From Structure to Soil: The Home that Grows, Dies, and Revives

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Acknowledgement

To my parents, for their encouragement, patience, and unwavering support,
To my friends for your continued support throughout this process,
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Thank you.

Abstract

In the face of escalating climate change and construction waste, this thesis explores how biodegradable biomaterials can form the basis of a regenerative architectural model — one where buildings are not static monuments, but living, temporal systems that return to the earth and contribute to new ecological growth. Modern architecture often prioritises durability and permanence, yet the environmental crisis calls for a radical rethinking of material lifecycles — one that acknowledges temporality as an inherent condition of all living systems. Here, time is not treated as a force to resist, but as an active agent in design, guiding how buildings emerge, transform, and eventually dissolve.

This research investigates how natural materials such as straw, wood, and others can be used in small-scale housing that supports both human habitation and ecological regeneration. These materials are selected for their ability to break down harmlessly at the end of life, feeding soil systems and creating conditions for plant and wildlife growth. Through a modified practice-led methodology, the thesis is structured in three phases: contextual and theoretical grounding; speculative design strategies informed by material and decomposition research; and applying findings to a speculative architectural design that embodies decomposition as a generative act.

The project frames architecture as a synanthropic and posthuman practice — where materials, humans, and nonhumans co-exist and co-evolve. By engaging with temporality, degradation, and ecological cohabitation, this research reimagines architecture as a process rather than a product — a temporal practice that values change, decay, and renewal. Designing with degradation in mind, this thesis proposes a new material narrative in architecture — one where buildings are not end points, but beginnings.

Content Page

I hereby declare that this submission
is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor used artificial intelligence tools or generative artificial intelligence tools (unless it is clearly stated, and referenced, along with the purpose of use), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Chapter One – Research Outline

Figure 1. Demolition Waste Collage

1.1 Problem Statement

Construction & Demolition Waste

Construction and demolition (C&D) waste is a critical contributor to global environmental issues, including climate change, resource depletion, and ecological degradation. Rapid urbanisation and population growth have intensified the demand for construction, making the industry responsible for a substantial proportion of global waste streams (Dodampegama, 2024). In New Zealand, the scale of this problem is evident in government data. According to the Ministry for the Environment, C&D waste accounts for an estimated 40–50% of all material sent to landfill, representing one of the largest waste streams in the country (Beca Limited, 2025).

Figure 2. A Pile of Debris on the Side of a Road

Despite ambitious targets set by government and councils, including Auckland Council's Low Carbon Auckland plan, which set ambitions of 30% total landfill waste reduction by 2020, 60% by 2030, and "zero waste" by 2040 (Auckland Council, 2014), little evidence suggests these goals are on track. Earlier commitments, such as New Zealand's 2002 goal of reducing C&D waste to landfill by 50% by 2008, were also unmet (Storey & Pedersen, 2014).

The persistence of missing these targets reveals not only a material challenge but also a cultural one, particularly a reliance on material permanence and wasteful building practices