimes up steep staircases (A. Mattogno, personal communication, March 5, 2024). Most towns are also disconnected from Italy's vast public transportation and train network, and therefore require car access to reach, but even with a car getting to these towns can be challenging. In the winter, many mountain towns can be cut off completely for days due to the extensive time it takes to clear snow off of miles of tight mountain roads or because dense fog makes the lack of visibility dangerous for drivers (A. Mattogno, personal communication, March 5, 2024).

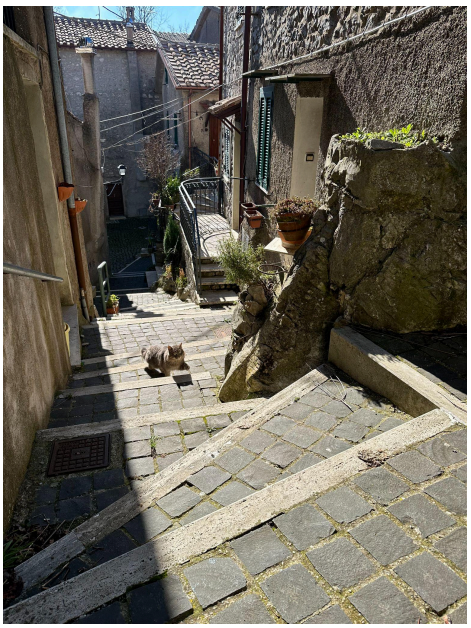


Figure 2: Image depicting the narrow staircased streets of Guadagnolo. These inaccessible, steep staircases that are typical to medieval mountain hamlets experiencing depopulation.

All of these factors have contributed to many towns in the peripheral areas of Italy becoming abandoned and showing clear signs of deteriorated infrastructure, further complicating repopulation efforts. As these medieval structures become more unstable and dangerous they simultaneously become more difficult and expensive to restore. Oftentimes, this leads to even fewer prospective new residents being able to move into rural towns, despite being interested. Additionally, as these abandonment processes speed up, more businesses and amenities close, making the environment even more difficult for new residents to thrive. When the cost of renovation becomes too high to justify the living environment, towns can end up in a spiral of abandonment triggers.

Italy's current governance structures can also pose challenges, particularly in rural areas. For example, Italian census data tends to be less accurate in these peripheral areas than in more urban centers. When it comes to accessing government funding, this poses a significant problem for small municipalities as oftentimes the most funding is dedicated to towns that are most at risk of disappearing. Therefore, if rural towns are overcounted in terms of population, they paradoxically become more at risk of becoming depopulated.

All of these challenges make reprogramming rural Italy to encourage repopulation and economic development very difficult, however, without new strategies and investments, the cultural heritage within these towns will be lost to time. Identifying opportunities that work to improve the status of several of these challenges at once is critical to the long term survival of these towns.

Encouraging Economic Regeneration & Addressing Depopulation in Italy

Funding Opportunities

In rural Italy, development work is primarily driven by a range of organizations that establish strategies and priorities to support localized economic regeneration. These organizations play a crucial role in facilitating sustainable growth and addressing challenges faced by these regions.

LEADER (or Liaison Entre Actions de Développement de l'Economie Rurale) is a funding approach to territorial development established by the EU's Common Agricultural Policy Network, which defines sets of priorities for regions between 10,000 and 150,000 residents (*LEADER - Local Development Plan*, 2024). At a baseline, LEADER strategies are responsible for defining territories and affected populations, providing an analysis of the development needs and potential of a territory, defining a potential strategy approach that includes measurable implementation benchmarks and an action plan, and describing the local community engagement process (*LEADER - Local Development Plan*, 2024).

In most cases, LEADER projects are carried out by LAGs, or Local Action Groups. LAGs typically cover a small rural region and are responsible for developing the region's local development plan in rural communities as a response to LEADER priorities (*Gruppo di Azione Locale Castelli Romani e Monti Prenestini*, 2020). A mix of both public and private partners, LAG organizations are key to improving the socio-economic outcomes of these regions and are typically positioned to apply for funding to support these projects (*Gruppo di Azione Locale Castelli Romani e Monti Prenestini*, 2020). Within LAGs, organizations work collaboratively to establish and implement strategies that address specific challenges and opportunities in rural Italy. Their efforts focus on promoting economic regeneration, preserving cultural heritage, and improving the well-being of local communities.

In addition to the international structures provided by LEADER, Italy has several of its own dedicated initiatives to encourage rural regeneration. Funding opportunities for tourism have come through Italy's Ministry of Culture, including a major initiative in 2022 that provided 20 million dollars to one rural municipality in every region of Italy to encourage economic development (Raney, 2022). These funds were provided by the Recovery and Resilience Facility of NextGenerationEU, a program from the European Commission that raises funds by borrowing on capital markets, thus allowing for massive investments to be made in places recovering from the wake of the COVID-19 pandemic (European Commission, 2021). The Ministry of Culture also supports rural tourism through its Bando Borghi initiatives, a set of several programs that provides funds to networks of rural towns working together on

entrepreneurial initiatives that encourage tourism (Ministero della Cultura, n.d.). Through Italia Domani's National Recovery and Resilience Plan (NRRP), Italy has also allocated upwards of 3 billion euro towards challenges in the Inner Areas and similar peripheral territories, including €825 million to SNAI initiatives, €1.78 billion toward the tourism economy broadly, and €600 million toward facilitating reuse of historic buildings in rural areas (*Cultural Participation in Peripheral Urban Areas*, 2024; *Integrated Funds for the Competitiveness of Tourism Businesses*, 2024).

It is expected that more private and public investments will continue to be channeled into Italy from both international and local sources. In all, the Recovery and Resilience Facility provided Italy with 200 billion euro to use across hundreds of different initiatives related to economic recovery and resilience, with many programs facing 2026 deadlines to use the funds (Horowitz, 2022; Raney, 2022). In 2019, 36% of the EU's total operating budget went to agriculture and rural development initiatives, and although this funding is divided across the many nations within the EU, it is expected that Italy will continue to receive some of these funds for their rural-focused programs (Directorate-General for Budget (European Commission), 2019). These investments make a clear statement that both Italy and the EU at large see rescuing these regions as critical to the country's long-term economic future.

Past & Current Repopulation Schemes

One Euro Home Program

In recent years, one strategy taken to spur repopulation has been to implement incentive programs, such as the One Euro Home, to entice people to relocate to towns with a multitude of unoccupied or abandoned homes in need of repair. In the scheme, the new residents can purchase a home from the municipality for a single euro as long as they undertake the necessary renovation to make it habitable again and maintain its character, which costs significantly more than the down payment (Giuffrida et al., 2021). It is anticipated that, in the immediate future, these renovations will generate new employment opportunities within the municipalities, while, in the long term, the influx of new residents to the town will foster the development of a vibrant and flourishing community and economy. Despite the media attention this program has received over the past several years, the scheme has seen a mixed level of success due to the state of social and physical infrastructure in these areas. Without weather-proofed homes, easy access to child education services, medical services, convenient businesses, and other amenities, new residents who successfully complete these renovations can still struggle to adapt to living in these areas and end up leaving.

Some towns, however, have greatly benefited from the scheme. In Sicily, some residents have characterized the results of the program as a "second Renaissance" (Todiwala, 2024). For instance, the town of Sambuca now hosts new residents who live in town for a significant portion of the year, most of them originating from outside of Italy. Despite the influx of new people, the town has preserved the intimate community ambiance that local residents were initially apprehensive about losing and has taken major steps toward restabilizing the

population and economy (Todiwala, 2024). From the municipal perspective, the scheme has also produced economic success in places. Within the municipality of Mussomeli, a substantial economic benefit has been observed due to a significant increase in pedestrian traffic. The tourism industry experienced a remarkable growth of 3,000% in the town during the initial year of the One Euro Home program's implementation (Todiwala, 2024).

Rural Italy as a Remote Work Destination

Another strategy that has been explored to regenerate rural Italy is to market towns as remote work hubs, particularly to those already living and working in Italy. With a lower cost of living and fast internet, many remote workers could thrive in these territories while providing the municipalities with a needed economic boost. Several organizations, such as SouthWorking, are working to create large infrastructure networks that support newcomers to marginalized regions, making the transition to rural life easier while ensuring towns benefit from their economic investments (*South Working - Advocacy*, 2024). This strategy enjoyed particular success during the peak of the COVID-19 pandemic when remote work was made possible across many industries. However, as return to work schemes have begun gaining strength across industries, the share of population who could partake in this scheme has grown smaller. One study in Trentino found that despite remote working surging to 22% in the area during the COVID-19 pandemic, the trend was quickly reversed once workplaces reopened (OECD, 2021). These trends indicate that although there could be some opportunities for people to relocate to more peripheral areas, it is likely that many workers will still need to live in a location that is an accessible distance from their workplace. The strategy still could have impacts on rural geographies, but may capture a smaller percentage of local Italian workers than originally predicted during the pandemic.

However, additional programs from the Italian government could increase the number of people able to work in Italy in the near future. In March 2024, guidelines for Italy's Digital Nomad Visa were announced, providing people of other nationalities who work remotely with a visa that allows them to work anywhere in Italy for at least a year given they reach a certain income bar (O'Donoghue & Brown, 2024). Applications for the visa have yet to open, but the potential influx of remote workers could represent a significant opportunity for rural municipalities.

Investing in Tourism

Tourism is another key strategy being explored by the NRRP and other national organizations and governing bodies. Over 10% of Italy's GDP was generated by tourism and travel related activities in 2022, and boosting tourism to rural areas represents a key method being explored for economic development in the Inner Areas (*Italy*, 2023). There have been a variety of case studies showing the importance of the tourism industry on local economic development as municipalities benefit from both business and job creation as well as the direct influx of tourist spending on their local economies. In Apulia, the region has been focused on boosting year-round tourism by investing in their artistic and historic resources, and between 2008 and

2014 saw a 70% increase of accommodation options for tourists as a result of the Rural Development Programme for the region, with over 2.2 billion euro generated as a result of tourism in 2015 (Schiavone et al., 2016). Many regions also focus on agri-tourism as an economic driver, linking in their natural resources to entice visitors and tourist spending in the area. One study across Montaione, Castelfiorentino, Certaldo and Gambassi Terme in Tuscany found that about 30% of the impact of tourist spending in the area contributed to industries not specifically related to agritourism, thus helping to boost the area's economy overall in addition to developing more more business and jobs related to the tourism industry (Contini et al., 2009).

Tourism can also be combined with strategies that utilize the country's existing historic infrastructure, ensuring that cultural heritage is preserved while also boosting local economies. One case study showing the potential impact of this combined approach exists in the municipality of Favara in Sicily, where FARM Cultural Park is located. Built inside a series of buildings that were set to be demolished due to failing infrastructure in the municipality's old town, it is now a vibrant collection of new programming including: a contemporary art exhibition space, a children's architecture school, artist co-working spaces, bookshops, and open public space (Baraldi & Salone, 2022). Since opening, FARM has led to about 120,000 tourists per year visiting Farvara, which previously had no tourism economy, and about 150 new hospitality offerings have opened (Baraldi & Salone, 2022). The Cultural Park's reprogramming of these abandoned buildings to draw more tourism in the area has created a significant economic impact for the town and presents a clear example of how other territories could approach regeneration efforts even if they are not currently engaged in the tourism economy.

However, tourism can be a difficult approach for very remote municipalities, largely due to the lack of convenient services in these areas that many tourists would need to rely on for short stays, such as an abundance of local food vendors or luxury hotel options. As a result, more towns are looking toward long-term tourism approaches, which, similar to the remote work opportunities, bring tourists for several months or weeks at a time. Rather than a short stay, tourists become more like temporary residents, integrating more deeply with the pace of life and available resources present in the town. This approach allows more towns to take advantage of potential tourism-related funding without the need to form the municipality's entire economy around tourism (G. D'Agostino & N. Delgado Alcega, personal communication, January 15, 2024). Additionally, it works against potential displacement caused by over-tourism that is seen in cities across Italy such as Naples (Esposito, 2023).

New Ways to Approach Redevelopment & Decision Making

Efforts are underway not only to develop strategies for municipalities to use in regeneration schemes, but also to create a more participatory and equitable process for redeveloping these areas. An ongoing goal of preservation and reuse strategies is to make the process of planning more participatory to ensure community benefits, which at the same time helps grow the strength of heritage communities in these areas (Gravagnuolo et al., 2021). In one case study in Salerno, researchers used mapping exercises, stakeholder engagement, and other community

co-design strategies to develop a clear proposal to use their cultural heritage site, ancient clay tile furnaces, to promote economic regeneration (Gravagnuolo et al., 2021). To begin this process, residents defined key elements of cultural importance that needed to be preserved within their territory, and then worked to map their potential value as economic drivers for the local economy, eventually moving forward with the clay tiles (Gravagnuolo et al., 2021). Determining the stakeholders required to then engage this cultural heritage site also played a key role in their process, as there can often be conflict between private owners of these sites and the public interest in adapting or reusing them as economic drivers (Gravagnuolo et al., 2021). This study points to the idea that the process of preserving and adapting cultural heritage sites, historic structures, and other locations of cultural importance can not only support local economies, but can also build a community that is more invested in and connected to their space.

There are often multiple potential scenarios that can come out of community-driven regeneration and adaptation projects, and so clear evaluation techniques are needed to determine which strategies should be prioritized. One potential method, explored in a monastery conversion in Tuscany, used a set of four weighted criteria, each with many distinct subcategories, to determine which reprogramming plan had the highest potential for economic impact, the most potential community involvement, and the least invasive restorations (Amato et al., 2021). These four categories were: economic, cultural, territorial integration, and restoration impact (Amato et al., 2021). Other studies, such as one in Trieste, have evaluated the designs from a sustainability and environmental impact perspective, looking at potential energy consumption that will be mitigated with building restorations and using SWOT analysis to continue to highlight community priorities (Jiang et al., 2023). In all cases, it is critical to evaluate each reprogramming proposal on a set of criteria that accurately reflects the priorities and constraints of the specific area of study.

The framework tested in this thesis focuses on combining community desires with existing building constraints to determine a feasible path forward for towns, balancing both the technical considerations outlined in much of this literature with the goal of having the work be rooted in community consensus. In Guadagnolo specifically, an extensive community engagement process has already been carried out by both the thesis client, Liminal, as well as the municipality itself to build community consensus around potential reuse. As such, the framework used in this work focuses more heavily on understanding and mapping the required building criteria to support these varied uses, rather than doing the initial use scenario identification itself. The framework builds on the many of the visual indicators specified throughout this literature and combines it with a set of indicators identified by residents of the region.

Liminal & Their Impact in Rural Italy

Background on Liminal

The thesis client for this work is Liminal, a non-profit organization based in Italy that is working to support rural municipalities by building capacity on the ground and engaging young people interested in finding solutions to the challenges rural municipalities are experiencing. Liminal emerged from the shared vision of its three founders – Ginevra D'Agostino, Nicolas Delgado Álcega, and Carmelo Ignaccolo – who were interested in tackling the architectural, urban, and social challenges confronting depopulated and abandoned small towns across Italy. While pursuing their studies in architecture and urban planning at the Massachusetts Institute of Technology and Harvard University, the idea took shape to establish an interdisciplinary collective capable of addressing the pressing infrastructural, political, and economic issues within rural territories. Through this innovative, interdisciplinary approach, they aim to play a significant role in reviving Italy's rural areas. Liminal is still active within both of their former universities, engaging current students across disciplines to support their ongoing projects in Italy, which is how this thesis client partnership initially began (*Liminal Values*, 2023).

Working in partnership with public and private institutions, Liminal takes a multifaceted approach to rural economic regeneration. By facilitating revisioning efforts, providing advocacy and support to attain funds from NRRP and other large organizing bodies, and building capacity within towns in a variety of sectors, Liminal works to foster sustainable development practices and address the unique architectural, urban, and social challenges faced by rural communities (*Liminal Values*, 2023). Liminal's work is deeply community-centered. Through partnerships with LAGs, residents, and municipal employees, Liminal creates hyper-local programs and proposals that have the potential to inspire long term reinvestment in rural locations. Liminal is further supported by several private institutions, including several universities in the US, Italy, and Chile, who provide additional resources and support for their various activities.

Currently, Liminal is in the process of opening their first set of Embassies, a set of workspaces in rural territories that can be used as homebase for people in the community and Liminal members to collaborate on implementing new economic development initiatives. Given the pace of progress within the Italian government, many of the proposed approaches to reuse for these towns and regions are multi-year endeavors that need to be sustained through a continued on-the-ground presence. In 2024, Liminal is opening their first Embassy in the region of Monti Prenestini, where they have worked for the past several years already on community capacity building and data collection.

Liminal Labs: Understanding Individual Contexts

Over the past several years, Liminal has worked across the regions of Lazio, Abruzzo, Liguria, Sicily, and Molise on a variety of projects with plans to expand to Valle d'Aosta within the year. One of Liminal's primary models to understand and begin visioning work in each of these

locations is through conducting Liminal Labs, which bring students and community members together to collect, analyze, and respond to quantitative and qualitative data. Over the course of 3 to 8 weeks, groups work together to study the rural focus area, create important new datasets that the town can use to apply for funding, and ultimately outline a set of proposals for a town to explore to help entice economic regeneration. Students from across the globe participate in these Labs and collaborate directly with local residents to ensure every proposal is context-specific and representative of the community's vision for itself.

To ground the work, the Liminal Lab begins with a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) that is developed over the course of many interviews with local stakeholders and residents. This allows incoming students to have an opportunity to learn directly from community stakeholders, get first hand perspective on the challenges facing territories, and build context of the territory at large. This activity is key to creating deep relationships with community members and ensuring that community-voice is centered in the generated proposals.

The Lab then moves on to data collection work, primarily focusing on mapping the territory using 360 cameras in an exercise called Digital Paths. In this exercise, students learn the process of 3D data capture and metadata collection to ultimately create data that can be viewed on Google Street View. This process provides territories with a key technological base layer for their community and a new online presence, helping to immediately boost the accessibility of and interest in these rural towns. Additionally, Labs have tested an abandonment survey to collect data around occupancy and deterioration. The initial surveys developed a set of potential exterior building indicators that could reveal the likelihood of abandonment or level of decay of a town.

All of this work culminates in a localized, community-rooted set of proposals that municipalities, LAGs, and other key stakeholders can use to pursue funding opportunities, complete with multiple sets of data that validate these approaches.

Thesis Contributions to Liminal's Long-Term Vision

The primary objective of this project is to develop and pilot a new data collection method that could support Liminal's technical work, specifically in tracking building abandonment within the municipalities they collaborate with. The approach was designed to be iterative, allowing for refinement and replication across different territories as Liminal expands its efforts and incrementally builds a national dataset. In the short-term, the thesis work aims to support Liminal's collaboration with Monti Prenestini, providing the town with an extensive base data set that both Liminal and the municipality itself can leverage while working on grant applications and engaging community members. This work represents an initial pilot for a framework that Liminal intends to implement across various Italian towns. The long-term goal is to create a comprehensive national dataset comprising key indicators related to occupancy rates, building typologies, and structural conditions. By gradually accumulating data from rural communities throughout the country using the survey methodology outlined in this thesis,

Liminal aims to build a dataset that can support their national advocacy efforts. This dataset can then be leveraged to argue for changes in national funding structures that can better support the revitalization of Italy's rural areas.

In general, this thesis aims to understand how data collection and surveying of a specific town can reveal key insights on how to effectively reprogram, and tests a new survey and data collection process within a town that Liminal already has a significant presence. The remainder of this thesis focuses on Monti Prenestini, and specifically one its hamlets, Guadagnolo, as a case study, allowing the work to leverage Liminal's connections, understanding, and existing data about the region. The following chapter reviews in more depth the reasons why Monti Prenestini, and specifically Guadagnolo, was chosen as a case study for this work.

Chapter 2: Monti Prenestini & Guadagnolo

Monti Prenestini in a (Chest)nut Shell

Context of the Mountains

Only an hour drive outside of the city center of Rome, Monti Prenestini is a mountain range in central Italy that illustrates many of the challenges and strengths of rural Italy, making it ideal for a case study. While technically being within the limits of the Metropolitan City of Rome, Monti Prenestini itself contains many individual municipalities, several of which have created long-standing partnerships to help promote the area for tourism and agriculture. In particular, three of the municipalities have successfully partnered to receive funding from Italy's Ministry of Culture: the hamlets of Castel San Pietro Romano, Rocca di Cave, and Capranica Prenestina (which also includes the fraction of Guadagnolo) (G. D'Agostino & N. Delgado Alcega, personal communication, January 15, 2024). The three municipalities were awarded funds through Bando Borghi Linea B, which provides funds to improve the "attractiveness" of areas for tourists, primarily through investment to renovate existing infrastructure and improve marketing around existing natural resources, turning regions into destinations for local tourism (G. D'Agostino & N. Delgado Alcega, personal communication, January 15, 2024).

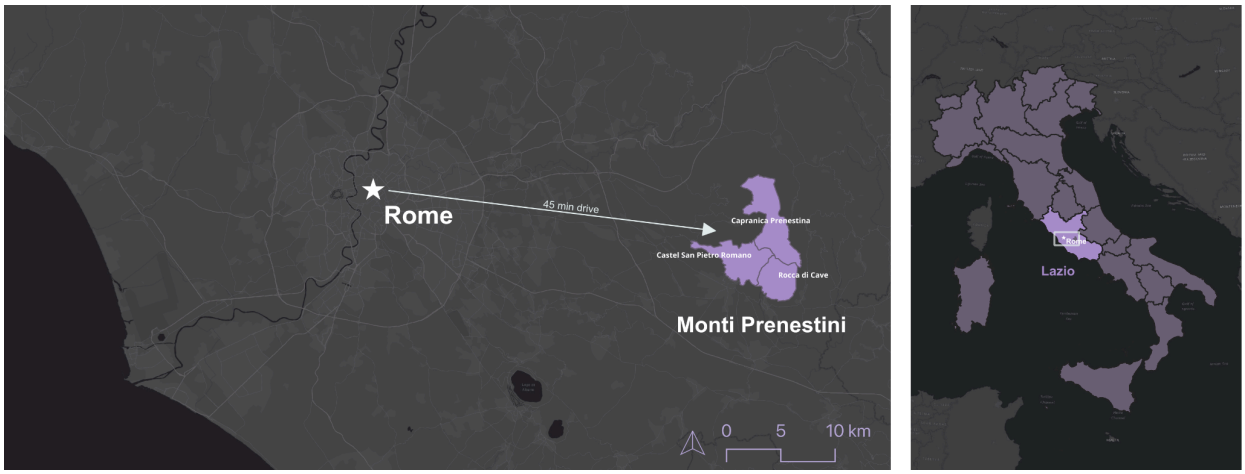


Figure 3: Monti Prenestini & its proximity to Rome.
The three municipalities of Monti Presentini are only a 45 minute drive to Italy's capital Rome, which is unique given the deeply rural nature of the area.

In medieval times, these towns were used as strategic military lookouts for larger cities situated in the mountain valleys surrounding the area. At peripheral elevations starting at over 700 meters (~2,300 ft), these hamlets could leverage their distant view of the Mediterranean to the west to identify incoming ships during conflicts (G. D'Agostino & N. Delgado Alcega, personal communication, January 15, 2024). However, as time passed, technology improved, and conflicts died down, the hamlets' use as lookouts became less critical and these towns became residential villages for people working in the surrounding agricultural fields. Over time, the allure

of living in the larger nearby cities, which had easier living conditions, more stable employment, and greater access to healthcare and other key amenities, brought many hamlet residents out of their homes, thus beginning the trends of depopulation still being seen today (A. Mattogno, personal communication, March 5, 2024).

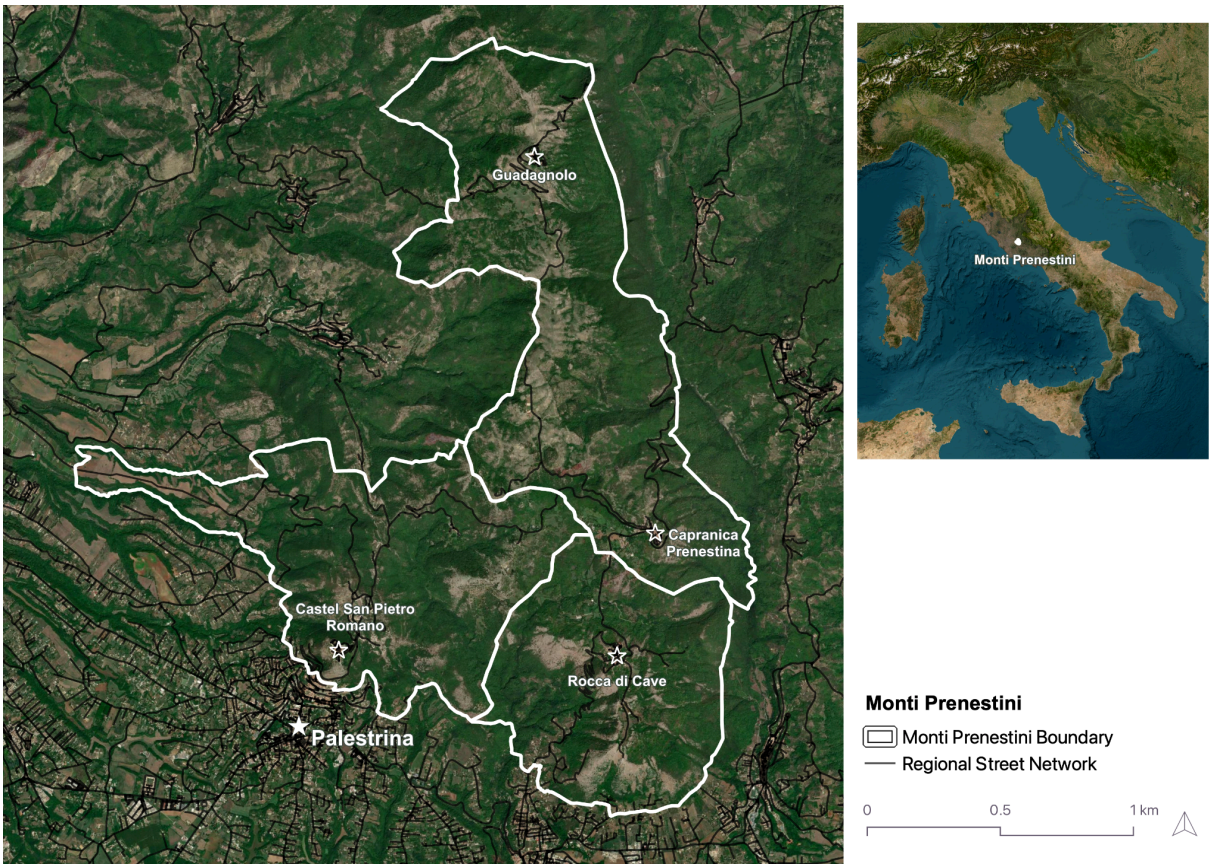


Figure 4: The three municipalities of Monti Prenestini.
Monti Prenestini is made of three municipalities: Castel San Pietro Romano, Rocca di Cave, and Capranica Prenestina. There are several small cities on the outskirts of this region, including Palestrina, which rests in the valley just south of Castel San Pietro Romano.

Presently, Monti Prenestini struggles with several of the same socioeconomic challenges seen throughout the country, including depopulation, limited job opportunities, and variable access to essential resources. However, new networked partnerships are helping to address these challenges and revitalize the region. One of the current projects is formalizing a network of trails that connect the towns to each other, allowing for tourists to explore the region more easily and safely (*Discover Monti Prenestini - Hike*, 2023). Additionally, several museums have been restored or renovated in the past years to help attract more visitors to the towns. The LAG for the region, LAG Castelli Romani e Monti Prenestini, has been very active in the past several years, and has been a partner with Liminal in their ongoing work in the region.

From an ecological perspective, Monti Prenestini has several unique features. Part of the pre-Apennines in Lazio, the mountains are composed of limestone cliffs, forests, and pastures

for wild farming (*Progetto - Campo Base Guadagnolo*, 2022). Of particular interest is the chestnut woods in the area which produce a species of chestnut called Mosciarella, which are native to the region, and harvested and dried by local farmers. Mosciarella season is marked by a festival each year, celebrating the harvest and process of transforming these fresh chestnuts into dried produce. In total, 36 traditional Mosciarella dryers are still present in the region's chestnut woods, but the practice is slowly being lost as fewer young people are interested in taking over the trade (*Progetto - Campo Base Guadagnolo*, 2022). Fondazione Slow Food has been working with the community to try to preserve these traditions, in particular by attempting to expand the use and sale of the chestnuts to a broader audience to boost the industry and make the field more economically viable (*Capranica Prenestina Mosciarella*, 2024). Fondazione Slow Food works closely with Liminal and LAG Castelli Romani e Monti Prenestini to integrate Mosciarella traditions into ongoing reinvestment activities in the area.

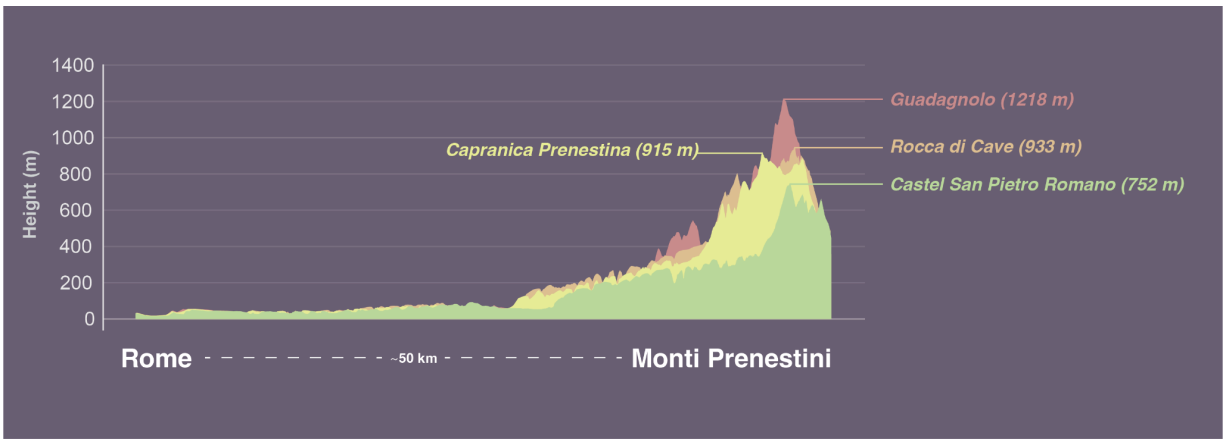


Figure 5: Elevations of Monti Prenestini compared to Rome.
The towns of Monti Presenstini range from 752m to 1218m in height. Given their proximity to Rome which is effectively at sea level, the region experiences a significant elevation increase within a short distance, creating a steep landscape (Tarquini et al., 2023).

Although Monti Prenestini as a whole contains 17 municipalities, Liminal's focus and this thesis is concentrated on the four towns currently working together, which represent only three of the municipalities. Castel San Pietro Romano, Rocca di Cave, Capranica Prenestina, and Guadagnolo all exist within about a 45 minutes drive of one another, and unlike many other rural hamlets, have a Monday-Saturday public bus service that connects the towns to each other. Cotral, Lazio's regional bus system, provides routes between these four locations three times a day, creating an unusual level of access for otherwise remote locations that is used by both tourists and residents. Despite their close proximity, each of these towns provides the region with a different resource to create a mix of different cultural and religious destinations, sites for outdoor activities, and unique agricultural traditions that work together to provide a structure for repopulation and economic regeneration efforts.

Figure 6: An image showing cattle blocking the road from inside a Cotral regional bus.
Monti Prenestini benefits from a bus network that connects the four towns to Palestrina and other small cities on the periphery. Despite the ruralness of the area, there can still be "traffic" jams due to the cattle farming in the area.

The Towns of Monti Prenestini

This section explores the broader regional dynamics and unique characteristics of the four main towns in the area (Castel San Pietro Romano, Rocca di Cave, Capranica Prenestina, and Guadagnolo) to provide needed context for this thesis. While Guadagnolo serves as the primary research site, the town is significantly shaped by the surrounding municipalities. Funding sources are often shared across all four locations given their existing partnerships, which has led to strategic development decisions needing to be made at this regional level. The cultural contexts of these towns also influence one another. Gaining an understanding of this regional context is essential to accurately situate Guadagnolo's unique position among the four towns when considering large-scale reuse scenarios for the territory.

Castel San Pietro Romano

The most populated town of the four at about 900 people, Castel San Pietro Romano (CSPR), benefits from its close proximity to both Rome and the city of Palestrina, which sits just at the bottom of the mountain and has a population of about 20,000 people (Italian National Institute of Statistics, 2024). CSPR is one of "Italy's most beautiful villages", a designation made by the country to help spur tourism to more rural, lesser known areas throughout Italy (L'Associazione de I Borghi Più Belli D'Italia, 2018). With its panoramic views, medieval architecture, and access to lush forests, the town has a variety of notable features worthy of the designation. Historically, CSPR gained significance in the 1950s when the famous Italian movie "Pane, amore e fantasia" or "Bread, love, and fantasy" was shot there (L'Associazione de I Borghi Più Belli D'Italia, 2018). In recent years, it has become a local tourist destination for people looking to visit sites from the movie or see its 6th-century polygonal walls and the medieval castle the town takes its name from.

Figure 7: An image of Castel San Pietro Romano. Like the other towns of Monti Prenestini, Castel San Pietro Romano is full of staircased, pedestrian-only pathways.

Of the four towns, CSPR has the largest number and variety of amenities within the historic center. A convenience store, mini-grocery, wine bar, cafe, bakery, gym, and restaurant are all present within the historic core, and the town has the only grade school in Monti Prenestini. The school typically educates about 50 students a year across all grade levels, with classes often spanning several grades and students coming from the farthest town in the region (Guadagnolo) every day (A. Mattogno, personal communication, March 5, 2024). Either as a result of all of these amenities or vice versa, the town is one of the few that remains well populated year round, but is also the most expensive to live in. CSPR is often called the gateway to Monti Prenestini, as from both Palestrina and Rome it is typical to pass by the town en route to the other towns of Monti Prenestini.

Rocca di Cave

Rocca di Cave is a hamlet of the larger town of Cave that sits at its base (its name translates literally to Rock of Cave). Although population estimates in 2023 claim that Rocca di Cave's population is about 360 people, the reality is much lower, particularly during non-summer months and in the historic center (Italian National Institute of Statistics, 2024). Like many of the other towns in Monti Prenestini, Rocca di Cave's population is highly seasonal, so many houses are not equipped for full time use. Of the four towns, Rocca di Cave has one of the steepest and most complex street networks, with narrow staircases connecting different levels of buildings all built atop each other, with most of the perimeter built directly up to cliff sides. These conditions make renovation and restoration work extremely difficult, leading to total abandonment in some parts of the town.

Figure 8: An image of Rocca di Cave from the valley.
Rocca di Cave, like many of the other towns of Monti Prenestini, is built right up the mountain edge, making renovations of buildings on the periphery very difficult.

Notably, the town has a paleontology museum and astronomical observation center built within its historic fortress called the "Ardito Desio" Civic GeoPaleontological Museum. The museum covers 100 million years of history in the region, complete with fossils from a coral reef that visitors are able to touch (*Geomuseo Planetario*, 2021). In 2009, the museum was visited by almost 5,000 young students learning about the paleogeographic significance of the area, making the museum a critical part of the town's economic regeneration strategy (Amadori & Grossi, 2010). Presently, however, the museum is only sometimes open on the weekends and by appointment only during the week, likely because the cost of staffing exceeds the potential revenue generated by walk-in visitors in such a remote location.

Figure 9: An image of a collapsed structure turned into a garden in Capranica Prenestina.
Capranica Prenestina is the biggest town of Monti Prenestini by volume, but also sees some of the most abandonment and physical deterioration.

Capranica Prenestina

Capranica Prenestina is the biggest of the four towns by volume of buildings and area, and similar to CSPR has several key amenities to help with livability. The town has two restaurants,

two cafes, a bakery, and a food vendor who comes several times a week to sell fresh fruit and vegetables, and, unlike many other towns, has reliable, free WiFi available throughout the town. Residents are more likely to live here year round than in Capranica Prenestina's hamlet of Guadagnolo, but its lack of jobs still make it a difficult economic choice. As such, it also has some of the most widespread abandonment and degradation issues, with many buildings experiencing extreme facade degradation and some with collapsed roofs. Like many of the other towns, Capranica Prenestina is surrounded by agricultural land and is the center of the Mosciarella production in the region (G. D'Agostino & N. Delgado Alcega, personal communication, January 15, 2024).

Contextualizing Guadagnolo

This thesis uses Guadagnolo as a case study to represent many of the challenges and opportunities that face rural mountain towns across Italy, including a declining population, seasonal fluctuations in population, and industry reliance on agriculture typical to rural towns experiencing economic decline. To understand the larger motivation behind selecting Guadagnolo as a case study site, a deeper background of the challenges and opportunities in the area is explored in this section, in conjunction with a review of its historical background and present ideas for revitalization.

Background on Guadagnolo

Guadagnolo exists within the same administrative commune as Capranica Prenestina, with Capranica Prenestina being a larger town with more amenities and Guadadgnolo being its historic, strategic lookout point or hamlet. Together, their population is estimated to be about 300 people (Italian National Institute of Statistics, 2024). Unlike the other towns which are situated nearby to a city or larger town in a valley, these two towns are deeper within the mountain range and do not have a valley counterpart. Their placement in Monti Prenestini makes them more difficult to access, requiring many visitors to pass several other hamlets on narrow mountain roads before reaching these towns. Guadagnolo is also the smallest of the four towns both in population and physicality. The population of this town is heavily seasonal,

Figure 10: An image of Guadagnolo.
Guadagnolo is deep within the Monti Prenestini range, and from its summit the snow-capped mountains of Abruzzo are visible.

with it dwindling to about 10 residents during the winter months and booming to about 60 people during the summer (A. Mattogno, personal communication, March 5, 2024). The town has two restaurants (one of which also acts as a cafe) and a publicly funded hostel, but beyond these three features has no other major amenities in its vicinity. Like the other towns of Monti Prenestini, Guadagnolo is surrounded by agricultural land, including horse and cattle farms whose livestock is permitted to roam the roads leading up to the town. Guadagnolo also has a number of potential tourist attractions. Guadagnolo is the highest inhabited town in the region of Lazio, at 1218 meters, and has panoramic views in all directions, including visibility to the Apennines in Abruzzo. Due to its position on the cliffs of Monte Guadagnolo, the town is also a destination for avid climbers from Rome. Furthermore, the town is very close to the Sanctuary of Mentorella, the oldest Catholic Marian sanctuary in Italy and a pilgrimage location in its own right. The Sanctuary is famous for being a favorite of many popes, including Pope John Paul II (*Progetto - Campo Base Guadagnolo*, 2022). This mix of few amenities, interesting tourism drivers, and a declining population is typical of many rural towns in Italy, therefore making it particularly illustrative of the challenges of rural Italian territories.

Figure 11: Building use in Guadagnolo.
Guadagnolo consists primarily of residential buildings, but benefits from two restaurants and a hostel in the town's center.

Figure 12: The landscapes around Guadagnolo.
Guadagnolo is primarily agricultural, with fields for cattle and some farming surrounding the mountain town.

Historic Context of Guadagnolo

Understanding how Guadagnolo's historical context led to its present day condition is key to being able to identify realistic, feasible reprogramming strategies that could work within the town. Although the exact origins of the town are unknown, some theorize that the site was settled as early as the 5th century (Comune di Capranica Prenestina, 2017). However, the village likely grew to its current scale starting in the 1200s as a response to the nearby Sanctuary of Mentorella, as workers who farmed the land owned by the monks needed a place to live nearby (Comune di Capranica Prenestina, 2017). Guadagnolo was built in a defensive layout, with the town center protected by a large rock formation to the south and a ring of multi-story buildings to the north (*Progetto - Campo Base Guadagnolo*, 2022).

Guadagnolo's infrastructure development has been gradual, with electricity only arriving in 1955, a road wide enough to support carriages in 1958, and an aqueduct to support modern plumbing in 1972 (*Progetto - Campo Base Guadagnolo*, 2022). (For context, in America there

were major efforts underway to electrify rural areas by the 1930s (Wallace, 2016).) Beyond these major infrastructural updates, Guadagnolo has seen almost no additional development over the last 150 years. The town has a total of 147 properties, 98% of which are not publicly owned and most of which were built during the major settlement in the 1200s. Within the historic center, only two of the buildings are publicly owned - the hostel and a meeting place for local organizations (*Progetto - Campo Base Guadagnolo*, 2022).

Figure 13: An image of the Santuario della Mentorella.
The Sanctuary of Mentorella is a popular pilgrimage destination and a favorite place of many past popes.

Historically, the primary vocation in Guadagnolo has been agriculture, and agricultural activities in the town are still centered around wild breeding of cattle, sheep, and goats. Farmers also work to produce cheese and grow mushrooms and chestnuts local to the area. However, the town's economic activities (and subsequently available services) have declined over the years due to the abandonment of agriculture for more profitable professions and the resulting depopulation of the village. In twenty years, between 1991 and 2011, the town experienced a 51.2% decrease in population, leaving only 42 current inhabitants according to one census. Of that remaining population, 62% of them are over the age of 74. This dramatic population decline has led to the decay of both public and private building stock, with only occasional work being done on individual buildings to repair critical infrastructure (*Progetto - Campo Base Guadagnolo*, 2022).

Figure 14: An image of one of the public squares in Guadagnolo.
Given its altitude of almost 4,000 ft, Guadagnolo is particularly exposed to the elements. During winter mornings, the town is often in a cloud of dense fog.

However, more modernization efforts are underway. In the past several years, there has been renewed activity to install fiber internet in the town, and a serious effort has been started to stabilize the surrounding rock formations to protect the town during seismic activity. The town has also in recent years been claimed as a radio transmission site due its location, however these stations are planned to be moved to restore the panoramic views from the summit,

which have been severely interrupted by these industrial sites (*Progetto - Campo Base Guadagnolo*, 2022).

Guadagnolo still enjoys tourist visits from people on pilgrimage to the nearby sanctuary and from people looking to scale its unique and challenging rock formations. As a result, renewed interest has been placed in the public hostel in the town center, and additional funds have been directed toward renovating the building. Work on the hostel renovation began in January 2024, in part to prepare for potential pilgrimages to the sanctuary that may happen as part of the Vatican Jubilee in 2025 (A. Mattogno, personal communication, March 5, 2024).

Liminal's Past Work in Monti Prenestini & Base Camp Guadagnolo

This thesis work leverages Liminal's past efforts and data collection in Monti Prenestini, including the base data layer which includes an orthophoto of the historic center of the town and 360° footage of its street network. Crucially, Liminal collected the town's vision for its future, capturing residents' wants and desires through a SWOT analysis. This exercise provided the organization with several important relationships, including one that expounded on this present day context by providing records of a past grant application that was put together by town officials and residents to combat depopulation. Although ultimately unsuccessfully, the grant application provides a snapshot of what Guadagnolo could see for itself in the future.

The application proposed reforming the town as "Base Camp Guadagnolo" through a coordinated set of urban-building interventions and social initiatives that involved the replacement, reuse, and redevelopment of the built environment. The proposal, which would have provided the town with 20 million euros via the Ministry of Culture, showcased an idea to turn the town into a university outpost, bringing students to study the vast, unique ecology of the area while simultaneously breathing new life, jobs, and infrastructure into the area. The proposal included a variety of major projects, including renovations to existing buildings, restoration of key areas and public spaces in the town, and the development of a trail network that would highlight Guadagnolo's natural beauty. The scheme was focused on bringing students, remote workers, tourists, and educators to the area, both for the short and long term, and updating facilities to provide the needed space for people to work and live. A key component of the proposal was the structuring of a permanent "InterUniversity Campus" on the site to benefit students and foster potential partnerships across universities and local organizations (*Progetto - Campo Base Guadagnolo*, 2022).

The grant writing process was led by the municipality, but was ultimately a collaboration with many community groups and local residents, with over 18 different institutions involved in the final plan. Notably, the University of Rome and the University of Tuscia signed on to be academic partners who could eventually benefit from having the campus node within their network. Municipal community engagement for the proposal began in 2021, and during the process, four critical objectives were identified by the grant writers that were used to guide all potential reprogramming strategies. These four objectives were to generate attractivity,

develop employment opportunities, generate community, and prevent harm to the land (*Progetto - Campo Base Guadagnolo*, 2022).

The grant also highlighted several of the major challenges currently facing Guadagnolo. One notable challenge to this scheme is that much of its building stock is privately held and therefore difficult to restore without permission of the owners or potentially expropriation of the property. Additional challenges, such as the accessibility and safety of the medieval village road system, the number of disconnected car and pedestrian routes throughout the town, and the lack of lighting in many places of the town, were also cited as issues that needed to be addressed with the grant money (*Progetto - Campo Base Guadagnolo*, 2022).

The plan included a strategy to diffuse residences for trainers, students, tourists, and remote workers across the town, making use of many of the presently unoccupied buildings. As part of the grant writing process, 19 private owners agreed to participate in the potential scheme, in which their primarily unoccupied houses (which represent 12% of the town's buildings and 20 different properties) would be renovated to become accommodation or working spaces for either new full-time or temporary residents. Most participating private homes belonged to people still connected to the town but no longer living there, and therefore saw the scheme as an opportunity to restore their family homes while also generating income. The selected properties were to undergo structural and seismic analysis and then restored to become cultural, co-working, study, social, and recreational spaces. The plan also included an additional renovation of the Guadagnolo hostel, one of two public properties, to make the ground floor classrooms and labs in support of the academic node (*Progetto - Campo Base Guadagnolo*, 2022).

The effort also sought to safeguard specific elements of the landscape and ecosystem. The proposed "InterUniversity Campus" was set to work with the Community Cooperative of Capranica Prenestina and Guadagnolo, among other organizations, to support study in forestry, agronomic sciences, climate change, and other related disciplines. On the tourist side, additional designated routes were to be developed to allow hikers and climbers to explore more of the nature around Guadagnolo without interrupting habitats or native plant ecosystems (*Progetto - Campo Base Guadagnolo*, 2022).

Despite the fact that the proposal did not win the 20 million euro grant, it still represents a realistic reprogramming plan for the town that is supported by the majority of residents and provides key data about which buildings are potentially unoccupied. In future years, these projects could be split up into smaller initiatives funded by other national and EU grants.

Guadagnolo as a Case Study Site

Between the "Base Camp Guadagnolo" grant proposal and the additional information collected by Liminal about Guadagnolo, it represents an ideal case study candidate. Its small size allows for a thorough survey to be carried out on the town, while its specific challenges and opportunities serve as an accurate representation of other rural municipalities throughout Italy.

Like many other towns, Guadagnolo currently lacks key amenities such as schools, grocery stores, and pharmacies that are often needed to prevent depopulation. It faces weather-proofing issues in its buildings, a lack of industrial or economic opportunities for residents, and difficulty with internet access, all of which are common features of depopulating towns across Italy.

Guadagnolo's unique opportunities also make it an interesting site to analyze and understand. Its proximity to the Sanctuary of Mentorella and status as a haven for rock climbers and hikers provides context for how the town could be reprogrammed and used, and it's likely that towns across the country have their own individual set of drivers that could facilitate the direction of reprogramming, like these. Base Camp Guadagnolo provides significant context for the direction residents wish to move the town, which further data work can help continue to shape and inform. Liminal's past work in the area also provides a strong base layer of data that can be built upon. All of this prior work, resident activation, and community vision creates a remarkable opportunity to not only understand how much can technically be understood about a town through surveying and data collection, but also how this data can be used to inform and strengthen grant applications for towns in similar situations.

Chapter 3: Survey Framework & Data Methodology

Potential Impacts of the Proposed Framework

Short-Term Impact

This thesis demonstrates that understanding the state of occupancy, building condition, and building typology within a rural Italian town can provide key information useful in determining feasible reprogramming strategies and strategic reuse opportunities. Additionally, it illustrates how local, participatory, in-person survey methods can be beneficial in collecting the required data for this analysis. The thesis proposes and tests a new survey framework under which data can be collected and sorted to develop a robust digital model of a town. An eligibility assessment and suitability assessment can also be conducted on this collected data (after potential new uses for the town are defined) to generate a reprogramming proposal that the municipality can use immediately.

In the short term, the methodology used within the case study in Guadagnolo will provide Liminal with an understanding of how the framework functions on-site in a rural town and which parts of the survey provide the most accurate and useful pieces of information. Information on successful and unsuccessful indicators and which indicators are too difficult to survey will be key to helping Liminal frame the next steps of their participatory survey toolkit, which will begin being tested in the summer of 2024 in the Valle D'Aosta region in Italy, in partnership with local residents.

More technically, the methodology should provide enough robust data to be able to analyze the spatial connections between the three different survey lanes and identify which clusters of buildings might be appropriate and feasible options for different types of reprogramming. Being able to identify spatial patterns of abandonment and what influences them across lanes will be particularly important in thinking through how towns should approach reprogramming activities. Therefore, one primary goal of this research is to generate this data set, which will then allow for the creation of an extendable digital model of the town that further analysis can be done on.

Long-Term Impact

Furthermore, this thesis demonstrates that the learnings from an attempt of the methodology within a particular town, in this case Guadgnolo, can both provide clear next steps and improvements to the survey format, and can provide the case study town with useful, reliable data to help expand their potential funding opportunities. The case study format will provide Guadagnolo with a robust digital model that can be used for years to come and help test the feasibility of reprogramming ideas, such as those explored in the Base Camp Guadagnolo grant proposal. The case study will also provide Liminal with a new testing framework that they can leverage across regions to understand which towns are in the best position to apply and

receive additional funding for redevelopment. Understanding the strengths and weaknesses of the survey model will allow Liminal to create a participatory tool-kit that local residents can use to help document and understand the technical attributes of their municipality in the future. The case study approach and methodology test will provide new best practices that can be incorporated into the toolkit before involving public participation and time. In addition to its relevance to reprogramming strategies, over the long-term, the data collected from these surveys in regions across the country will allow for Liminal to develop a greater understanding of the connections between occupancy, typology, and condition within rural towns nationwide. This dataset could also prove meaningful in providing suggestions on how to approach national funding allocation strategies.

Proposing a Multi-Phase Framework

The proposed survey and assessment framework consists of two main phases: understanding the town and reprogramming the town. In the first phase, data is collected through a survey process that consists of three primary streams: occupancy, condition, and typology. In the second phase, a reprogramming proposal is generated by passing the data through an eligibility assessment and a suitability assessment, with the end result being a potential reprogramming plan for the town based on the data collected through the surveys in the first phase. A diagram illustrating this framework at a high level can be seen in Figure 15 below.

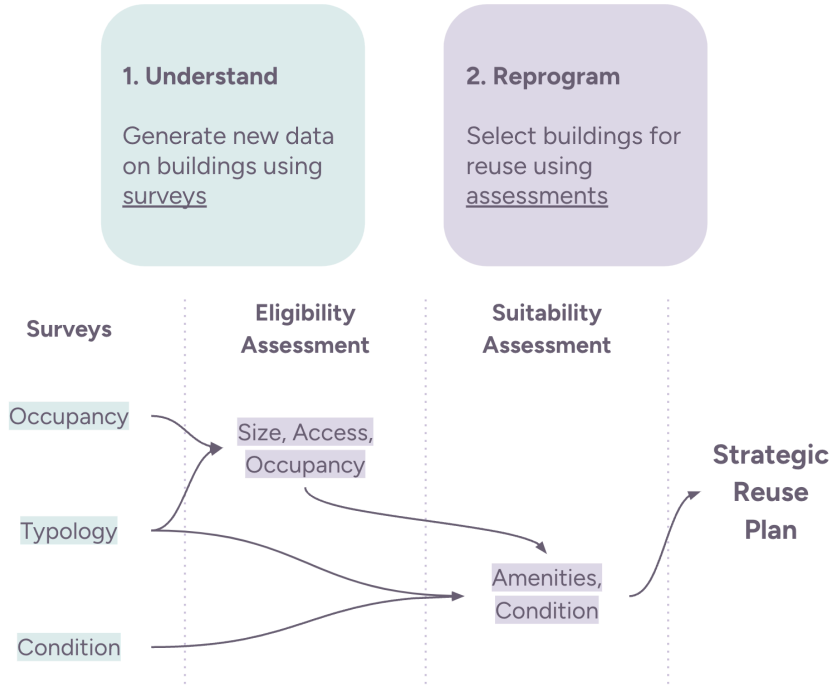


Figure 15: Diagram visualizing high-level framework methodology.
The framework is divided into two main phases: generating new data through building surveys to understand the town, and selecting buildings through assessments to reprogram the town.

Understanding the Town: Surveys

The three streams of the survey methodology are designed to work together, answering complementary questions to help address the larger question: What data on building conditions is necessary to inform feasible reprogramming proposals to drive repopulation and economic development? Occupancy helps to determine the level of abandonment and depopulation in the town, as well as what buildings might be available and empty for reprogramming. The condition survey helps inform the potential cost associated with a renovation or reprogramming based on the potential damage to infrastructure. Typology helps to catalog what types of buildings are available within the town and their access limits to understand what types of reprogramming might be feasible. Table 1 below highlights the primary research question as well as the underlying questions for the three research focuses.

Primary Question	What data on building conditions is necessary to inform feasible reprogramming proposals to drive repopulation and economic development?		
Research Sub-Focus	**Occupancy**	**Condition**	**Typology**
Secondary Questions	Which buildings are abandoned and are available for repurposing in each town? What do the patterns and timelines of abandonment look like?	Based on the physical condition of the building, how much would restoring it cost? Is the building a feasible option for reprogramming?	Are there physical limitations of what this building could be used for based on its existing typology? Beyond renovations, what might need to change about the building to reprogram it?

Table 1: Survey methodology driving questions.
The survey methodology is subdivided into three focuses, which each represent a different survey.

Indicators for each type of survey were developed through talking to local stakeholders and completing in-person walkthroughs of the four towns of Monti Prenestini. Through these field notes and conversations, a list of final indicators for the complete survey was developed and tested. Some indicators are highly regionally specific, and so it is expected that the survey will require refinement within each new region to ensure the information collected is reasonable and relevant. Indicators were also generated through discussions with Liminal based on their prior work studying abandonment in rural regions. More work on indicator development is available in Appendix A.

Survey Data Schema

The survey data schema that captures each of the indicators is split into four primary categories: building data, facade data, entrance data, and street network data. Within this split,

there are various levels of nesting and connections that allow for deeper understanding of the spatial model as a whole. Data is collected at the most specific level possible and then generalized when necessary to a broader level for comparison. For the purposes of this thesis, all data was compared at the building level, which is the most broad, but the granular data is still captured to ensure a robust and reconfigurable spatial model can be produced. Figure 16 below shows how the nesting and connections work between the four data categories. The building data is the broadest category, and can encompass data from all of the other categories through averaging and other forms of summarizing. Facade data is the next broadest, encompassing its own data as well as being able to summarize from entrance and street network data. Finally entrance data and street network data are the most narrow. Entrance data can be expanded on by its proximity to street networks, but otherwise is static. A more complete set of data schema tables for each of these categories is available in Appendix D. These data schema are used throughout the three survey types (occupancy, typology, and condition) to consistently capture and document information on the town.

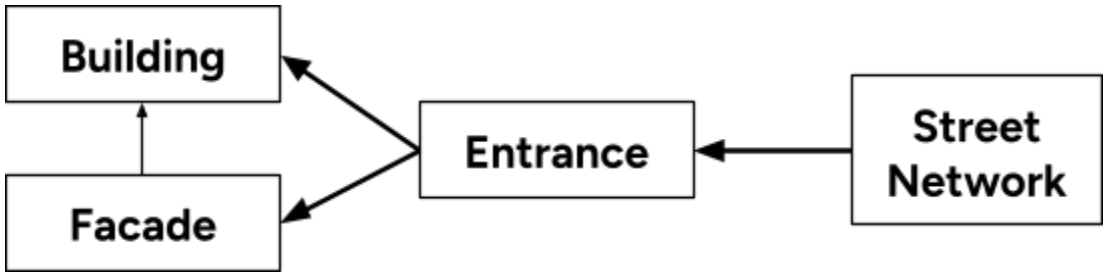


Figure 16: Cascading survey data structure.
Data can be collected on four different levels: building, facade, entrance, and street network. For comparison purposes, most data is consolidated onto the building level, which is possible given this cascading structure.

Occupancy Indicators

Which buildings are abandoned and are available for repurposing in each town? What do the patterns and timelines of abandonment look like?

Given that one of the most difficult challenges that these towns face is depopulation and abandonment, understanding the occupancy levels within the town in different seasons is key to developing an understanding of the scale of the issue within a municipality. Knowing which buildings are occupied and when can provide data around which buildings may be easily available for reprogramming and which are less likely to become available. Viewing this data spatially will also help provide context as to which parts of the town are more occupied in relation to other factors, like condition, typology, and access. Understanding the spatial patterns of occupancy and how seasonal occupancy might influence those patterns creates a picture of how the town currently functions and where people are most likely to reside.

Furthermore, the occupancy survey plays a potential role in validating or invalidating census information provided by the government. Despite often being outdated or incorrect, national Italian census information is often used as an application constraint when applying for funding from both public and private grants. Providing a more accurate count of people living in the town in different seasons could help municipalities be eligible for additional funding.

The indicators outlined in the table below provide a range of certainty for if a particular building is presently occupied. Of the three streams, occupancy is the most difficult to confidently measure due to its flexible nature. Indicators can mean different things in the presence of other indicators, seasonality can majorly impact the results of the survey, and some strong indicators (such as the presence of people within the building) can vary greatly depending on the season, the time of day, or day of week the survey is conducted. All of these variables can lead to uncertainty in the outcome.

Occupancy Indicator	Meaning	Explanation	Type	Units / Options	Data Level
Person Present	Occupied	This is the strongest occupancy indicator - if a person is present in the building or door, the building is occupied.	Boolean	True False	Building
Dogs Present	Likely occupied	Given the remote location of the towns in Monti Prenestini, there are rarely stray dogs in the vicinity, so if a dog is present, it's likely that there are owners also present.	Boolean	True False	Building
Functional Roof	No roof -> not occupied (else not strong meaning)	If a building has a collapsed roof or major holes in the roof, it is likely not habitable and therefore not occupied.	Boolean	True False	Building
For Sale Sign	Agency-listed sign -> likely not occupied Owner-made sign -> likely occupied	Typically, when residents put their properties for sale through an agency, it is because they are no longer living in the town to be present for the sale, meaning it's likely not occupied. On the other hand, if the building is for sale by the owner, it's more likely to be occupied.	String	“Self-made” “Agency-listed” “None”	Building
Hanging Laundry	Occupied	Clean laundry hanging outside of homes indicates someone is recently present inside.	Boolean	True False	Building
Belongings Outside	Belongings in good condition -> likely occupied or seasonally occupied Belongings in in bad condition -> likely not occupied	Oftentime residents leave belongings (such as brooms for removing leaves from stairs, flower pots, etc) outside of their homes. Belongings in good condition can mean that someone was there recently or seasonally as they have been kept in order despite weather events, but belongings in	String	“Good condition” “Bad condition” “None”	Building

		bad condition mean it's likely no one has occupied the house recently.			
Open Shutters	Open in summer -> likely occupied (potentially summer only) Closed in summer -> likely not occupied Open in winter-> likely not unoccupied if other strong negative occupation indicators Closed in winter -> likely summer occupation if positive occupation indicators present	Most windows across these towns (and across Italy) have shutters, and opening them each morning is typically a sign of occupancy. However, in the winter if shutters are open and there are no other signs of occupancy, it could be because they are in bad condition and have been blown open over time. Therefore, the meaning behind open shutters can change significantly depending on the season and what other occupancy indicators are present.	Boolean	True False None or N/A	Facade
Open Windows	No other positive occupancy factors -> likely not occupied Other positive occupancy factors present -> likely occupied	Similar to the open shutters, open windows often mean someone is currently inside if there are other positive occupancy factors. However, if there are open windows with no other positive indicators, it often means the property has been exposed to the outside elements long enough to leave it unoccupied or abandoned.	Boolean	True False Null	Facade
Broken Windows	Likely not occupied	Broken windows mean that the property has been continually exposed to outside elements, meaning it is most likely unoccupied or abandoned as winter conditions are not hospitable for permanently open windows in these towns.	Boolean	True False Null	Facade
Door Boards	Boards in good condition -> likely summer occupancy Boards in bad condition -> not occupied	Door boards are used by residents to prevent water from entering through gaps in the front door as many of these towns lack sufficient drainage in pathways. Door boards in good condition mean that the building is likely seasonally occupied and the board was resecured when closing the house up for the winter. Door boards in bad condition mean it's likely the boards were secured years ago and haven't been rescued or replaced since, meaning it's likely unoccupied or abandoned.	String	"No Door Board" "No Damage" "Mild Damage" "Severe Damage"	Entrance
Secured Curtains	In summer -> likely occupied (potentially summer only) In winter -> likely seasonally occupied	Curtains are used in many doors to allow for privacy while still being able to have the airflow and light come through. In summer, it typically means someone is currently present in the building and they are providing privacy. In the winter, if they are present but unsecured it can mean the building is occupied in the summer or is presently occupied. If curtains are	String	"Present & Secured" "Present & Not Secured" "Not Present"	Entrance

		secured at the bottom with rocks or other heavy objects, it means the building is seasonally occupied since the entrance is not currently being used. Securing curtains in this way is also a strategy residents use to tell if there has been attempted access to the building while they have been away for a long stretch.			
Civic Number Condition	Updated or Tiled in Good Condition -> Likely occupied at least seasonally Updated in Bad Condition -> Likely unoccupied, no strong meaning Not Updated -> no strong meaning Not Present / Visible -> no strong meaning	In some cases, residents update the civic number on their building. Typically, updated numbers indicate some level of occupancy, and in particular seasonal occupancy, as the updates are most often for tourists using the homes as summer retreats, as most people within the town know each building without the civic number present. In many cases, there is no civic number present or it has not been updated, and so little can be said about if this means the building is occupied or not.	String	"Updated or Tiled in Good Condition" "Updated in Bad Condition" "Not Updated" "Not Present / Visible"	Entrance

Table 2: Occupancy survey indicators and data schema.
This table documents the physical indicators collected during the survey process to assess the probable occupancy level of each building. Each indicator is accompanied by its meaning and explanation, data type, potential values, and the part of the building it pertains to (entrance, facade, or the entire structure).

Typology Indicators

Are there physical limitations of what this building could be used for based on its existing typology?

At present, some municipalities are unable to apply for particular grants due to the lack of data of the infrastructure present in the town. Certain funding is designated to towns that have a certain number of units or buildings, but since many towns only update municipal maps every 15-20 years, it can be difficult to know if a particular municipality can confidently submit an application for one of these grants.

Additionally, many reprogramming strategies are limited by typological constraints that are presently undocumented in these municipal maps, making it difficult to understand the feasibility of many ideas. Data around the available built square footage of towns, the accessibility of particular streets or entrances to buildings, and even the amount of light access a cluster of buildings has all can have a significant influence on the cost, effectiveness, or implementation difficulty of various reprogramming strategies.

The typology survey leverages both in-person surveying as well as GIS and orthophoto analysis to generate accurate data about the municipality. In particular, this survey concentrates on the accessibility metrics of buildings, entrances, and the street itself. This data will help

municipalities understand where particular changes need to happen in order to make historic town centers more accessible to more people, and when combined with the other two surveys, may also illustrate why particular patterns of abandonment or infrastructure deterioration are occurring.

Typology Indicator	Potential Impact Category	Explanation	Type	Units / Options	Data Level
Number Units	Renovation	Having a larger number of units may make the renovation more costly and difficult due to shared walls or structural features that are present in a unit owned by a different entity. Having to deal with multiple parties to do one renovation extends the time and potential cost associated with a restoration or renovation.	Integer	Housing Units	Building
Estimated Area	Livability	Most homes were built during Italy's medieval period, making them smaller than current expected living standards. Understanding the floor area available in each build can help scope which are suitable to be converted into modern housing.	Integer	Square Meters	Building
Estimated Volume	Livability	Similar to area, understanding estimated volume helps understand livability as compared to modern day standards. Volumetric estimates are also often used in renovations to quote potential costs for a renovation (for example, the estimated amount of plaster needed to redo all interior walls), so understanding the volume of each unit can also help gauge potential renovation costs.	Integer	Cubic Meters	Building
Perceived Use	Renovation	Most buildings in the town are set up to be housing, but a small group presently have other uses. In order to understand potential renovation needs and costs of a potential conversion, the current use needs to be documented.	String	"Housing" "Fallen Housing" "Restaurant + Housing" "Hostel" "Church" "Municipal Services"	Building
Garden / Open Space Access	Livability	Having access to open space is an important quality for most modern living accommodations and can provide access to natural light that medieval buildings can lack. Knowing which building has access to open space can help determine which are eligible candidates for conversion into modern housing.	String	"Direct Access" "Partial Access" "No Access"	Building
Stories / Floors	Renovation	For renovation purposes, the number of floors for each building is documented. This not only helps	Integer	Stories	Facade

		calculate potential living area but also the estimated cost of difficulty of a renovation.			
View Access	Livability	For conversions to new use cases, such as hotels or short-term accommodation, buildings that have views of the surrounding natural beauty can be prioritized to encourage tourism.	String	"Direct View" "Partial View" "No View"	Facade
Window Number	Sunlight/livability	Access to natural light is a key piece of modern living standards, so understanding the ratio of windows to the size of the building can help predict the amount of natural light access residents could have.	Integer	Windows	Facade
Estimated Elevation	Renovation	Building elevation is useful in understanding the difficulty of a potential renovation. Additionally, elevation can be used to calculate slopes and therefore access difficulty for pedestrians.	Integer	Meters	Entrance
Stair Requirements	Livability	Stair requirements to enter a specific building can restrict access from people with limited mobility. This not only changes currently livability standards, but also can be useful in understanding what type of renovation might need to be completed to make the building more accessible and what costs are associated.	Integer	Steps	Facade
Car Access	Renovation/livability	Buildings that only have car access make it difficult for consistent, large-scale deliveries to be feasible, which makes these buildings less viable for businesses or other uses that require consistent truck loading access. For most other types of buildings though, car access is ideal to be able to provide modern-day living amenities.	Boolean	True False	Street Network
Truck Access	Renovation/livability	Buildings that have access to truck loading zones are well suited for reprogramming to uses that require consistent, large-scale deliveries such as labs, classrooms, and businesses.	Boolean	True False	Street Network
Pedestrian Only Access	Renovation/livability	Buildings that are only accessible via walking can be difficult to reprogram due to modern-day accessibility guidelines. For certain, able bodied people, they can be reprogrammed into housing or workspaces.	Boolean	True False	Street Network

Table 3: Typology survey indicators and data schema.
This table documents the physical indicators collected during the survey process to understand the typology of each building. Each indicator is accompanied by its potential impact and explanation, data type, potential values, and the part of the building it pertains to (entrance, facade, or the entire structure).

Condition Indicators

Based on the physical condition of the building, how much would restoring it cost? Is the building a feasible option for reprogramming?

As towns have experienced depopulation and abandonment, historic medieval structures have experienced a lack of care that has led to the deterioration of many buildings. Given the age of many of the structures, it is expected that some physical damage or weather-related deterioration has occurred, and without a human-presence to fix or update structures, many are seeing the infestation of plants, significant water damage, or instability due to seismic activity. The condition survey works to understand the potential damage the structure has, particularly in how it relates to the cost of necessary renovation and restoration work that would be needed to make the building usable or functional again.

Primarily, this survey is used as a way of refining the selection of buildings to reprogram after determining which building meets the basic typology and occupancy requirements. For the purposes of this thesis, this survey has been condensed into two questions around damage, ranking facades and openings (windows, doors) as having either no damage, mild damage, or severe damage. These two categories encompass many indicators that were also explored during the development of the survey through conversations with restoration experts and professors at Sapienza Università di Roma and local renovation and construction specialists. The full list of potential indicators can be seen in the Appendix A.

This survey is most relevant to complete after a reprogramming strategy is confirmed and should be viewed as an additional component to a professional's technical survey on the properties, which will provide a much more accurate and clear view of the renovation costs. Since this thesis is primarily focused on access and occupancy, and since the structures within the case study location are in relatively good condition in comparison to other regions in Italy, this survey has been condensed for testing purposes.

Condition Indicator	Scale	Meaning	Type	Units / Options	Data Level
Facade Damage	None/Minimal -> Facade has been recently painted, no cracking visible, minimal water staining (covering less than ~20%) Mild -> Facade has some water staining (20-60%), some cracking present but only small sections, some crumbling plaster present, some plant infiltration seen Severe -> Facade has major, visible cracks, more than 60% covered in water damage, significant plant infiltration	The level of facade damage can indicate the amount of potential water and plant infiltration present in a structure and the potential cost of a renovation. It is hypothesized that a building with more severe facade damage will cost more to restore.	String	"No Damage / Minimal Damage" "Mild Damage" "Severe Damage"	Building
Openings Damage (Doors, Windows)	None/Minimal -> Openings have been recently renovated, no damage along frames, wooden and metal shutters are in good condition	The damage level of openings is a key indicator to potential water infiltration of a building. Openings in bad condition are more likely to let water in, and therefore are	String	"No Damage / Recently Renovated"	Facade

	Mild -> Some warping present in frames and shutters, paint peeling off shutters, some rust present on metal features Severe ->Cracked and rotting wooden frames and shutters, metal features covering almost entirely in rust, broken windows	likely to increase the cost of a renovation		“Mild Damage” “Severe Damage”	

Table 4: Condition survey indicators and data schema.
This table documents the physical indicators collected during the survey process to assess the estimated condition of level of damage of each building. Each indicator is accompanied by its relative scale and explanation, data type, potential values, and the part of the building it pertains to (entrance, facade, or the entire structure).

Reprogramming the Town: Assessments

After collecting data through the three surveys to understand the current state of the town, this thesis proposes and tests two assessments that can be conducted to generate a strategic reuse plan. The eligibility assessment defines the critical needs to each building to be able to effectively serve a new use case and filters the buildings in the town to only the ones that meet these requirements. The suitability assessment can help further filter which buildings are strategic for reuse based on their non-critical attributes. In conjunction, the data is meant to generate a map of the town with optimal buildings highlighted for each potential use case.

Caveat: Identifying Reuse Themes

These assessments assume that the town has already come to a consensus about potential reprogramming themes and instead work to assess different buildings within the town to meet the needs of those themes. In the case of Guadagnolo, these themes have already been developed by the community, both through the Base Camp Guadagnolo grant and the extensive community engagement work done by Liminal over the past several years. Therefore, for this thesis, the assessments will focus on identifying opportunities for reuse to support investments in education and long-term tourism, which are the two themes the community has already identified as priorities.

For towns that have not yet coalesced around a theme, an additional step would need to be integrated into the framework to support the town in developing a vision for its future. In parallel to the surveying process, a visioning workshop, community SWOT analysis, or other community-led exercise would need to happen to build consensus within the community and identify potential realistic reprogramming themes. Additional work on potential community engagement methods towns could use to build consensus is available in Chapter 5.

Eligibility Assessment

The eligibility assessment aims to identify buildings within the town that can accommodate the critical needs of a proposed new use. This assessment filters out structures that fail to meet the specified eligibility criteria, leaving the municipality with a map highlighting only the

buildings capable of adapting to the proposed use. This approach enables the reprogramming plan to concentrate on structures with the highest likelihood of a successful conversion. For this iteration, three eligibility criteria were chosen as filters: size, accessibility, and occupancy.

Size is a crucial eligibility requirement because much of the building stock in rural towns is smaller than modern structures, whereas many proposed uses demand reconfigurable, large open spaces. Similarly, a building's accessibility also presents an important constraint, as both of the proposed uses for Guadagnolo require loading access for vehicles. Therefore, buildings accessible solely by pedestrians may pose challenges for reprogramming and are marked as ineligible. Finally, likely occupied buildings are filtered out to prevent the displacement of full-time residents. By applying these three eligibility criteria, the assessment produces a set of buildings most strategically suited for reprogramming. Future assessments are intended to be tailored to the specific use cases and needs of the town and could include additional factors such as access difficulty due to street slope, volumetric size of buildings, the number of units within each building, and more.

Suitability Assessment

Unlike the eligibility assessment that filters out buildings entirely, the suitability assessment evaluates and marks the remaining set of eligible buildings with different indicators to gauge their suitability to adapt to a particular use. This assessment aims to optimize the selection process from the subset of eligible buildings. For this iteration, two suitability criteria were chosen. First, the building's condition, as determined by the condition survey, is used to prioritize structures perceived to be in better shape, potentially requiring lower renovation costs and increasing the likelihood of successful reprogramming. Second, the building's viewshed, identified through the typology survey, is used to highlight structures particularly well-suited for conversion, as access to views of natural beauty could be a draw for tourists. By applying these two suitability criteria to the set of eligible buildings, it becomes easier to select structures that are best suited for a particular reuse. Similar to the eligibility assessment, future iterations can include different suitability criteria tailored to the desired reuse scenarios. Additional options could be existing access to natural light, proximity to open spaces or gardens, or other relevant factors.

Data Collection Processes

The majority of the data analyzed in this thesis was collected over the course of three weeks during a field visit to Monti Prenestini in January 2024, with some additional post-processing data generation done remotely leveraging previously collected field data. The dataset includes both qualitative and quantitative findings on Guadagnolo, and several different publicly available tools were used in the creation of the dataset, which are outlined in the following sections. All data collected from phone-based applications occurred on an iPhone 14 Pro running iOS 17.3.1. Information on the data collection method for each indicator is available in Appendix D.

Orthophoto & Municipal Map Data Collection

In 2023, an accurate, high resolution orthophoto of Guadagnolo was created by Liminal and subsequently provided to Google to display high quality satellite imagery of the town. The orthophoto contains accurate distances that can be used to measure buildings and street networks confidently given the post-processing done to account for distortions created by elements like camera angle and topographic changes. This georeferenced orthophoto, seen in Figure 17, became the source of truth for additional data analysis for the remainder of the thesis. The orthophoto, rather than a satellite map provided by services like Google or Open Street Map, was used due to inconsistencies between other map providers and the georeferenced photo. Some providers showed Guadagnolo in exactly the same location as the orthophoto, while others showed it slightly to the north. Different versions of QGIS also showed the town in slightly different locations, even with the same map provider. Because of all of these inconsistencies, the orthophoto was chosen as the source of truth since its coordinate system was static and was visualized in the same location across QGIS versions.

Figure 17: Orthophoto taken of Guadagnolo by Liminal.
This orthophoto of Guadagnolo, taken by Liminal in 2022, is the primary base layer for the spatial analysis conducted in this work.

To begin initial data collection, the municipal parcel map provided by the town of Guadagnolo, which included parcel ID numbers, generic parcel outlines, and designated public space was overlaid on the orthophoto. This allowed for the parcels to be correctly aligned over their corresponding buildings, so measurements like area of each parcel could be confidently extracted using QGIS. Additional measurements, such as street network segment length, segment width, and more were then generated using QGIS. All of these data points became the base layer for data later collected during fieldwork. The municipal map, which was last updated in 2006 can be seen in the Appendix B.

Field Data Collection

JotForm for Qualitative & Quantitative Data

One difficulty of data collection in Guadagnolo is that major portions of the historic center suffer from spotty internet access and also lack publicly available Wi-Fi. Therefore, finding ways to collect data offline that still allows for the auto generation of analyzable data sheets was paramount to ensuring data could be collected efficiently and securely. After testing several tools, JotForm was chosen as the best method to allow for this type of field data collection as it supported a fully offline mode, where data would be stored on a phone locally and uploaded as soon as internet connection was made. JotForm also supports a "Kiosk Mode" that automatically reloads the survey after a submission, which additionally made data collection more efficient. The free version of JotForm was used for this data collection, which was only possible because there are under 100 buildings in the town to survey and only one survey needed to be done. For larger towns (over 100 buildings), a paid version would be needed to complete the whole survey or further exploration into other offline survey data collection tools would be necessary.

The JotForm data collection method was used for both qualitative and quantitative data for each building during the 3 week field visit. Data around the number of units in each municipal plot, the number of stairs required to enter, number of windows on each facade, the floors present on each facade, and many more attributes were all taken for each building. Additionally, during this process photos were taken of every visible facade of every building and their file names were documented within the survey. This ensured that further analysis of every building could later be done on high quality photos. At least one photo of every visible facade was documented during this survey.

In addition to these quantitative data attributes, several qualitative measures were also documented in this survey. Field notes for every building were recorded within unstructured space that allowed room to explain unique features of each lot or attributes that might not be captured in the photos or existing survey. Additionally, a qualitative occupancy check was recorded as a first pass to spatially understanding where people were presently residing. After submission, this data was downloadable from the JotForm website in CSV format, where it was then moved into QGIS for further spatial analysis.

MyTracks Elevation & GPS Data

A detailed digital elevation model is needed to calculate slope and understand the potential accessibility concerns within Guadagnolo. Several attempts at capturing elevation data were attempted through various applications, including the default iPhone elevation app, My Altitude, and Altimeter, with little success. All of these applications rounded the elevation data too heavily for the data to be useful on the scale of Guadagnolo or mishandled data spottiness by reverting to the underlying contour map, which further rounded elevation to the nearest 10 meters. Although these applications would work well for spot elevation data capture in places with strong internet access, in a location like Guadgnolo, a more consistent data capturing method was needed that relied only on GPS and allowed for continuous data capture to help mitigate incorrect data caused by lost connection.

MyTracks is an GPS logging application that collects elevation data and other spatial data on iPhones and allows for continuous data capture recordings - taking a point every second it is connected to GPS. In order to create an elevation map of the street network and entrances in the town, data was collected using MyTracks during one day of the field work visit. During data collection, every path in town was recorded twice using MyTracks, by walking very slowly once from point A to point B, and once from point B to point A, with an iPhone held at a consistent level. The slow walking speed is critical to allow opportunity for the GPS to connect at multiple points along the line segment. The length of each segment was primarily determined by the street network itself, so in a typical case one segment recording would cover the full length of a town block. However, in cases where elevation changes occurred in more than one direction over a single segment, that segment was split into two recordings. This allows for each segment to start at a minimum and end at a maximum, or vice versa. Primarily, this method was done to ensure that maximum heights within each segment were recorded and that MyTracks had an opportunity to reconnect to the GPS satellite at this critical point to ensure it was more accurate. The following recording settings within MyTracks were used for all data collection: Tracking Mode - GPS, Accuracy Threshold - Narrow, Time Interval - 1 second, Smooth Recording - On, Record in Motion Only - Off.

This data collection strategy created a map of hundreds of elevation points across the town of Guadagnolo that aligns to the existing street network. There is some inconsistency and gaps across these points due to inconsistent access to GPS services, and so this elevation data is said to provide an estimated elevation for different data attributes. More information on how this data was processed is available in the Appendix C.

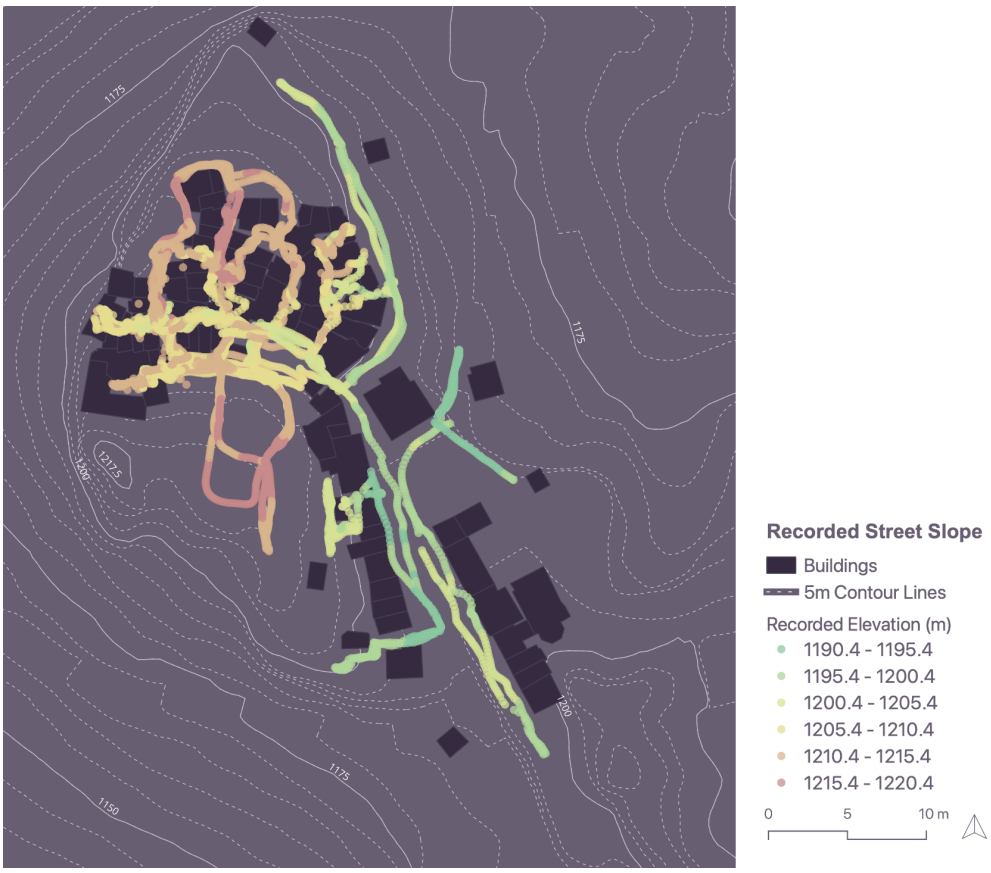


Figure 18: Recorded elevation map of Guadagnolo.
Using the GPS application MyTracks, the elevation of every street within Guadagnolo was captured.

Field Notes & Hand-Drawn Maps

Throughout the field visit, additional analog surveying took place to capture insights and data that would not have effectively been collected in the survey format. In many cases, this took the form of hand-drawn maps of the street network or spatial annotations of buildings drawn over aerial images of Guadagnolo. Written field notes about buildings, movement patterns throughout the town, and how shadows and light changed the visibility and pedestrian experience throughout each day were also collected. Maps showing buildings with active renovations, exposed living spaces, and occupied storage spaces were all developed during this process. Additionally, multiple sets of data were collected about the street network. Additional maps on access categorization, storage spaces, and slope difficulty are available in Appendices B and C.

Importantly, the location of every entrance on every building was mapped during these processes atop an existing municipal map. The location of each of these entrances play a key role in understanding the overall accessibility of every building as a whole. Another key development from these maps is the facade number identification of every building. Every building was split into Facades 1-4, with Facade 1 always being the perceived main entrance to

the building, and Facades 2-4 wrapping the building in counter-clockwise order. Since not every building is split into 4 perfectly straight facades, designating specific features within a building as one facade or another in this way allowed for clear data collection at later steps.

All of this data was digitized in QGIS for further analysis and data processing, as discussed in the following sections. A selection of these annotated maps before QGIS analysis can be seen in Appendix B.

Post Field Work Data Collection

Using the images of every facade collected during the fieldwork, an additional survey was done to collect more data on occupancy, typology, and condition. For this process, three Google Forms were created to capture data at the building level, facade level, and entrance level. This process allows for more data to be revealed about the town without the need to be in person, and primarily consists of data that is not difficult to decipher from photos alone. For example, determining perceived unit counts can be difficult to do from photos alone because there are subtle differences in renovation quality that can indicate a separate unit that are less noticeable in static photos. Additionally, the presence of ground floor storage can also be difficult to tell from photos alone, as the interiors of the space are only visible through close proximity to the windows, and this level of detail is not often captured in a photo. For these surveys instead, overall condition data, facade details around window quality and state, and the presence of certain items to indicate occupancy were all collected. Each survey collects the municipal number of the building, facade number (if relevant), and entrance ID (if relevant) in order to easily reconnect this new data set to the data sources.

Data Processing Methods & Enhancing Basemaps

To spatialize the field data collected through the previously described methods, several QGIS methods were leveraged. As previously stated, much of the typology data could be derived directly from the base maps created in QGIS, but additional processes were needed to manage the data collected in the JotForm and Google Form.

Before the spatialization of these datatables could take place however, the basemaps needed to be further expanded on using the information gathered in the field. This took two primary steps: adding all of the entrance data points and providing them a unique ID and splitting the building shapefiles to be able to assign facade numbers (1-4) to each building edge. Facade numbers worked counterclockwise around the building, with facade 1 being the edge with the building's main entrance, facade 2 being the edge to the right of that, and so on. Most of this documentation work was done manually in QGIS with snapping turned on to ensure that entrances were sufficiently near building outlines for future network analysis purposes. With entrances, facades, and buildings all now uniquely identifiable, fieldwork datatables could be joined to the spatial files, typically using the municipal plot ID as the source of truth and deriving connections between entrances, facades, and building through spatial joins. This produced the following map (Figure 29), which shows each building with its municipal lot

number as well as its entrance locations and relevant contour lines, which were provided by Liminal.

Figure 19: Guadagnolo's building and street network according to the municipal map.
Leveraging the municipal lot map provided by the Comune di Capranica Prenestina, this map of Guadagnolo's building and street network was created. Entrances were documented during field work to be able to complete a network analysis on the buildings and street network in future iterations.

Importance of the Case Study Approach

A case study approach for this thesis allows the proposed multi part survey methodology to be tested within realistic existing conditions. Testing in-person is particularly important in a place like rural Italy, where access to internet and Wi-Fi is not always guaranteed. Using an in-person case study approach provides ample opportunity to work through challenges created by these constraints while providing benefits to Liminal and the case study location itself and allowing for deeper and more thoughtful data collection.

Benefits to Liminal & Guadagnolo

The case study approach benefits both Liminal and Guadagnolo. In particular, the case study provides an opportunity to understand which indicators are duplicative and can potentially be

iterated on or removed in the future to make the surveying process more lightweight for other potential data collectors. This is particularly important to Liminal as they move toward making this type of data collection and analysis into an ongoing community-led workshop. Having fewer indicators that more accurately capture the same data is one way to improve and simplify the process and make it more accessible to people at all levels of technical expertise. Furthermore, conducting a case study with the proposed methodology also provides an opportunity to test multiple data collection methods for Liminal. Testing new supporting applications in the field can help Liminal determine which are easiest to use and can provide the most accurate data, which is critical to understand before engaging the methodology with local residents. In a place like Guadagnolo, which has limited access to Wifi and internet and is therefore representative of many other rural mountain towns in the nation, understanding and testing the technical constraints of the survey software is key and will allow for Liminal to work more confidently in reproducing the survey in other towns and regions.

The case study also benefits the town in question, Guadagnolo, by providing it with a robust digital model that can be used for future grant applications and planning endeavors while not requiring significant time investment on behalf of residents of the town itself. Like many towns, Guadagnolo has relatively low municipal capacity to collect information on itself, so providing a free, new dataset can provide a benefit to the municipality without being extractive.

Opportunities for a Deeper Analysis

By focusing on Guadagnolo rather than every town in the region, it was possible to make several visits and collect more accurate and robust data. Having time to visit multiple times on different days of the week helped to ensure a more complete data set, particularly in the case of the occupancy survey, which as previously noted contains indicators that are very flexible and time dependent. Multiple visits to Guadagnolo allowed for more confidence in the obtained results, whereas spreading this fieldwork across multiple towns could have meant missing key information about occupancy. (For example, if residents often come on the weekends during the summer, but the town was only surveyed on the weekdays, the surveyor would miss the seasonal occupancy of the buildings which would create a lower occupancy count than accurate). Furthermore, multiple visits provided additional time for more relevant indicators to be developed and then tested on-site. Regionally specific indicators (such as how curtains are secured in entrances or the condition of house numbers) that had not been considered prior to the on-site work were able to be added during the fieldwork sessions. These indicators could be added in part because there was enough time on-site to recognize these more subtle habitation patterns and building features, and these would have likely been missed if only working in a town for a day. In all, the case study approach on one specific town provided more time and therefore opportunity to collect data that made way for a deeper analysis and understanding of Guadagnolo.

Chapter 4: Analyzing Guadagnolo's Strategic Reuse Opportunities

Survey Results: Understanding the Town

Occupancy

Using the survey indicators outlined in Chapter 3, an understanding of the town's occupancy patterns can be developed, which is key for being able to identify buildings for reprogramming that are available. In general, buildings that do not currently have residents are more likely to be converted into new uses since a renovation will not displace a resident (*Progetto - Campo Base Guadagnolo*, 2022). However, because of the qualitative and temporal nature of the indicators used to measure occupancy, it is difficult to know with absolute certainty the state of occupancy for each building. Therefore, the occupancy map is split into four main categories: likely occupied, likely seasonal occupation, likely unoccupied, and unknown. Buildings get assigned to one of these four categories using an algorithm co-designed with a local resident (A. Mattogno, personal communication, March 5, 2024). Indicators can either be classified as "weak" or "strong" depending on how much they contribute to the likelihood of occupancy. If a strong indicator is present, it alone can sort a building into a category, but if a building only has weak indicators, several are needed to be present within a category in order to classify the building. If a building does not have any strong indicators or enough weak indicators to sort it into a category, it gets placed into the unknown category. These combinations of weak indicators are important to be able to correctly qualify each building, as one weak indicator alone can help sort a building in different directions depending on the presence of others. For example, the "open windows" indicator can move a building from unknown to either likely occupied or likely unoccupied depending on what other weak indicators are present. In the case where several other indicators suggest occupancy, the open windows mean that the building is likely presently occupied. However, in the opposite case, where there are not positive occupancy indicators but other negative occupancy indicators, the open windows likely mean that the building is exposed to the elements and therefore unoccupied or abandoned.

The following table illustrates how these indicators are combined to classify buildings, based on conversations with a local resident who provided clear cultural expectations for different indicators. This table is specifically focused on qualifying the data collected during January 2024, which is off-peak season for the town of Guadagnolo, which typically sees seasonal summer occupancy and occasionally occupancy during the Christmas holidays (A. Mattogno, personal communication, March 5, 2024). A different version of this qualifying table would need to be made to analyze data collected in the summer or other peak-occupancy seasons. The sorting algorithm used to qualify buildings in this way can be seen in Table 5.

	Likely Occupied	Likely Seasonal Occupation	Likely Unoccupied
Requirements to Qualify for Category	1 strong indicator OR 3 or more weak indicators	2 or more weak indicators	1 strong indicator OR 3 or more weak indicators
Strong Indicators	People Present Dog Present Hanging Laundry	N/A	No Functional Roof Broken Windows
Weak Indicators	Open Windows Unsecured Curtains Present For Sale by Owner Sign Belongings Outside in Good Condition Updated Civic Number in Good Condition Open Shutters	Door Boards Present in Mild or Good Condition Closed Shutters Belongings Outside in Good Condition Curtains Present (Secured OR Unsecured) Updated Civic Number in Good Condition	Agency-Listed For Sale Sign Belongings Outside in Bad Condition Door Boards Present in Bad Condition Open Windows Open Shutters Updated Civic Number in Bad Condition

Table 5: Explanation of the occupancy algorithm.
Three levels of occupancy (or unknown of a building does not qualify to any of the three levels) are determined using the key occupancy indicators listed in this table. This algorithm was co-designed with a resident of Palestrina based on their familiarity of the cultural context of Monti Prenestini.

Following this algorithm, Figure 20 is generated. It shows buildings with likely occupation concentrated around the center of town where there are the most accessible car and truck loading zones, with only a few likely occupied buildings further into town in areas of greater elevation gain. It also shows a significant amount of the town as being likely seasonally occupied, which aligns with Guadagnolo's current use as a summer retreat for folks living in bigger cities like Rome. Finally, there are only a few likely unoccupied buildings and many buildings that are unable to be confidently sorted, and are therefore marked as unknown. Given that the survey was taken during the winter, off-peak season, buildings qualified as likely occupied are likely the most accurate, but further potential refinement is needed to understand how this algorithm performs for seasonal and unoccupied buildings. The initial maps of each indicator are also shown below in Figure 21 to compare the influence that small and weak indicators have on the final outcome. For example, the map showing broken windows across

the town has significant overlap with the final locations that are likely unoccupied given its role as a strong indicator.

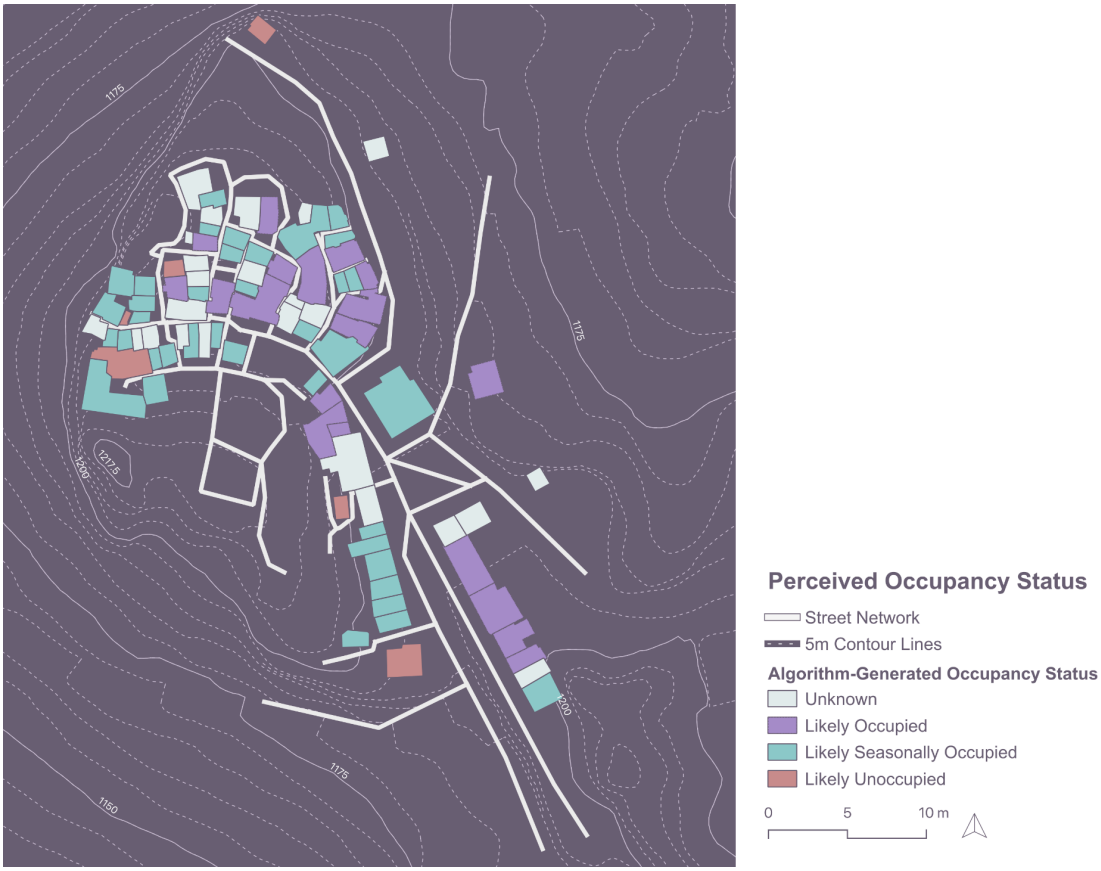


Figure 20: Map depicting the perceived occupancy status of Guadagnolo.
This map shows the results of the occupancy survey and algorithm in Guadagnolo. Likely occupied buildings show some correlation to their proximity to the town square, but generally there is a mix of levels across the town.

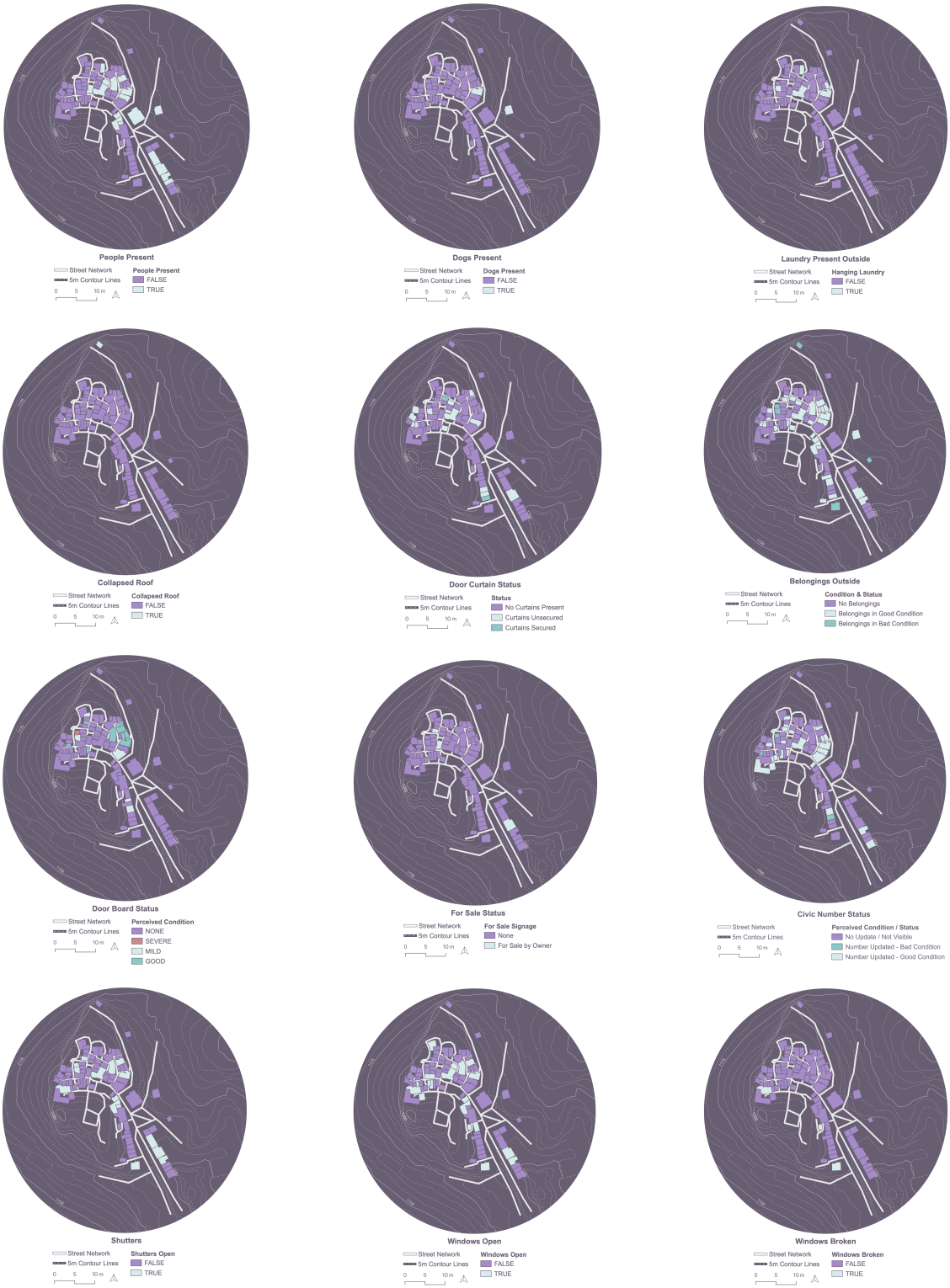


Figure 21: Maps of occupancy survey indicators.
These maps show the spatial results of each occupancy survey indicator, which were combined using the occupancy algorithm to develop Figure 20.

Additionally, Table 6 below shows images of buildings meeting each category to provide examples of what these buildings look like in practice. The indicators create clear visual delineations between buildings that are likely occupied and likely unoccupied according to the occupancy algorithm.

Occupancy Level	Image
Likely Occupied Plat ID #69 Likely Occupied Indicators Present: - Hanging Laundry - Belongings Outside in Good Condition - Open Shutters - Open Windows	
Likely Seasonal Occupation Plat ID #62 Likely Seasonal Indicators Present: - Door Boards Present in Good Condition - Closed Shutters - Belongings Outside in Good Condition - Updated Civic Number in Good Condition	
Likely Unoccupied Plat ID #44 Likely Unoccupied Indicators Present: - Belongings Outside in Bad Condition - Door Boards Present in Bad Condition - Open Shutters	 

Table 6: Visual results of the occupancy algorithm.
This table shows the results of the occupancy survey and algorithm on a select set of buildings in Guadagnolo.

These maps present a data-driven assessment of how occupancy in Guadagnolo is distributed, but further work on the occupancy indicators and algorithm to make the results more accurate is possible. One potential way to better understand which buildings are seasonally occupied is to run the survey again during a peak season for the town and analyze the results, which in Guadagnolo's case would need to happen during the summer or potentially during the Christmas holidays. Comparing data during these two time periods could make a strong case for the validity of the algorithm in capturing the reality of occupancy in the town. Doing this in the future would allow for a comparison against the data presented here. Further ideas on how to potentially validate this data are available in Chapter 5.

Typology

Like occupancy, different aspects of building typology can significantly influence the feasibility of a reprogramming strategy for a town. Between data analysis in QGIS and field survey data, extensive new data has been collected on Guadagnolo. For the purposes of this thesis, typology data can be used for both the eligibility assessment and the suitability assessment. The eligibility assessment pulls typology data on size and accessibility, while the suitability assessment focuses on building amenities.

Access

Existing access levels can significantly change which buildings in a town can be utilized in modern conversions, so understanding the different levels of access available in the town is key to developing a feasible reprogramming strategy. Barring making significant changes to the road network or connecting several buildings internally, it's predicted that most structures will retain a similar level of access before and after a renovation. Figure 22 shows an integrated view of access in Guadagnolo, split into several distinct categories that influence to whom and to what a building is accessible. Structures were categorized by analyzing the access levels of each building entrance, as implied by the nearby street network, and extending the most accessible level to the entire building. For example, if a structure has three entrances, two of which are only accessible to pedestrians and one of which is accessible to cars and has parking, the whole building would be classified as having access to cars and car parking. Access is categorized into the following eight levels, which become less accessible as they increase. Only seven levels are present in Guadagnolo, which can be seen in Figure 22.

1. Truck Access & Parking, Car Parking & Access
2. Truck Access, Car Parking & Access
3. Car Access & Parking
4. Car & Truck Access
5. Car Access
6. Pedestrian Only (No Stairs)
7. Pedestrian Only (Stairs)
8. Pedestrian Only (Trail)

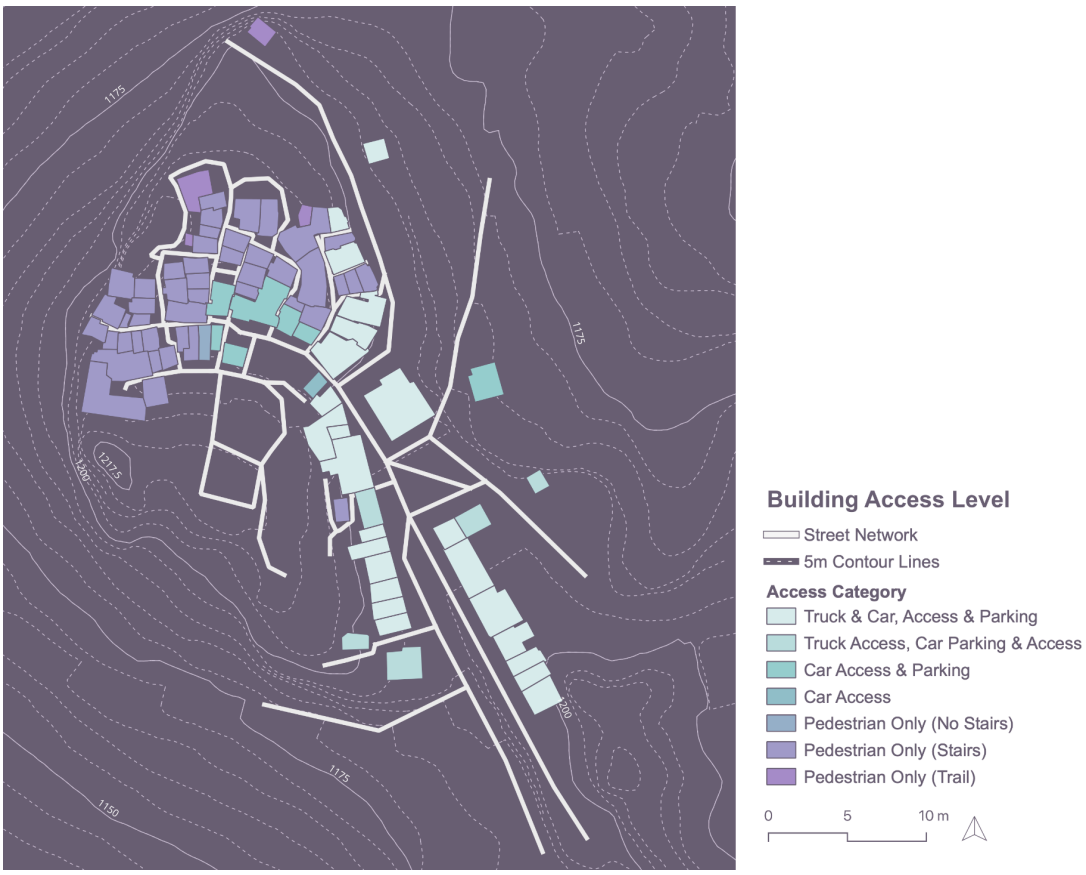


Figure 22: Building access levels in Guadagnolo.
This map depicts building access for each building in Guadagnolo. These levels are based on the most accessible entrance of each building.

In Guadagnolo, the center of the town near the main square is the most accessible, providing truck and car access to the majority of buildings in its vicinity, while most buildings further into the town become pedestrian only due to small sidewalks and the presence of stairs as elevations increase. Notably, several buildings on the northern perimeter of the town are also accessible due to an additional access road that provides space for trucks and ample parking. In Figure 23 below, several important distinctions between access maps are shown, including pedestrian only, truck access, and car access. These three submaps are used extensively in the assessment methodology to determine which buildings meet eligibility reqirements.

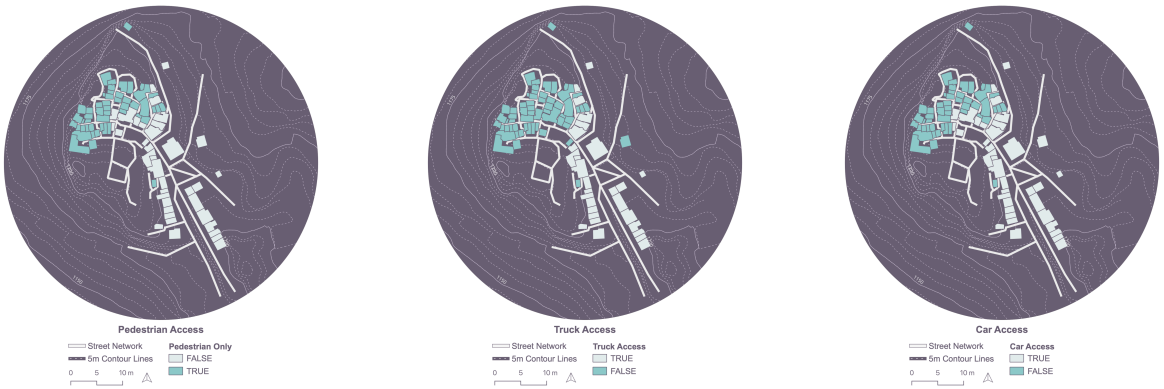


Figure 23: Pedestrian, truck, and car accessible buildings in Guadagnolo.
These three levels of accessibility of buildings in Guadagnolo will be used to understand which buildings are eligible for new uses.

Size

In addition to access, size also plays a serious role in restricting available reprogramming options as many uses require a certain size footprint in order to be useful. Classrooms for example need a larger footprint than standard housing, which needs a larger footprint than an individual office space. Volumetric size of a building can also play a role in these decisions. The following maps show the footprint area and estimated volume of each building in Guadagnolo. In comparison to access, larger sized buildings are more equally spatially distributed across the town, with some particularly large structures on the south western perimeter of the town.

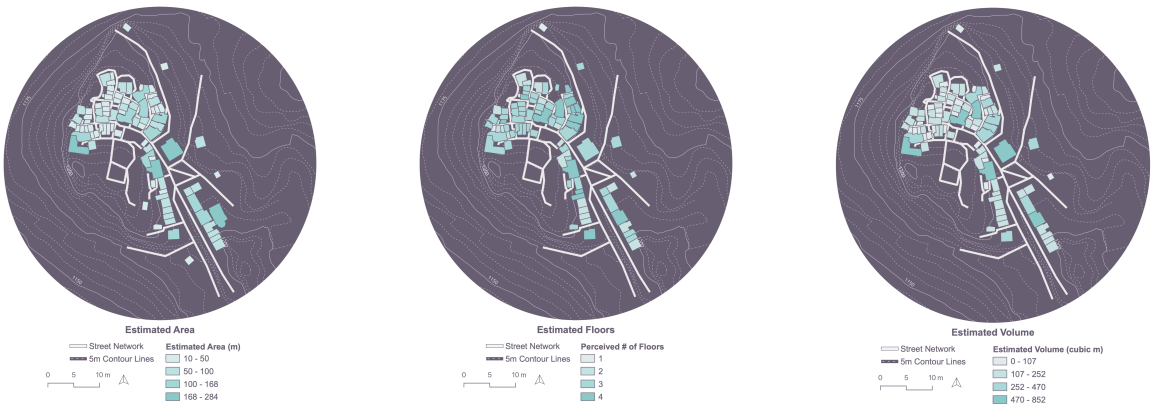


Figure 24: The area, number of floors, and estimated volume of buildings in Guadagnolo.
Understanding the size of different buildings in Guadagnolo is key for identifying ones large enough to house new uses.

Amenities

As opposed to elements needed for the eligibility assessment, several types of building typology data can also be useful for comparing similar structures to each other while designing a reprogramming plan, and therefore can be beneficial to include in the suitability assessment. In terms of amenities, access to a garden or open space, access to views of the natural beauty surrounding many rural towns, and the number of units in a building (and therefore potential neighbors and renovation partners) can all play a role in determining which of several options might be more feasible for reprogramming. The following maps show each of these different amenities with data collected entirely from field work.

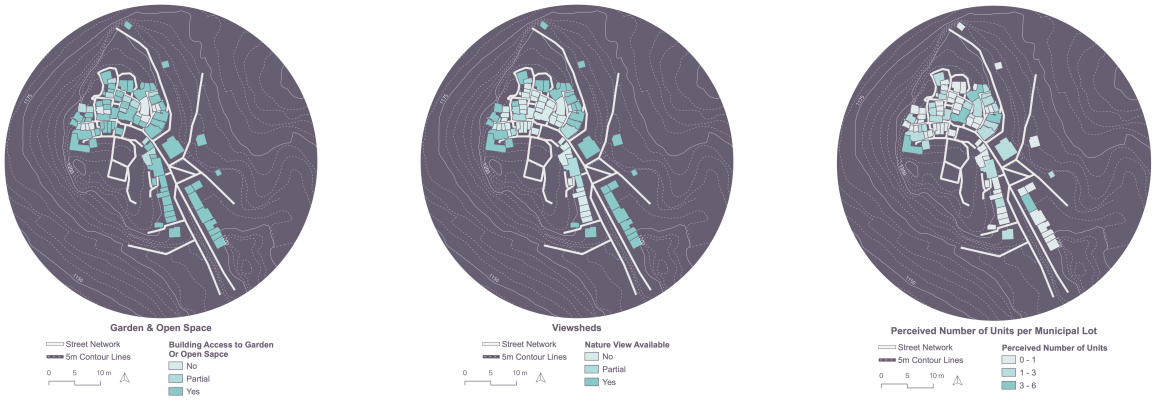


Figure 25: Maps of building amenities in Guadagnolo.
These maps show the spatial distribution of buildings with gardens/open space and viewsheds, as well as the perceived number of units within the municipal lot.

Condition

In comparison to typology and occupancy, the condition survey is relatively minimal, partially because it is only used in the suitability assessment, rather than both the eligibility and suitability assessment. One major reason for this is that without a more technical building survey done by a professional, it is very difficult to know the condition of a building with full accuracy, particularly when only viewing the building's exterior.

To generate the following maps to support the suitability assessment, the condition of facades and of openings (windows, doors) on each building was measured on a scale of 0 to 2, where 0 is no damage and 2 is severe damage. The image table below shows examples of each damage level for both facade damage and opening damage.

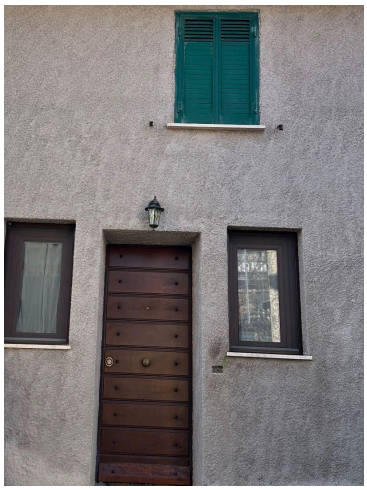
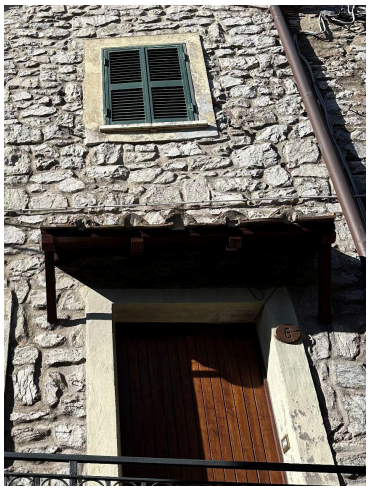
	Facade	Opening
No Damage (0)		
Mild Damage (1)		
Severe Damage (2)		

Table 7: Visual illustrations of damage scale within condition survey.
This table depicts examples of the scale used within the condition survey to understand estimated damage.

To understand the condition of the building as a whole, the values for facade damage and opening damage were added to give each building an overall damage rating out of 4. Table 8 below shows the meaning behind each of these damage levels.

Damage Level (Total)	Facade Damage	Opening Damage
0	No Damage	No Damage
1	Mild Damage	No Damage
	No Damage	Mild Damage
2	Mild Damage	Mild Damage
	Severe Damage	No Damage
	No Damage	Severe Damage
3	Severe Damage	Mild Damage
	Mild Damage	Severe Damage
4	Severe Damage	Severe Damage

Table 8: Explanation of condition algorithm.
The condition algorithm works by adding the values of facade damage and opening damage together to get a perceived total damage level

The maps generated by this algorithm are below in Figures 26 and 27, and Table 9 depicts a set of images showing buildings falling into each of these damage bands. Although this survey will not replace a full technical expert's report on the condition and infrastructure quality of each building that would be necessary prior to any renovation beginning, it does demonstrate an ability to correctly sort buildings into larger damage bands to understand relative condition. This level of information is useful as a part of the suitability assessment as municipalities think about how to thoughtfully utilize existing buildings in town. It should be noted however that this survey only ranks buildings on perceived damage on the exterior of structures, and therefore cannot directly predict the resulting renovation costs that would be associated with a restoration.

Figure 26: Perceived building condition in Guadagnolo.
This map shows the perceived level of building damage in Guadagnolo, based on the results of the condition survey.

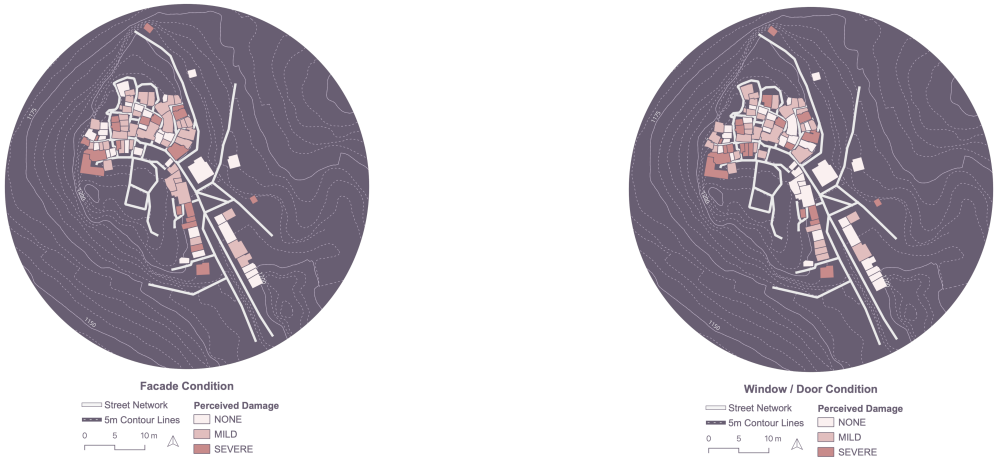


Figure 27: Maps of facade and window/door condition in Guadagnolo.
These two maps were used to produce the total damage level map in Figure 26 based on the condition algorithm.

Scale of Damage & Building Info	Photo
0 - Damage Plat ID #76 Appears recently renovated, wood window & door in good condition, no staining or cracks in facade	
1 - Damage Plat ID #92 Windows and doors in good condition, no cracks in the facade but some staining	
2 - Damage Plat ID #179 Paint on windows and door chipping but ok structurally. Increase in facade damage from water and cracking	

3 - Damage Plat ID #108 Significant, untreated damage to facade	
4 - Damage Plat ID #113 Significant untreated damage to both the facade and openings. Broken windows and shutters, crumbling exterior plaster	

Table 9: Visual results of condition survey.
This table shows the results of the condition survey and algorithm on a set of buildings in Guadagnolo, with explanations of the exterior damage perceived of each building.

Assessment Results: Reprogramming the Town

Given these survey results, the data can be analyzed further to formulate a potential reprogramming plan for the town of Guadagnolo. Leveraging the three surveys, two assessments can be conducted on the buildings of Guadagnolo to identify which are strategic candidates to be reused to support economic development and repopulation in the area. After identifying reuse scenarios that the town is interested in pursuing, the assessment work is then done in two phases: one assessment to determine which buildings are eligible for reuse based on the typology and occupancy surveys, and one assessment to determine which of the eligible buildings are most suitable to a particular reuse based on the typology and condition

surveys. Three main building typologies are considered for the reuse scenarios, places for living, meeting, and working.

Proposed Reuse Strategies

The assessments within the proposed survey framework assume that the town has coalesced around potential reprogramming themes as a community. In Guadagnolo's case, these themes were identified through the development of the Base Camp Guadagnolo grant proposal as well as the ongoing community engagement work Liminal has done in the area. Through these processes, two reuse scenarios were developed for Guadagnolo: transforming it into a satellite campus university based primarily in Rome, or developing it to support long-term tourism, particularly to entice remote workers. The Base Camp grant focused specifically on the idea of restructuring Guadagnolo to support a satellite university campus, with particular buildings strategically reprogrammed to support classrooms and other university facilities. On the other hand, Liminal's work primarily revealed the potential focus on long-term tourism and supporting remote workers.

Given that most municipalities face limited budgets, even with national and international supplements, it is critical to strategically select only a few buildings for reprogramming that can each have a large impact. In an ideal scenario, one transformed building could support multiple scenarios, so that municipalities can adjust to support a different use based on the season or other shifting priorities. In the case of Guadagnolo, the two desired use scenarios are complementary, both in terms of seasonality and their needed building typologies. This kind of flexible or dual-usage can maximize the limited resources of the town.

Use Scenario 1: University Satellite Campus

Guadagnolo's reuse as a university satellite campus is strategic for many reasons. From a timing perspective, the reuse strategy will help stabilize the population year-round. As a town that experiences its peak population during the summer months, a university will be able to ensure the town is active all year long and can provide use to buildings during the fall and spring. This new activity could also encourage more year-round businesses to open up to support the incoming students and professors, allowing for even more reinvestment in the town's buildings and infrastructure. Further types of support services for students and teachers could also be developed over time, boosting the town's economy and population. Guadagnolo is also uniquely positioned to be able to support campus activities. Given its unique ecology and environment, Guadagnolo is an ideal place to study agronomy and other agricultural or biologically related fields. The farms available for field-work opportunities and other industry-related connections that can additionally help strengthen the educational opportunities for students.

The satellite campus use scenario requires buildings of three main types: 1) housing for students, professors, and administrators, 2) classroom and lab spaces, and 3) a place for administrative offices or meetings.

Use Scenario 2: Long-Term Tourism

In addition to supporting satellite campus activities, Guadagnolo could also try to position itself as a long-term tourism destination, particularly for remote workers, that would see newcomers staying for several months at a time. This would allow for temporary residents to embed themselves in the community while also providing a needed economic boost to the businesses and municipality. The town's proximity to the Sanctuary of Mentorella and outdoor excursions, such as hiking and climbing, make this a particularly viable option for tourists. To support remote workers, the town is currently in the process of establishing stronger internet capabilities. Seasonally, it's possible that remote workers or long-term tourists would also be looking to stay during the summer when the current resident population is at its highest. However, if combined with the satellite university proposals, these buildings would likely need to be used during the opposite times, which is ideal for the town to be able to maximize its investments in individual buildings.

The long-term tourism use scenario also requires buildings of three main types: 1) housing for temporary residents (likely through an albergo diffuso or similar set up), 2) co-working spaces, and 3) communal spaces and offices for the albergo diffuso to operate from.

Building Typologies

The following table shows how one building typology could serve either of the two use scenarios for the town of Guadagnolo. Depending on the season and use priority, the building can be configured to support a different scenario, but the overall requirements for the building between the two cases are the same due to the similar nature of the building's usage.

	University Satellite Campus	**Long-Term Tourism**
Living Spaces	- Housing for students, teachers, administrators, etc	- Housing for remote workers - Housing for long-stay tourists in alberghi diffusi
Meeting Spaces	- Welcome center - University administrative offices - Secondary meeting space	- Albergo diffuso communal spaces - Albergo diffuso administrative offices
Working Spaces	- Classroom - Lab - Seminar room	- Co-working spaces

Table 10: Explanation of two reuse scenarios for Guadagnolo and their needed building typologies.

Eligibility Assessment

Assessment Development & Criteria

The eligibility assessment leverages the typology and occupancy survey results to determine which buildings could be available for reuse within the town. For Guadagnolo, three main categories were selected to filter buildings for eligibility: the size of the building's footprint, its level of accessibility, and its perceived occupancy status. These three criteria were selected through conversations with Liminal who felt they accurately captured the first several critical needs that municipalities look for within their building stock when considering a reprogramming strategy (G. D'Agostino & N. Delgado Alcega, personal communication, January 15, 2024).

Eligibility Criteria	**Driving Question**
Size (sqm)	Is the structure big enough to house the proposed use?
Access Level (Car, Truck, or Pedestrian-Only)	Is the structure accessible enough to be renovated? Is it possible for people with limited mobility to access it? Does it have access to the needed loading zones to support a new use?
Perceived Occupancy Level (Likely Occupied, Likely Unoccupied, Likely Seasonally Occupied, or Unknown)	Would reusing the building displace a full-time resident?

Table 11: Explanation of what drove the selection of each eligibility criteria.

For the two potential use scenarios outlined above, three types of spaces need to be generated around common uses: places to live, work, and meet. Due to the complementary nature of the two proposed use scenarios, the same building can be leveraged for both scenarios. Table 12 shows the proposed eligibility criteria for these three typologies. Notably, all of the typologies require that the occupancy does not include buildings that are likely occupied to avoid displacing year-round residents, however, the other two criteria change to support the desired use cases. The table also discusses why particular parameters are applied to particular types of buildings. These categories were formulated through conversations with Liminal based on their experiences working with municipalities to identify buildings for reprogramming.

	Size	Access Level	Perceived Occupancy
Living Spaces	>= 60 sqm	Car Accessible	Likely Unoccupied, Likely Seasonally Occupied, or Unknown
	Given the outdoor and public open space available within the town, housing in Guadagnolo could be developed in buildings of 60 sqm (~645 sqft) or larger. This meets modern living standards regarding size, while also keeping in context the average size of Guadagnolo's medieval housing stock which is around 50 sqm. The buildings need to be car accessible to support residents with limited mobility and also to make renovations and deliveries easier for the proposed uses. Finally, the space needs to be likely unoccupied to prevent displacement of any full-time residents.		
Meeting Spaces	>= 100 sqm	Car Accessible	Likely Unoccupied, Likely Seasonally Occupied, or Unknown
	The meeting spaces (which are used for offices and communal space for the albergo diffuso in the long-term tourism model or offices and meeting spaces for the university model) need to be reconfigured to suit multiple uses, so scaling up the footprint of these buildings to 100 sqm (or ~1075 sqft) is necessary. However, similar to the requirements for housing, the buildings need car access to support residents and accommodate more uses, and need to be likely unoccupied to prevent displacement.		
Working Spaces	>= 100 sqm	Truck Accessible	Likely Unoccupied, Likely Seasonally Occupied, or Unknown
	The co-working and classroom spaces require a similarly-sized building to the meeting spaces of 100 sqm or more, but these buildings need to be truck accessible to support delivery of lab equipment or other large items to support a classroom or lab use in the university model. Again, these buildings also need to be likely unoccupied in order to prevent displacement of existing residents.		

Table 12: Explanation of the eligibility criteria of the three different needed building typologies.

Eligibility Assessment Results

Using the proposed eligibility assessment for living spaces, a number of buildings within Guadagnolo are revealed to be potential candidates for housing spaces for either universities or alberghi diffusi. In total, 11 out of Guadagnolo's approximately 90 buildings are eligible for reprogramming into housing, mostly concentrated around the town's central square due to the need to have car accessibility. Out of the three building typologies, housing has the most eligible building options within the town. Figure 28 shows where these buildings are located within the town, with the rest of the town's ineligible buildings shown only as outlines.

On the other hand, there are only four buildings eligible to be meeting spaces within the town based on the eligibility requirements, largely due to the size constraints placed on these spaces

to make them capable of handling multiple diverse uses. Three of these buildings are in the town center, with one toward the edge of town near an outlet road that goes down the mountain, which can be seen in Figure 29.

Finally, the buildings eligible to be classrooms or co-working spaces are actually the same as the ones available for meeting spaces, primarily due to the similarity in their size requirements. Although classrooms require a higher level of access, many of the buildings within the town toward the center are both truck and car accessible. However, within these truck accessible buildings, there are some that have higher access to loading zones which could prove to be more beneficial for reuse. The results of the eligibility assessment for working spaces can be seen in Figure 30.

Figure 28: Map of eligible housing units for Guadagnolo.
This map depicts the buildings that meet all three eligibility criteria to be leveraged as housing for either reuse scenario.

Figure 29: Map of eligible meeting spaces for Guadagnolo.
This map depicts the buildings that meet all three eligibility criteria to be leveraged as meeting spaces for either reuse scenario.

Figure 30: Map of eligible working spaces for Guadagnolo.
This map depicts the buildings that meet all three eligibility criteria to be leveraged as working spaces for either reuse scenario.

Suitability Assessment

Assessment Development & Criteria

The suitability assessment leverages the typology and condition survey results to help determine which of the buildings that passed the eligibility assessment are best suited for a particular use. In this case study, two categories were focused on to help determine potential suitability: the perceived condition of the building and the building's access to a natural view. For the former, it is expected that a building in better condition will be more cost effective and easier to reuse, which is why it is included in the suitability assessment. The condition survey cannot replace a professional technical review of a structure to determine restoration costs, so therefore cannot be used as an eligibility criteria for the assessment portion of this work, however, it can be used to help prioritize which buildings get selected within the eligible set.. Viewsheds are also considered as part of the suitability criteria, because although not critical to any particular use, they can offer a draw for both tourists and universities. Therefore, buildings with access to view of the natural beauty surrounding the town can be prioritized over buildings that do not have access to these views.

Suitability Assessment Results

The following maps show the results of the suitability assessments for each type of proposed building typology, as generated from the survey results. In each of the maps, the buildings outlined in a thick border are the buildings that have at least a partial view of the surrounding landscape, and the buildings that are shaded by a diagonal hatch are those that have a condition score of 3 or above, meaning at least one element of the building is perceived to have severe damage. For the housing spaces (Figure 31), many have views given their location within the town center rather than the historic core, but also several are in severe condition. On the other hand, of the four buildings eligible to be either meeting spaces or working spaces, all have at least a partial view, but half are in severe condition (Figures 32 and 33).

Figure 31: Map of eligible housing units with suitability criteria.

Figure 32: Map of eligible meeting spaces with suitability criteria.

Figure 33: Map of eligible working spaces with suitability criteria.

Proposing a Strategic Reuse Plan for Guadagnolo

Given the results of the surveys and assessments, a plan for Guadagnolo can be developed to support both reuse scenarios of long-term tourism and a university satellite campus. The reprogramming plan was formulated by first identifying buildings based on their typology's eligibility constraints, prioritizing those with the most restrictive criteria, which in this case is the working spaces.

Building Selection Process

The suitability assessment reveals two out of the four buildings eligible for reuse as a working space are in severe condition, so therefore are not optimal to select for reuse, which leaves two options to select from. Of the two remaining, the building further north has multiple roads around it with both car and truck access, while the other option has only one road with truck access and one that is pedestrian only on its perimeter. Given the need for the working space to be able to handle larger deliveries more frequently, particularly if used as a classroom or lab for the university satellite campus, the building that is further north was selected to be reprogrammed as the working space. This building can more easily handle large deliveries due to its several access roads, particularly in comparison to the other option which is within a large aggregate of buildings. Notably, the building selected for the working space is the same building that Base Camp Guadagnolo chose to reprogram as a classroom space, and it is presently the town's hostel. The grant's proposal, which could also potentially be applied here,

was to turn the ground floor into the working space and keep the top floor as a public hostel for the town.

After working spaces, meeting spaces present the second most restrictive eligibility criteria, so a building is selected for this use next. Because the eligibility buildings for meetings are the same as those for working, there is now just a single option from the four eligible buildings that does not have any severe damage. Therefore, this building is selected to be a single structure to be reprogrammed into a meeting space for either university or albergo diffuso usage.

Finally, the housing spaces present the least restrictive eligibility criteria and are therefore chosen last. Unlike the other two housing typologies where only one building needed to be selected for each typology, several housing buildings are needed to be able to support either use scenario. For this proposal, seven total buildings were selected in order to be able to qualify to be an albergo diffuso under Italian law, which requires at least seven units of housing within a town to qualify (De Montis et al., 2015). The following steps were then taken to determine which of the remaining eligible buildings should be selected as the seven housing spaces for the town.

Of the remaining nine eligible buildings:

1. All five without severe damage are selected first for reuse.
2. From the four other eligible buildings, three with desirable views are prioritized as better candidates.

However, two of those three are large enough to potentially serve as working or meeting spaces, so to allow for future expansion of classroom or meeting spaces concentrated around the town square:

3. The larger building closest to the selected working space is left unassigned so it can be available for future reprogramming.
4. The larger building farther south is selected as housing.
5. The remaining building with a view is chosen as the final housing space.

With all of this sorting, the following plan shown in Figure 34 gets generated. The plan is also shown in context of the town's existing usage in Figure 35.

Figure 34: Proposed reprogramming plan of Guadagnolo.
This map shows the buildings selected for reuse to support Guadagnolo's potential reuse plans.

Figure 35: Proposed reprogramming plan of Guadagnolo with existing building uses.
This map shows the same selected buildings as Figure 34, with the addition of the existing use of other buildings. From this map, it is clear that the majority of the town's potential activity is concentrated toward the town center.

Potential Impact of the Proposal

It is clear from Figure 35 that the majority of the activity, both existing and new, is concentrated around the town center. Given that the majority of the proposed reuse requires buildings that are accessible by car or truck, and that these roads are concentrated toward the center of town, this result is to be expected. However, when combined with the existing uses also incorporated on these streets, most notably the two restaurants in the town, it has the potential to create a vibrant town center. This type of spatially concentrated investment has proved to be economically beneficial to small towns (Robertson, 2004). Particularly in the United States, a movement to revitalize main streets within small towns to encourage economic growth has developed over the past years following several successful strategic reuse efforts (Robertson, 2004). Having a mix of uses within a single area improves the livability of the town and can create a desire for people to live there (Poorthuis & Zook, 2023; Robertson, 2004).

However, this proposal of concentrated reuse in the town center also means that many of the buildings in the historic core of the town are not being utilized for either use scenario, and will remain empty for a majority of the year. Concentrating all of the reuse efforts in one area may leave the pedestrian-only sections of the town at risk for further abandonment and deterioration, effectively perpetuating the cycles of abandonment seen throughout the country in one particular area of the town. As buildings deteriorate, they become too much of a financial burden to consider reusing for other purposes, so if no action is taken on them now, it could mean that these areas become entirely unlivable as time passes. To address these concerns, it's likely that the assessment criteria need to be adjusted or that additional, more acupunctural design work needs to be done to support making more buildings more accessible.

In summary, this plan strategically selects two buildings for adaptive reuse for working and meeting spaces, along with several additional buildings proposed as an "albergo diffuso'' scattered hotel or network of university housing units. Crucially, the selections are guided by survey insights around occupancy levels, building typologies, and structural conditions, collected over the course of several weeks in Guadagnolo in January 2024 and subsequently analyzed with the input of both people from Liminal as well as residents of the region. In future grant applications, Guadagnolo can leverage the data collected and analyzed through this process to effectively make the case for additional governmental funding, and the generated proposal can be used as an initial blueprint to help support the town’s adaptation into a university satellite campus and long-term tourism destination.

This comprehensive survey and assessment can also be replicated across other towns with similar or alternative reuse goals, allowing for more communities to be able to quickly understand their environment and generate plans to support grant applications. If done over a set of nearby towns, the process can also help regional municipalities pinpoint which locations are best positioned to leverage government funding for revitalization projects. However, before implementing a plan resulting from this process in Guadagnolo or elsewhere, a more granular review engaging local residents and officials would be necessary to ensure the reuse

strategy works within the context. Ultimately, this survey and assessment methodology provides the most value at a multi-municipal level, where aggregated data across numerous towns can reveal overarching trends and opportunities within the region's existing built environment, and the town-level proposals should be used primarily as a starting point in the larger needed design process rather than as a fixed plan for the town.

Chapter 5: Conclusions & Next Steps

Process Insights from Testing in Guadagnolo

The case study work in Guadagnolo has provided a large body of work to review, in terms of both the survey and assessment process itself as well as the outcomes of these processes. With a view to the larger goal of repeating this two-part process in many towns across Italy to better understand abandonment patterns and how they are potentially tied to building typologies and conditions, the process itself needs to be evaluated to understand how easy it was to use and how robust the results are. The following sections review the framework's performance, exploring the limitations, successful aspects, and potential improvements for both the data collection process through surveying as well as the analysis process through the two assessments.

Reviewing the Survey's Performance & Limitations in Data Collection

Survey Limitations

Inherently, the visual surveys used to collect the data for this case study have some limitations. To begin with, the timing of when the surveys are conducted, or when the data is collected, greatly impacts the results. In this case study, the survey was conducted over January, which is during Guadagnolo's off-peak period, meaning only full-time residents were present in the town. This allowed for particular indicators, such as the "people present" to indicate that the residence was occupied full time. However, if the survey had been done over the summer, when many part time residents return to their dwellings for vacation, the "people present" indicator could have meant that the residence was used full time or part time. Therefore, the survey as it is currently configured can only be used during these off-peak periods, and each indicator would need to be reevaluated in order to be used during a different time period.

In relation to the occupancy indicators specifically, this data collection is always going to contain some inaccuracy due to the nature of residency. In Guadagnolo, all of the survey data was collected between the hours of 9am and 3pm, due to the constraints of the bus timetable, but if people are at work during that period and have closed up their house, it could be perceived as unoccupied during the survey period but occupied outside of the survey hours. Similar inconsistencies will be created by people going on vacation elsewhere during the survey time. In these cases, it's possible that buildings that are likely occupied full time appear as occupied seasonally (or potentially are sorted into the unoccupied or unknown categories). Without additional ways to capture residency and occupancy information, potentially provided by the municipality itself or other residents, it is difficult to determine with certainty the occupancy state of buildings. In order to account for this limitation within the survey process, the three occupancy levels are all preceded with "Likely," to make it clear that these are perceived or estimated values rather than absolute truths.

Another main limitation of the data collection process is how regionally specific the indicators are. If using this survey in another region outside of central Italy, the same indicators could have different meanings depending on their unique cultural context. For example, in cooler climates, door curtains might be used in a different way or not at all, but residents could have other techniques to insulate the house that indicates their active presence. The current version of the survey needs to be expanded on and re-contextualized in each new region that it is tested in order to account for these differences.

Finally, as discussed, the data collected as part of the condition survey is limited in its ability to fully capture the structural state of the building given that the survey can only happen from the exterior. A more complete technical survey, done by a professional, that examines the interior structure of the building and its foundation is needed to be able to accurately capture the potential risk of the building and its associated renovation cost. It is expected that there will be some correlation between the severe damage identification of the exterior and internal structural damage, but there may also be buildings that look renovated from the outside and are not sound structurally. Therefore, this data should be used primarily as a suggestion of which buildings to consider first during the assessment, rather than as something that makes a building ineligible for reuse entirely within the framework.

Successful Aspects

On the other hand, the survey process was successful in many other aspects, and ultimately generated data about the town of Guadagnolo that was previously unavailable or undocumented. In particular, much of the typology data, including access levels of buildings and roads, the size and estimated volume of buildings, and the locations of the entrances of each building, is all data that the municipality previously did not have but could be leveraged for grant applications and other funding proposals. Although not used heavily in the analysis in this thesis, the entrance data collected can provide towns with the capability of doing network analysis to understand how difficult or time consuming different buildings are to reach. The spatial data around the location of entrances can also be important when considering more acupunctural design interventions. Knowing that no windows or doors exist on one side of a building for example could change how the space could be used or increase the cost of a renovation. Data around access to open space and viewsheds, as well as the locations of entrances that require scaling stairs can all provide more granular information about each building. At a high level, the condition data generated, within its previously outlined limitations, can also serve municipalities as a starting point to understand which areas within the town need attention from a restoration perspective if funding earmarked for renovations is granted.

There are also several successful aspects of the survey from a process standpoint. The collection of typology data, for example, was done both remotely and during the fieldwork, which allowed for continual new insights and analysis to be gathered after the time on the ground in Guadagnolo ended. As an example, although the orthophoto has to be taken during initial fieldwork, it can be analyzed remotely to understand size and access of different buildings, as well as help indicate where in the town there are collapsed roofs. Furthermore,

some of the occupancy survey was able to be done remotely, using photographs collected of each building, allowing for the time on the ground to be focused on meeting people and observing living patterns that could help refine the indicators.

In general, the surveys have generated a significant, granular dataset that can continue to be analyzed by people in the municipality beyond the scope of the assessments done in this thesis. Furthermore, when collected across several towns, the structure of this data can allow for cross-comparisons of different municipalities and regions to help Liminal and the national government more broadly understand how different aspects of these towns influence each other. This type of robust data will not only support the town as they try to implement new visions, but also support Liminal as they begin building a national dataset on abandonment to help guide policy and funding allocation.

Potential Improvements

Beyond the inherent limitations of the survey process, several pieces of the survey also did not function as intended during either the data collection or subsequent analysis process, all of which should be reconsidered for future iterations. One example is the attempt at a window density calculation, which is not included in the subsequent results due to the inaccurate data it generated. To generate window density, the number of windows per building was recorded in the field, and during the analysis that result was divided by the estimated volume of the building to get the estimated number of windows per cubic meters. However, since only the number of windows was counted, and the size of these windows was not taken into consideration, the resulting window density was extremely inaccurate. Buildings with a single large window lighting an entire floor had lower densities than large buildings with three very small windows in total. Looking forward, the size of the windows needs to be considered to ensure that the results are more accurate. This metric was meant to support the assessment process by filtering out buildings with minimal natural light, particularly for housing purposes, since there are recommended light access standards for modern living spaces. In future survey iterations, an additional step to indicate the size of the window would be necessary to make this metric usable.

Another major improvement that could be made to the survey process is removing the facade-level data collection. Although this did generate useful data overall, it added significant complexity to both the collection method and analysis of the surveys. Ultimately, the data ended up being coalesced into building-level data to be able to compare across indicators, so despite being potentially useful or interesting to analyze in its own right, in most cases it was not necessary to collect. Removing this level and assigning its attributes to either entrances or facades based on what is appropriate would greatly simplify the data collection process in the field and reduce the complexity of the GIS analysis afterward.

Furthermore, an additional improvement that could be made across indicators in the survey is to have stronger guidelines for determining the value of each indicator. Particularly for data around condition which assigns the indicators to a value within a scale, pre-setting the

attributes of these scales in advance would help ensure the data is more consistent. Although this was not a big issue for this thesis since only one researcher was categorizing each building according to the different indicators, it could present a problem as the research team expands and there is less clarity on what mild versus severe damage presents as on buildings. Addressing this in the survey development period will be necessary in order to prevent data inconsistencies from building up over time.

Validating the Data

The biggest survey improvement, however, is around determining ways to validate the collected data, with a particular focus on understanding if the occupancy algorithm is correctly identifying buildings of different occupancy levels. Without a more robust data validation process for all three survey types, it could be difficult for municipalities to rely on this data only during future grant writing. Determining methods that can validate the survey process, particularly at scale, is critical to ensuring future iterations create meaningful, robust datasets.

One potential option to validate the occupancy survey results is through a form of ground-truthing with local residents. Working directly alongside a full-time resident with deep knowledge of the town, a map could be generated of where exactly full-time residents live versus seasonally or unoccupied spaces based on their experiential knowledge. In a town like Guadagnolo, this type of ground-truthing would be possible given that there are fewer than 100 buildings total within the town, and far fewer residents, so it is likely that the residents who do live there full-time know this information off hand from decades of living in the town. In other places, ground-truthing could look like a door-to-door survey where the researcher tries to engage people at their residence during the peak season. Assuming people are in-residence during the peak season, it could offer a true account of where people are living seasonally or full-time. This type of validation would provide the most accurate basis on which to validate the existing occupancy algorithm, but it could be difficult to scale the method. Towns with more buildings would take significantly longer to ground-truth than a smaller town like Guadagnolo, and as towns get bigger, it becomes less likely that a full-time resident will know where everyone in the town resides. That being said, one potential idea is to do this type of ground-truthing in a small town in each region the survey is being held to level-set the indicators once. For example, a small town in the south of Italy that is a similar size to Guadagnolo could be chosen as the validation site that indicators are tested on, and then those indicators can be applied with more confidence throughout larger towns in the region.

Another potential strategy for validating the occupancy survey results is through random sampling. In this scenario, the survey would be carried out on all of the buildings in the town, and then a statistically meaningful percentage of the total number of housing structures would be ground-truthed using the method described earlier. Depending on the number of surveyed buildings overall, this sample size could range from 15-50%, depending on the desired accuracy (Ziafati Bafarasat, 2021). This random set of buildings would be visited and an attempt at engaging the person occupying the building would be attempted as a test to see if the building is occupied or not. Further interviews with local residents who may know the neighborhood

could also be conducted to determine the occupancy state for each of the buildings within the randomly selected set, further helping to validate the results of the occupancy algorithm. Although there is more room for error in this approach than the full ground-truthing method, it is a more feasible option to do in larger towns. In Monti Prenestini, for example, the town of Capranica Prenestina has about twice as many buildings as Guadagnolo and about three times as many residents (Italian National Institute of Statistics, 2024). Conducting complete ground truthing in Capranica Prenestina would not be feasible for a small research team, but this type of random sampling to ensure that the occupancy algorithm is working properly could be possible and is a good interim step.

Finally, another potential validation strategy that could be used is comparing the results of the occupancy algorithm to other data that the municipality has collected. The largest challenge with this strategy is that not all towns will have collected recent data that is related to occupancy, so it cannot be relied on in full. In the case of Guadagnolo, however, the Base Camp Guadagnolo grant proposal collected a list of approximately 20 units that owners were willing to make available to the town in order to reprogram them in support of the satellite campus, which can be seen below (*Progetto - Campo Base Guadagnolo*, 2022). The grant does not specify exactly which buildings are unoccupied, but suggests that the majority of offered buildings are used only seasonally or are totally unoccupied (*Progetto - Campo Base Guadagnolo*, 2022).

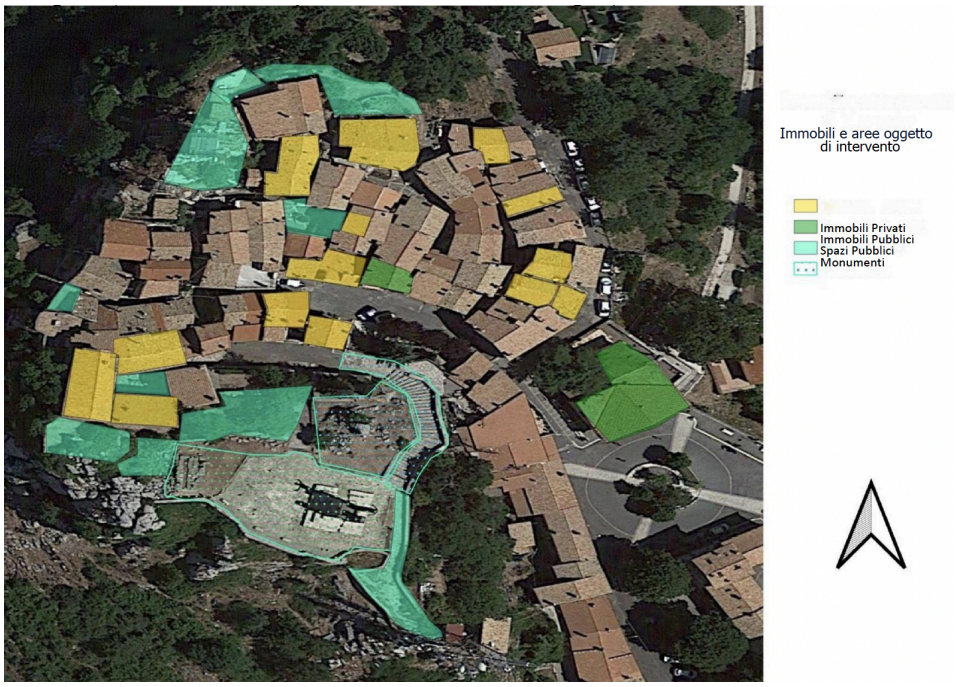


Figure 36: Buildings in Guadagnolo made available for reprogramming through Base Camp Guadagnolo. This municipal-generated map shows which buildings have been made available by their current owners for potential reuse in support of Base Camp Guadagnolo. Yellow represents privately owned units that have been made available, green represents publicly owned units, and teal represents public open space. (*Progetto - Campo Base Guadagnolo*, 2022)

In comparing the algorithm-generated map and this map, it shows overlap between buildings that the grant suggests are unoccupied and that the algorithm suggested are unoccupied or seasonally occupied. However, the grant specifies specific units that are offered for reprogramming, while the algorithm-generated map qualifies the whole municipal plot as a level of occupation, and many of these lots have several units within them. Therefore, there is some difficulty in direct comparison between the two maps, and therefore this strategy also cannot be used as a complete validation method. There are a few areas where the maps do not align, which could indicate that the algorithm is wrong, or could just indicate that the algorithm favored indicators for just some of the units within the building, which skewed the whole building. For example, there are buildings which are marked as “likely occupied” by the algorithm because one of several units qualifies the whole building as that category, but a different unit within the same building may appear in the grant-generated map as unoccupied. Figure 37 shows the two maps overlaid on top of each other to illustrate the overlaps and where the units and lot misalignment creates difficulty analyzing the results. It's important to note that the buildings identified as "likely unoccupied" based on the grant specifications do not represent the entire unoccupied building stock in the town. The occupancy algorithm flagged other buildings as potentially vacant, but because their owners did not make them available for inclusion in the grant application process, they would not show up within the “Grant-Specified Likely Unoccupied” map. While the grant-specified list covers part of the vacant inventory, there could be other unoccupied structures not accounted for simply because the owners chose not to participate.

Figure 37: Comparison of algorithm-generated occupancy status and grant-specified likely unoccupied buildings.
Comparing these two data sets is imperfect because the occupancy-algorithm specifies the occupancy status of entire municipal lots, but the grant shows specific units within those lots.

Further validation methods could also be considered for the typology and condition surveys, although these are overall less ambiguous than occupancy. Typology indicators, for example, are overall less imprecise, and their results are not influenced by an algorithm in the same way that occupancy is. The condition survey does utilize a similar algorithm, but as previously mentioned, since it is not trying to replace a full professional technical survey due to the limitation of only being able to assess the exterior of the building, the need for a more complete validation is not critical. The validation will happen on a case by case basis when buildings undergo these complete technical evaluations prior to renovation or restoration.

In all, there are several potential ways that the occupancy algorithm in particular should be validated before extensive use within Italy. The case study in Guadagnolo presents some unique opportunities since it is small enough to do a complete ground truth alongside local residents, and it is recommended that this work is done during the summer peak season of the town to generate the most accurate results.

Reviewing the Assessment's Performance and Limitations in Data Analysis

Assessment Limitations

The assessments used to analyze the collected survey data are limited in several ways. One primary limitation is that the assessment eligibility and suitability criteria were not developed in consultation with local residents but rather based on the expected needs of different use types. It is possible that residents or people interested in reprogramming these buildings have different standards for accommodating uses that are not being represented here, primarily due to the time constraints of the thesis. For example, the eligibility of many buildings hinges on its access level, which in a US context is critical due to laws around accessibility that ensure that new development is made accessible to people with limited mobility (Americans With Disabilities Act, 2010). However, in the Italian context, these types of laws are not as strong, so the need for buildings to be car accessible could be viewed as less critical by people working on these reprogramming plans (D. Marra, 2007). In general, a deeper understanding of the residents' desires for each of the reprogramming spaces, which is rooted more deeply in their needs rather than the expected needs of the building, would help make this assessment more valuable.

Furthermore, another limitation of the assessment process is that it does not take into consideration which of the private properties have been indicated as available to the municipality through the Base Camp Guadagnolo grant proposal process. All of the buildings outlined as potentially available are within the historic core, with most being only accessible by pedestrians, while all of the buildings proposed for reuse through the assessment are outside of the historic code and are car and truck accessible. In Guadagnolo's case, not leveraging these properties that have already been made available to the town presents a real limitation given that they could represent opportunities for more smooth reprogramming initiatives and prevent the need to convince a local homeowner to make their private property available to support the town. In general, this case illustrates how the rigidity of the assessment method is

also one of its limitations. The assessment is designed to be based on survey indicators that can stratify buildings into clear eligible or ineligible categories, but this method lacks room for local factors to be able to influence the outcome. It is unlikely that another town would experience the same exact pitfall with the survey given how uncommon it is to have an inventory of potentially available buildings like this, but it does signify how the assessment is presently hindered by its rigid structure.

Successful Aspects

On the other hand, there are several components of the assessment method that have worked effectively to produce a clear dataset for the town of Guadagnolo. The method reveals a set of buildings that the town can use as a blueprint for further conversations and workshops about how to strategically reprogram and reuse buildings to promote economic development. Highlighting just a few options for each potential building typology need can help center the conversation and remove some of the potential guesswork associated with making these decisions. In particular, the typology survey and its close relation to the eligibility criteria for different uses provides the town with a data-driven set of buildings that could most easily function under new uses. Although some of this information might have inherently been known by residents, having a clear connection to data can help convince potential funders about the feasibility of these conversions and strengthen the municipality's case for a particular use scenario.

Another element that indicates the potential success of the assessment to recommend buildings correctly is the fact that the method recommended the same building as a working or classroom space that the town has independently identified during the Base Camp Guadagnolo grant process (*Progetto - Campo Base Guadagnolo*, 2022). This demonstrates that the assessment method is correctly identifying buildings that would make sense for adaptive reuse within the local context. The data-driven assessment method overlapping with the town's own sense of an appropriate working or classroom space could signify that the methodology can generate sensible results within the relevant context.

Potential Improvements

Ahead of running this assessment again, several key improvements could be made to the assessment methodology that could benefit both Liminal and the municipalities. The biggest potential improvement to adjust how the municipalities could benefit from the data in the short term is changing how the assessment results are visualized. Presently, to keep the maps readable and clear, only the buildings meeting all three eligibility criteria are shown for each use type, leading to a very small number of potential buildings for towns to evaluate. Although this makes the process very straightforward for municipalities, it leaves out key information that could be leveraged during the building selection process, leaving potential strategic opportunities for reuse on the table. The case study of Guadagnolo already demonstrates this issue with the current filtering system within the eligibility assessment. If all of the buildings

that meet just one of the eligibility criteria are visualized using different methods, several more potential candidates can arise, and these previously masked opportunities become visible.

Looking again at the potential working spaces in Guadagnolo, if all three variables are visualized, the map becomes more difficult to read, but additional options for working spaces or classrooms, like the one illustrated below in Figure 38 are revealed. In this case, there are two adjacent buildings that each meet two of the three criteria necessary to pass the eligibility assessment. One is truck accessible and the other is greater than 100 sqm, but both are likely unoccupied, seasonally occupied, or unknown. Neither building shows up in the initial assessment method because neither meets all three criteria, but when a map shows all buildings that meet one of the criteria, it's clear that if the two likely unoccupied buildings were combined, they could meet both the accessibility and size requirements to be considered. Furthermore, it's likely that these two buildings already share an internal wall given that most of Guadadgnolo's building stock is made of aggregated buildings that at least partially share walls. In this case, it's possible that just a single wall would need to be opened (and potentially an elevator or set of ramps added) within the first building to make the second one accessible. A full technical survey would need to be expected to determine the real feasibility of this, but the fact that this potential option was hidden within the current assessment methodology indicates that there is room for improvement within the process.

Figure 38: An alternate visualization of eligible potential working spaces.
As can be seen in this call out, this alternate visualization of the three eligibility criteria for working spaces reveals previously masked combinations of buildings that could qualify for reuse using the assessment if internally combined.

One potential way to help reveal these options more algorithmically would be to incorporate adjacency indexes into the assessment methodology. Under this potential improvement, buildings that meet all three criteria would still be shown, but also shown would be any building

directly adjacent. For towns like Guadagnolo, where the majority of the building stock is built as aggregates of typically three or more lots sharing multiple walls, adjacent buildings represent natural opportunities for expansion. Although this will not reveal every potential scenario, it could still help reveal patterns within the buildings that could be leveraged. Pushing this idea further, visualizing buildings that meet one, two, or three of the eligibility criteria can also be helpful for identifying patterns. Figure 39 shows an example of this applied to the criteria needed for working spaces. Although the information about which indicators are present in each building is not shown, some initial connections between buildings that meet two of the three criteria can be more easily seen, including the example presented earlier. There are likely several other methods that could be used to visualize or filter the data using this assessment methodology, but it is likely that in any case, a community workshop with local residents who know these buildings well could help further refine this process. With their expertise and direction of what should be visible at each step, these several different attempts at visualizing the assessment process could be refined into an approach that works across several use cases.

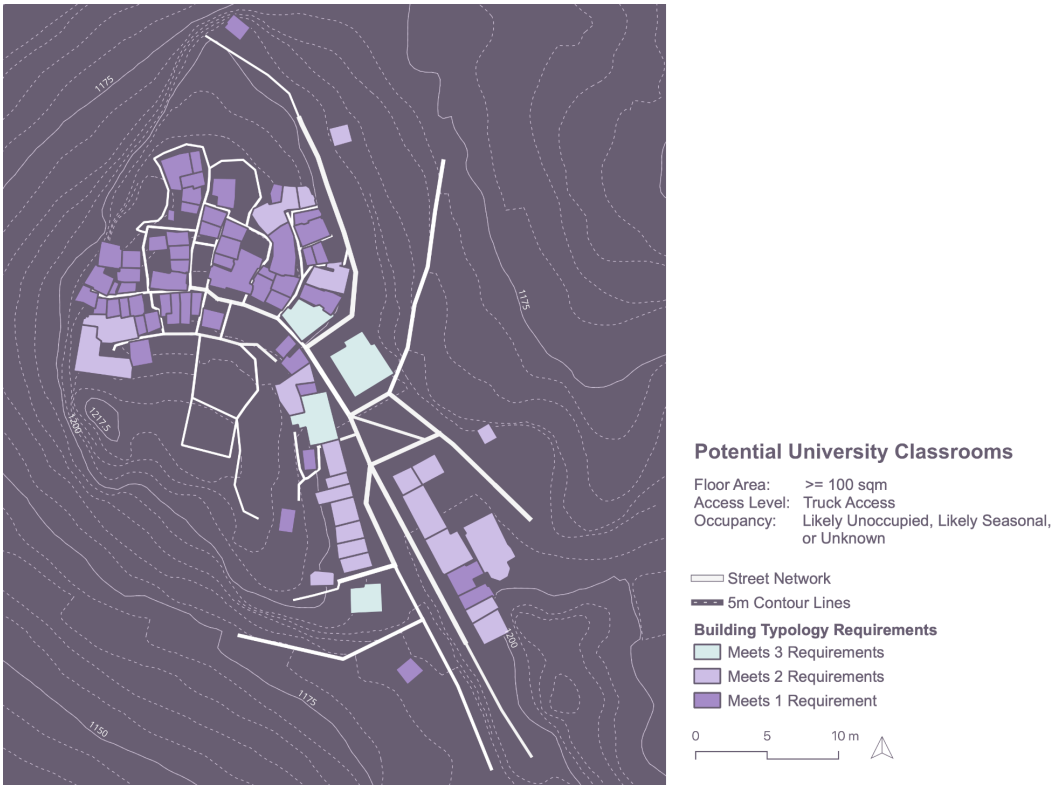


Figure 39: Potential working spaces visualized by the number of eligibility criteria they meet.
An additional way to view these potential structures for reuse is by the total number of criteria they meet, which could help reveal more potential building sets that could pass the eligibility assessment if combined.

In addition to changing the visualization and assessment methods used, the types of criteria the assessment uses could also be improved in later iterations. Another typology eligibility criteria that could be used in determining potential structures is the difficulty of access of different buildings, which would be particularly useful in regions with very few car accessible

buildings. Although similar to the access levels used in the current assessment methodology, this data focuses primarily on calculating the slopes of different areas within the street network to understand the relative pedestrian accessibility difficulty for each building. This type of data could be helpful in determining which of two buildings to reuse that have other similar properties, but one is only accessible via a steep stairway and one is accessible via a gentle incline with few stairs. Despite both being categorized the same under the current access levels, the two buildings would have very different user experiences. In future assessments where fewer buildings are car or truck accessible, this kind of calculated slope could serve as an additional metric to evaluate buildings on their accessibility.

Next Steps

An Opportunity for Iteration in Valle d'Aosta

In the summer of 2024, Liminal has the opportunity to run a second iteration of the survey in the region of Valle d'Aosta to support municipalities there interested in understanding their potential reuse opportunities. Over the course of three weeks in July, the survey will be run a second time, with many of the improvements outlined above incorporated, in the towns of Fontainemore and Perloz, to gather data on their existing building stock and occupancy levels. This opportunity provides room to test and refine several aspects of the framework and respond to the potential improvements outlined above.

To contextualize the new location, the region of Valle d'Aosta is one of the most northern regions in Italy, situated deep within the Alps and adjacent to both France and Switzerland. In comparison to Monti Prenestini, the central Italian region studied in this thesis, the cultural context of Fountainemore and Perloz is likely to be very different and influenced by the close proximity of these other European countries. Furthermore, the climate and ecology of the region, given its position and altitude within the Alps, is likely to further influence the building stock within the towns and how residents respond to seasonal temperature shifts or long term impacts of climate change.

This shift in context will likely have a significant impact not only on the occupancy indicators used in the surveys, but also potentially on the building typologies that need to be studied in the towns. Adjusting the survey indicators to fit the context of this new location will be critical to the success of the second iteration of the survey, and so the first third of the workshop is to be dedicated to observational research and community conversations to ensure the indicators used in the second version of survey are contextually and regionally relevant.

In terms of the occupancy survey, since the study will be conducted during the summer rather than the winter, the meaning of several of the occupancy indicators may change depending on the region's tourism flows. In Monti Prenestini, the summer is peak season for both tourists and people residing their vacation homes, but without further context from local communities, it is unclear how occupancy patterns might change in the summer in Valle d'Aosta. In any case,

each indicator will need to be reevaluated before data collection begins to determine if it is contextually accurate.

As an additional shift in approach, this research will also be conducted by a small team rather than just one person, which presents both a challenge and an opportunity for data collection. Since more people will be available to support the surveying, the work can potentially be completed more quickly, allowing for more time ahead of the data collection to refine the indicators being used. However, level-setting the survey indicators for the whole group ahead of data collection will be critical to ensure that data remains consistent as the research team grows. A data dictionary of photographic examples of every value of every indicator, as begun during this survey in Monti Prenestini, can be created prior to and during the research trip to ensure consistency. It is also likely that this group will include local residents as well as young professionals and college students, and so it will be additionally important to ensure that the survey is accessible for people at different levels of familiarity with the process, and that it can be easily translated between English and Italian.

In preparation for this next iteration, both the logistical process of conducting the survey, as well as the survey indicators and assessments themselves, need to be reviewed and improved based on the many considerations presented. The following sections will offer more detail on how these updates could be approached to prepare for a successful research experience with a larger team this upcoming summer.

Simplifying & Improving the Frameworks

To begin with, several of the previously mentioned ideas to simplify the frameworks (both the assessment and the surveys) should be implemented in this next iteration. To start, shifting several indicators away from being facade level to building level will allow for faster data collection and a more efficient analysis period. The indicators that would need to be shifted to building level are listed in Table 13 below.

Occupancy Indicators	**Typology Indicators**	**Condition Indicators**
- Open Shutters - Open Windows - Broken Windows	- Image IDs - Max Stories - Viewshed Access - Number of Windows - Number of Entrances - Maximum Steps Required for Building Access - Minimum Steps Required for Building Access	- Damage to Openings

Table 13: Lists of facade-level indicators to be moved to building-level indicators in future surveys.

An additional simplification is removing or reducing the elevation data collection process, which in the present case study was done during the typology survey data collection process.

If the towns have a high number of car or truck accessible buildings, slope data is therefore less useful, and since digital elevation models covering the entire country are readily available, these less granular data sets can instead be used to estimate average building elevations for the town. This would eliminate the need to collect a new dataset and would remove several steps in the GIS analysis process. Removing these processes would make the process as a whole more approachable for team members who are not familiar with GIS and overall faster to complete.

Finally, many of the assessment improvements should be incorporated in the second iteration. Through deepened community engagement activities, additional information can be collected by research team members about the types of maps it would be beneficial for municipal workers or residents to see during a town visioning process. Leveraging this additional time on the ground with residents to refine the methods within the two assessment processes will help ensure that the results are relevant and robust, and most importantly presented in a format useful to the people using them.

Beyond this, several other key improvements can be made to improve the logistics of the survey to serve a larger team of researchers and residents. Condensing the survey collection onto one platform (likely Jotform since it can be used offline) will be key to managing the process and will make post-collection data analysis much easier. Additionally, doing some of the orthophoto analysis work ahead of the time on the ground will be critical to ensuring that the data collection processes can happen smoothly. This can include outlining the road networks in GIS, ensuring that the GIS building plots are correctly labeled with their municipal IDs to be able to, and creating a photo dictionary of the values of different indicators to provide guidelines during field data collection.

Developing a More Robust Community Engagement Process

For the towns in Valle d'Aosta, as well as any other locations where another iteration of this survey takes place, the most important and largest adjustment that will need to be made to the framework is developing a deep and thoughtful community engagement process. This case study in Guadagnolo benefited not only from years of on the ground community building done by Liminal, through SWOT analysis, community conversations and interviews, and causal interactions, but also from the municipality's own efforts to engage and understand the desires of the community through town halls focused specifically on reprogramming and revisioning the town's future. This extensive prior work in community engagement was leveraged heavily in the proposed framework tested in this research. In particular, it allowed for the process to assume that the community had already come to a consensus around potential reuse scenarios, because in Guadagnolo it had. In other towns, the framework needs to be extended to include a significant and meaningful set of community interactions and visioning sessions to identify these reuse goals which the assessment process can then be shaped around.

In Valle d'Aosta, this should include a set of interviews to support the SWOT analysis, helping to understand individuals' potential visions for the future of the town. Additionally, community meetings and visioning workshops could be held to engage a larger group at once and start

building consensus around a few major themes of reuse. These activities could start by working to identify the highlights of the town and what kinds of industry people living there would be interested in seeing encouraged over the next many years.

Furthermore, engagements could also be done with folks living outside of the region who have considered moving but ultimately decided not to as well as people who have moved out of the towns in recent years. Given that preventing total depopulation is one of the overarching goals of these towns, understanding the perspective of people who have either recently left or decided not to come could provide key insights into the type of work, amenities, or resources that the town needs to focus on developing to be enticing. While writing a grant proposal for Base Camp Guadagnolo, the town consulted with young people from Rome to understand their preferences and desired features that would entice them to come to Guadagnolo over other rural towns. The town recognized that attracting and retaining young residents was crucial for its sustainable future development (*Progetto - Campo Base Guadagnolo*, 2022). While this approach may seem unconventional as it could prioritize the opinions of non-residents over current residents, which is opposite to the typical community engagement strategies used in the US, in this context it is a necessary endeavor. Young people from outside the town can bring in ideas for a realistic plan that would attract and retain them, the people the town needs to move there in order to stabilize its population. By giving voice to potential new residents, which will most likely be these young people, the town can understand how to encourage an environment that meets their needs while it also secures its own long-term viability. Balancing these differing priorities of outside young people and older residents will be a difficult effort, but will be critical to identifying the use scenarios needed for the building assessments to produce valuable, usable data.

In Valle d'Aosta, a set of engagements with current residents, people who moved out of the town, and people from Turin or other nearby northern cities is necessary to define these reuse scenarios. The engagements should build in scale as the ideas become more solidified to help build consensus, particularly among full-time current residents. Starting with individual interviews of people from each of these demographics, moving to group workshops to identify common themes and their strengths and weaknesses, and finally ending with a decision-making process to specify one or two potential scenarios to test with the assessments. This flow of conversation types leverages the Civic Design Framework, which provides a structure for framing conversations to ensure equitable community participation and community consensus (*MIT Civic Design Framework.Pdf*, n.d.). By focusing on a specific goal at each of the three engagement stages proposed, the proposed community engagement method for Valle d'Aosta can reveal a set of proposals around reuse strategies while still building deep relationships with local partners and establishing cultural context critical for other parts of the framework.

Scaling the Survey

The Impacts & Logistics of Collecting Data Across More Towns

As the survey becomes more robust, reliable, and easier to implement, the goal is to be able to have communities conduct their own self-assessments, without the aid of a research team established by Liminal or another organization. This will not only provide individual towns with an extensive base layer of data about their own town, but when combined with towns across the country can reveal potential statistical correlations between different data types. With only a few towns data collected through Liminal, this type of large scale analysis cannot be done to any statistical significance, but if many towns across Italy can collect data using this same process, it could create a national dataset that can be used to inform policy measures, funding attribution, and more. Importantly, this kind of large scale data could also reveal connections between elements in the built environment and the likelihood of occupancy in depopulating towns. Understanding what changes could be made to the urban form to help address depopulation trends could prove valuable overtime, particularly for towns that are not experiencing such rapid depopulation, like Castel San Pietro Romano.

In order to be able to empower these communities though, the survey needs to be simplified in the ways previously mentioned and restructured into a digestible toolkit that residents are able to execute on, either with no assistance from Liminal or with remote technical support. The toolkit needs to be able to balance generating a complete, robust set of technical data while still being straightforward enough to implement. After the second iteration in Valle d'Aosta and testing the survey in a new region, it is likely that additional indicators will be identified to better capture the current conditions of the towns there. Therefore, an additional attempt at streamlining the survey will be necessary before a wider rollout in order to create a concise and practical set of indicators that can be effectively utilized by residents across regions.

Adapting Data Collection Processes to Bigger Towns

Beyond scaling the survey to be able to capture more towns, the framework also needs to be able to support towns that are bigger than Guadagnolo volumetrically and in population. To a certain extent, larger research teams will make it possible to support physically larger towns, however, additional strategies should also be considered as towns move up in both population and building volume. One potentially promising strategy is to leverage machine learning to be able to automatically detect indicators in the survey. This would be much faster than having an individual visually review each building in a larger town, and therefore make it possible for the survey to scale to handle towns of a much larger size. Additionally, there is evidence in the field that machine learning research is expanding in its ability to recognize key objects that would be needed to fulfill these indicators (Liu & Sevtsuk, 2024). Furthermore, more research is also being developed that leverages computer visions and object detection within Google Street View (GSV) and other similar platforms (Biljecki & Ito, 2021). This is particularly relevant to Liminal given that one of the pieces of data they collect across all towns is high-quality 360 video that can be converted into GSV. As the machine learning field grows in this direction and

improves in its ability to do refined object selection, it could be possible for Liminal to conduct a survey data collection process by simply having researchers walk down the street with 360 cameras. However, there is still significant work to do in this area, particularly because most of the work done in these fields concentrates on cities and urban environments. Even with improved image segmentation and object identification, it may still be necessary to train new datasets and models because of the unique rural building features that are not always present in larger cities. For example, 3D imagery captured in rural Italy that was later uploaded to Mappilary, a database of 3D imagery that has several layers of object detection automatically applied, identified trees in the area as telephone poles (*Mapillary*, 2024). Although the machine learning field is promising when it comes to scaling this type of visual assessment framework, deeper research and training needs to be done to be able to apply the learnings of current researchers to rural towns in Italy.

Review of Key Contributions

In conclusion, this thesis has proposed and tested a new framework to collect and analyze data on rural towns in Italy. The two part framework first collects field data using visual surveys that reveal information about the town's occupancy, typology, and condition, and tests several algorithms to sort this data, producing a set of maps outlining the current state of the town. Then, the data is filtered through a series of assessments to reveal which buildings meet the eligibility criteria and can support new uses, with the expectation that investments in these spaces could help encourage revitalization and economic growth within the town. The collected data not only directly influences these reprogramming plans, but also provides both Liminal (the thesis client) and the town itself with a set of information on the town that was previously undocumented. This data can be used for a variety of reasons, including as leverage in funding applications from regional, national, and international organizations.

This methodology was tested in a town called Guadagnolo, in central Italy, over the course of a month in January 2024. Guadagnolo had previously identified that it was interested in reusing several of its buildings as spaces to support a university's satellite campus or to encourage more long term tourism in the area. Using the survey and assessment method outlined above, a potential reuse plan was developed for the town, which activates two large buildings to hold working and gathering spaces for the reuse scenarios, and taps several likely unoccupied buildings to become housing through either an albergo diffuso or campus housing plan.

Furthermore, the test of the framework revealed a set of potential improvements that can be made to the methodology, including simplifying the data schema, providing alternative ways to visualize the results to reveal more potential reuse options, and developing a more robust community engagement process to ensure consensus around future plans. All of these improvements and other potential refinements will be incorporated into the framework and tested again this upcoming summer in a set of towns in the northern region of Valle d'Aosta. This provides a unique opportunity to refine the framework within a new cultural context, which

will likely spur additional survey indicators to capture the region’s existing conditions and provide space to continue iteration on the assessment technique.

With 70% of Italy's municipalities comprising less than 6,000 residents, its rural towns are a key part of the country’s future (Berg, 2022). However, these places that make up the fabric of the country are rapidly disappearing as metropolitan centers draw people toward greater economic opportunities in bigger cities. The frameworks outlined and tested in this work aim to generate data and analysis that can help curb these depopulation rates by empowering towns to collect their own insights, and in the process potentially making them eligible for new funding sources. By providing rural communities with a toolkit like the one outlined in this thesis, Italy’s rural towns have the opportunity to chart a new economically viable path for their future, preserving their unique cultures, ecology, and ways of life.

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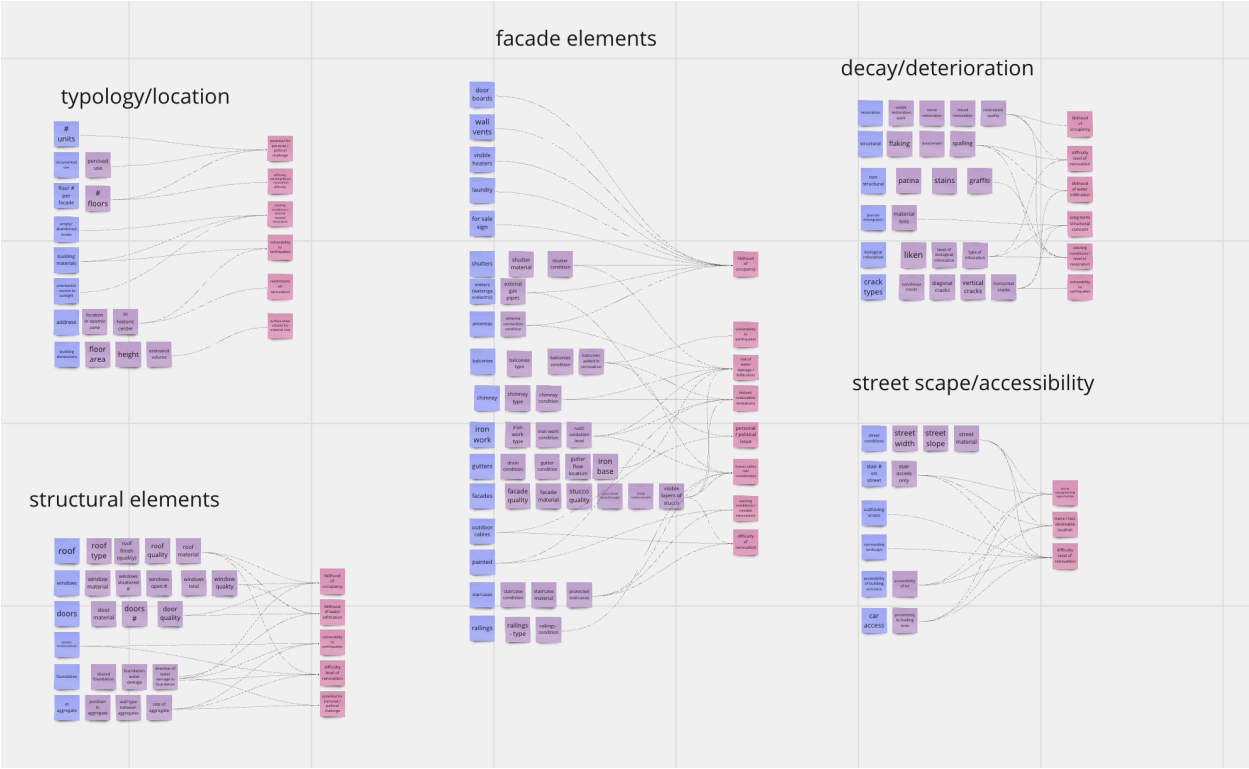
Appendices

Appendix A: Survey Indicator Development

Mind Map from Interviews & Conversations



Initial Condition Indicator Table (condensed due to time)

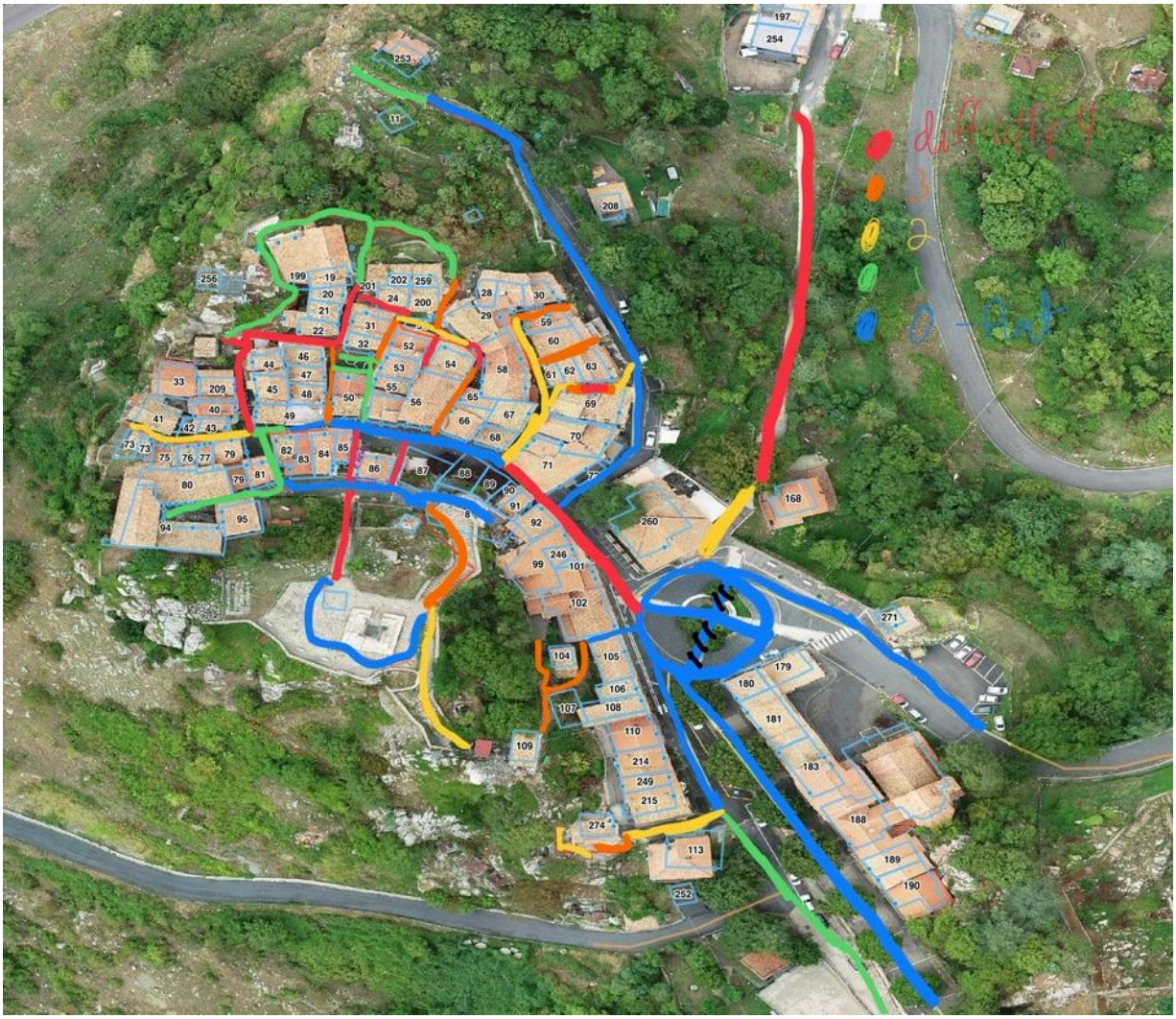
Condition Indicator	Potential Renovation Impact / Scale
Seismic Reinforcement	Present -> potential good condition Absent -> no meaning without more indicators
Foundation Damage	Large cracks visible along most of base, increased presence of deterioration toward base, large gaps -> Severe damage / High cost renovation Some cracking visible but concentrated in specific areas, crumbling of material -> Mild damage / Average cost renovation No visible damage -> Low cost renovation
Exterior Renovation	Present -> Potential low cost renovation Absent -> No meaning without additional indicators
Plant Infestation	Plants entering windows, covering more than 50% of surface, cumbling/weakness around plant area -> Severe damage / high cost renovation

	Plants present but not causing structural damage, covering less than 50% of surface -> Mild damage / average cost renovation No plant infestation present -> No damage / low cost renovation
Water Damage	Significant discoloration, lichen covering more than 50% of surface -> Severe damage / high cost renovation Some discoloration, lichen covering less than 50% of surface -> Mild damage / average cost renovation No visible water damage -> Low cost renovation
Wooden Fixture Damage	Cracking, visible wood rot -> Severe damage / high cost renovation Flaking paint, wood warping -> Mild damage / average cost renovation No visible damage -> Low cost renovation
Metal Fixture Damage	Visible holes from rust covering nearly all fixtures, wobbly or weak connections -> Severe / high cost renovation Some rusting covering many fixtures -> Mild damage / average cost renovation Minimal rust present -> Low cost renovation
Stucco Damage	Large cracks, gaps visible, spalling -> Severe damage / high cost renovation Small cracks, no gaps -> Mild damage / average cost renovation No damage / recently renovated -> Low cost renovation
Staircase Damage	Unusable or unsafe, wobbly steps, significant detachment/cracking/loss of material, missing stairs -> Severe damage / high cost renovation Cracking visible in material but still stable -> Mild damage / average cost renovation No obvious visual damage -> Low cost renovation

Appendix B: Hand-Drawn Maps, Field Notes, Municipal Resources

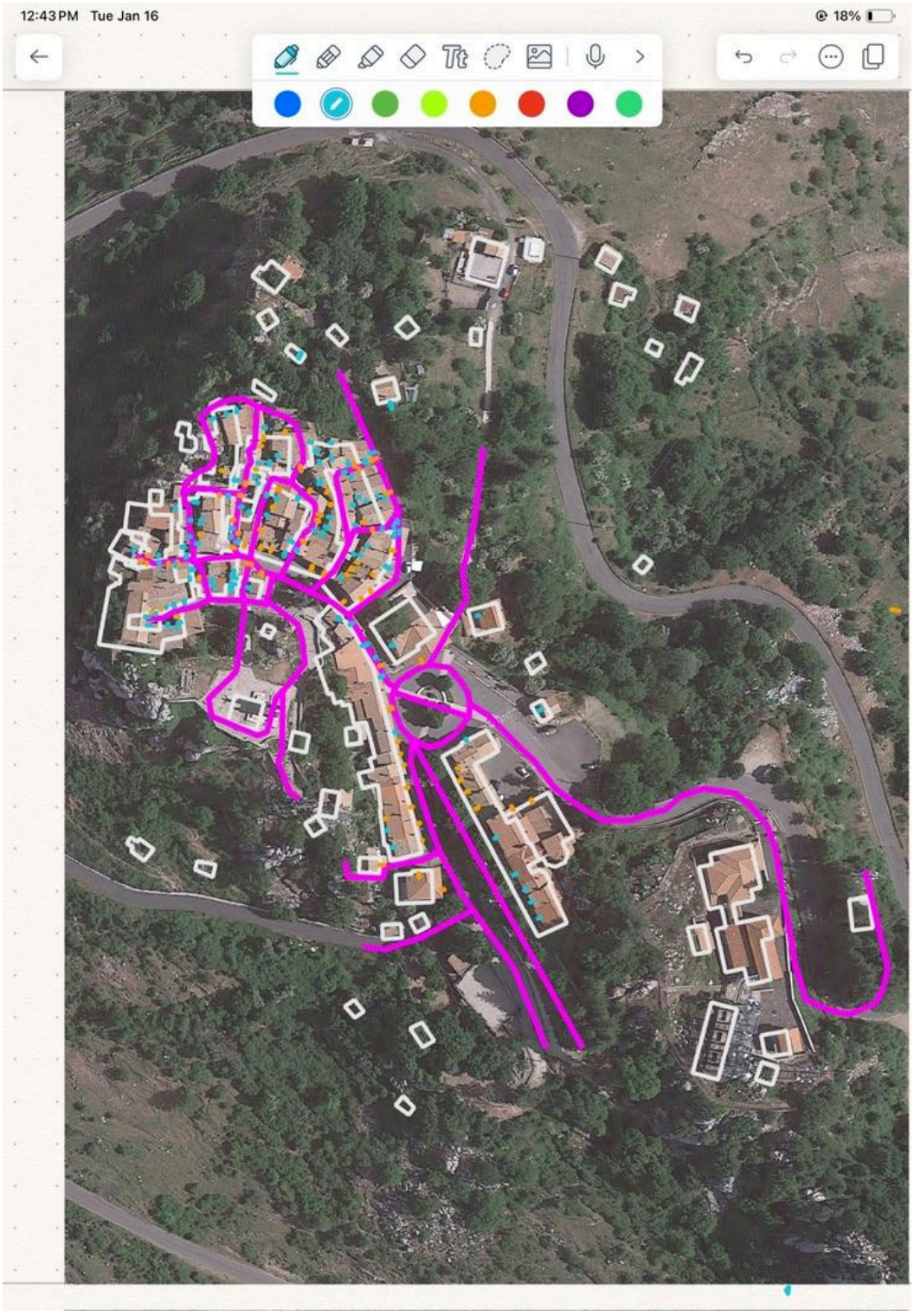
Municipal map of Guadagnolo provided by the Comune di Capranica Prenestina.

Map of Guadagnolo overrated with the provided municipal map. Plat in the municipal map and existing buildings in the orthophoto did not align which is why a re-tracing of each lot using the orthophoto was needed.

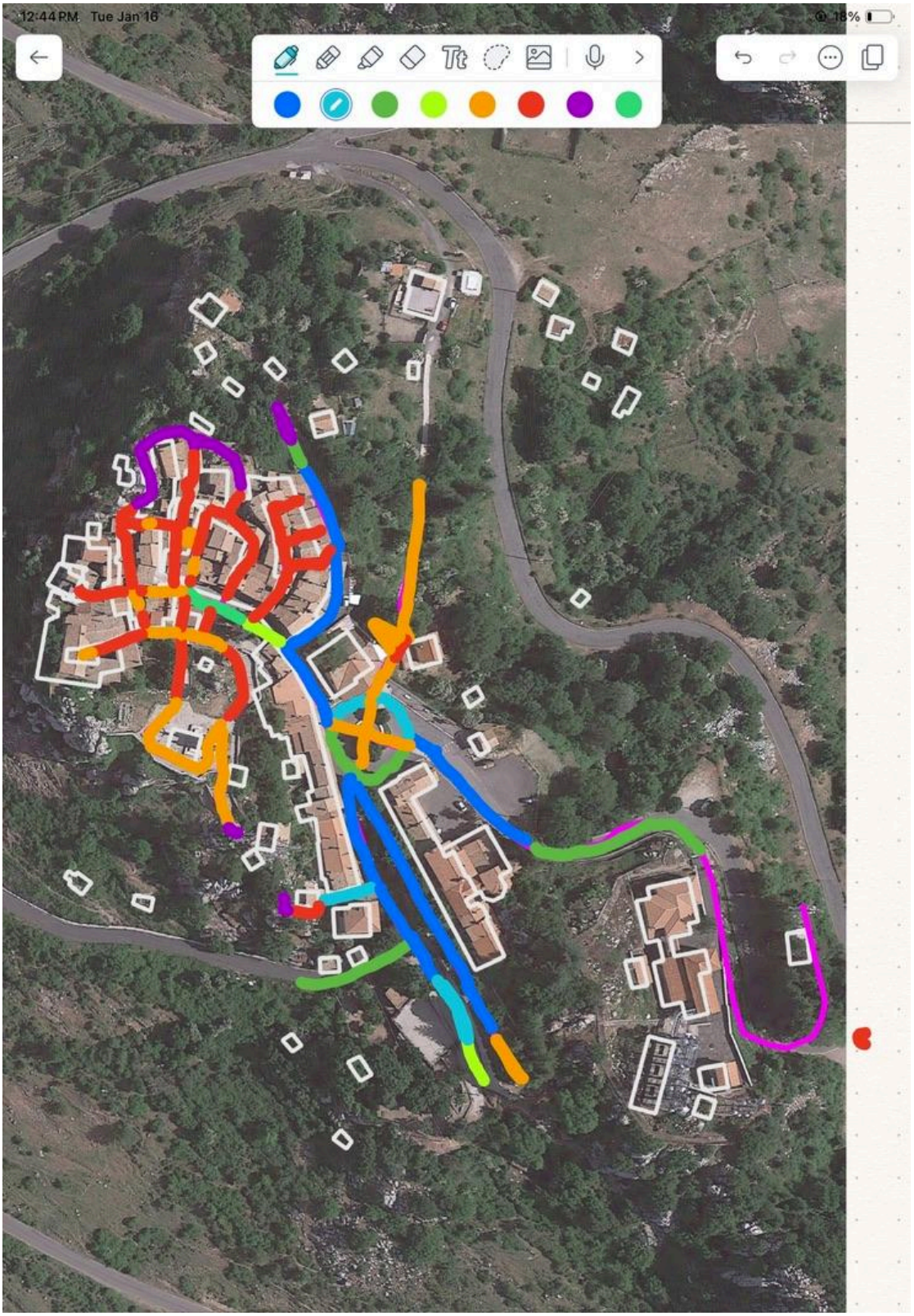


Hand drawn map of the pedestrian difficulty-level of each road based on personal experience. Blue (0) is easiest and red (4) is most difficult.

Map of locations in Guadagnolo where the bottom floor is used as storage is open to the elements.



Initial hand-drawn map of entrance locations on buildings in Guadagnolo. This was re-done after the municipal plots were re-outlined in GIS to ensure entrances were connected to the correct plat ID number.



Hand drawn map of access levels in Guadagnolo based on use observations and posted signage.

Map of locations in Guadagnolo where people were seen (blue), where there are active renovations (red), and where living spaces were perceived to be exposed to the elements (black).

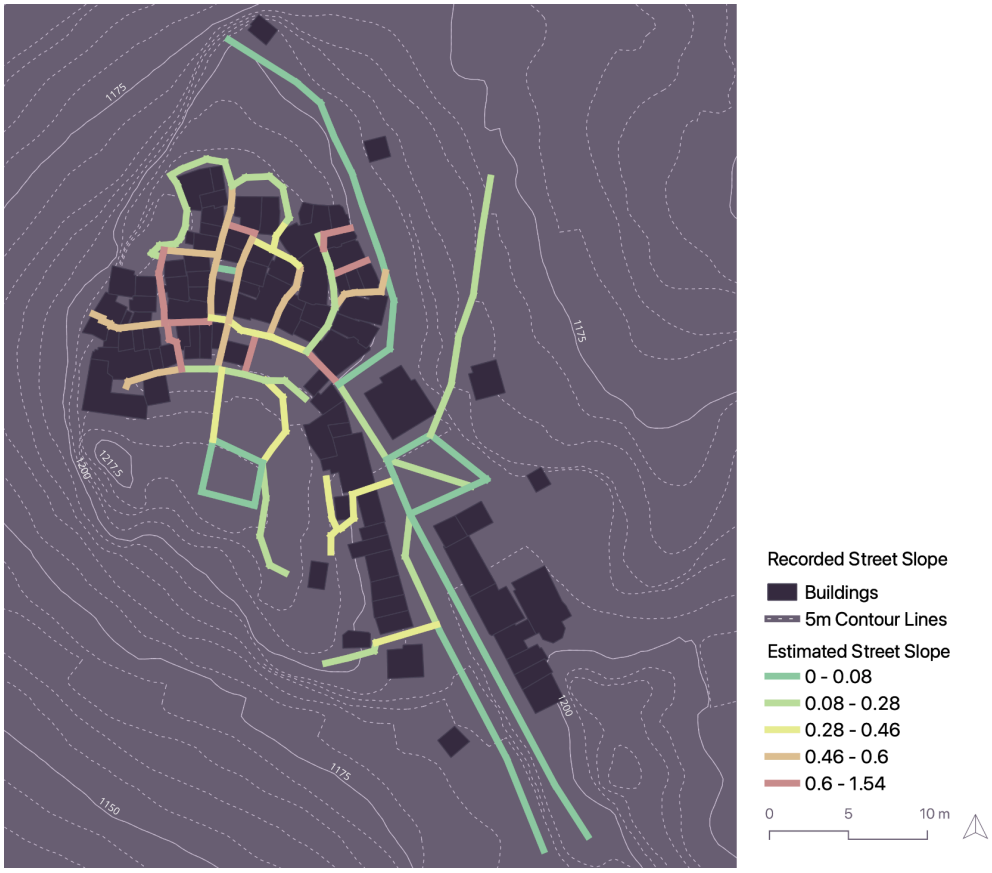
In-process map of Guadagnolo, with the facades of each building numbered and estimated time it takes to complete a portion of the visual survey.

Appendix C: Elevation Data Processes & Results

Elevation Data Processes

Entrance Elevation	1. Import all collected GPS elevation points. 2. Join each entrance by location to the 5 nearest elevation points within 6 meters. The *6 meter limit is necessary to ensure very distant points are not included, but accounts for some misalignment of the GPS collected points.* 3. Average the points (up to 5) and set the result to the entrance's elevation.
Building Elevation	1. Collect the estimated elevations of any entrances attached to the building. 2. Average the collected elevations and set the result to the building's estimated elevation.
Street Slope	1. Import all collected GPS elevation points. 2. Manually configure street network to create longest possible sub-paths that only slope in one direction (ie from lowest point to highest point, and then from highest point to lowest point.) 3. Assign each subpath a unique ID. 4. Calculate the length of each subpath using the QGIS geometry tools. 5. Join each subpath by location to the 100 nearest elevation points within 5 meters. 6. Aggregate across the results by the subpath's unique ID, collecting mean, max, min, and range. 7. Calculate the slope of each path by dividing the collected range by the measured length of each subpath (rise over run) and set the result to the slope of that street segment.

Map of estimated building elevations as determined by averaging entrance elevations for each municipal lot.



Map of estimated street slopes derived from recorded elevation points.

Appendix D: Data Schema

Buildings

Name	Type	Units / Options	Associated Survey	Collection Type
Municipal Plat #	Integer	None	Organizational (not survey related)	Municipal Map Data
Estimated Area	Integer	Square Meters	Typology	GIS Orthophoto Analysis
Estimated Volume	Integer	Cubic Meters	Typology	Field Data & GIS Orthophoto Analysis
Garden / Open Space Access	String	“Direct Access” “Partial Access” “No Access”	Typology	Field Data
Perceived Use	String	“Housing” “Fallen Housing” “Hostel” “Church” “Municipal Services”	Typology	Field Data
Ground Floor Storage	Boolean	True False N/A	Typology	Field Data
Dogs Present	Boolean	True False	Occupancy	Field Data
People Present	Boolean	True False	Occupancy	Field Data
Hanging Laundry	Boolean	True False	Occupancy	Field Data
For Sale Sign	String	“Self-made” “Agency-listed” “None”	Occupancy	Field Data
Functional Roof	Boolean	True False	Occupancy	GIS Orthophoto Analysis
Overall Building Damage Level	String	“No Damage / Minimal Damage” “Mild Damage” “Severe Damage”	Condition	Field Data

Facades

Name	Type	Units / Options	Associated Survey	Collection Type
Municipal Plat #	Integer	None	Organizational (not survey related)	Municipal Map Data
Facade #	Integer	1, 2, 3, 4	Organizational (not survey related)	Self Generated
Facade ID	Integer	None	Organizational (not survey related)	Self Generated
Image IDs	Integer	None	Organizational (not survey related)	Self Generated
Floors Present	String List	“-2”, “-2 Partial” “-1”, “-1 Partial” “0”, “0 Partial” “1”, “1 Partial” “2”, “2 Partial” “3”, “3 Partial”	Typology	Field Data
Max Stories Total	Integer	Stories	Typology	Field Data
View Level	String	“Direct View” “Partial View” “No View”	Typology	Field Data
Open Shutters	Boolean	True False None or N/A	Typology	Field Data
Open Windows	Boolean	True False None or N/A	Typology	Field Data

Broken Windows	Boolean	True False None or N/A	Typology	Field Data
Number of Windows	Integer	Windows	Typology	Field Data
Number of Entrances	Integer	Entrances	Typology	Field Data
Max Number Step Required to Enter	Integer	Steps	Typology	Field Data
Openings Damage Level	String	“No Damage / Recently Renovated” “Mild Damage” “Severe Damage”	Condition	Field Data

Entrances

Name	Type	Units / Options	Associated Survey	Collection Type
Municipal Plat #	Integer	None	Organizational (not survey related)	Municipal Map Data
Facade #	Integer	1, 2, 3, 4	Organizational (not survey related)	Self Generated
Facade ID	Integer	None	Organizational (not survey related)	Self Generated
Entrance ID	Integer	None	Organizational (not survey related)	Self Generated
Estimated Elevation	Integer	Meters	Typology	Field Data + GIS Analysis
Door Board Condition	String	“No Door Board” “No Damage” “Mild Damage” “Severe Damage”	Occupancy	Field Data
Civic Number Condition	String	“Updated or Tiled in Good Condition” “Updated in Bad Condition” “Not Updated” “Not Present / Visible”	Occupancy	Field Data
Curtains	String	“Present & Secured” “Present & Not Secured” “Not Present”	Occupancy	Field Data

Street Network

Name	Type	Units / Options	Associated Survey	Collection Type
Segment ID	Integer	None	Organizational (not survey related)	Self Generated
Pedestrian Access Only	Boolean	True False	Typology	Field Data
Car Access	Boolean	True False	Typology	Field Data
Car Parking	Boolean	True False	Typology	Field Data
Truck Access	Boolean	True False	Typology	Field Data
Truck Parking	Boolean	True False	Typology	Field Data
Stairs or Trail	Boolean	True False	Typology	Field Data
Access Category	Integer	1 - Truck Parking & Access, Car Parking & Access 2 - Truck Access, Car Parking & Access 3 - Car Parking & Access 4 - Truck Access & Car Access 5 - Car Access 6 - Pedestrian Only - No Stairs 7 - Pedestrian Only - Stairs	Typology	Field Data

		8 - Pedestrian Only Trail		
Perceived Slope Difficulty Level	Integer	0 - Flat 1 - Gentle Slope, No Stairs 2 - Average Slope, Some Stairs 3 - Difficult Slope, Majority Stairs 4 - Extreme Slope, Steep Stairs	Typology	Qualitative Field Data
Estimated Average Elevation	Integer	Meters	Typology	Field Data + GIS Analysis
Estimated Max Elevation	Integer	Meters	Typology	Field Data + GIS Analysis
Estimated Min Elevation	Integer	Meters	Typology	Field Data + GIS Analysis
Estimated Elevation Range	Integer	Meters	Typology	Field Data + GIS Analysis
Estimated Slope	Integer	Meters	Typology	Field Data + GIS Analysis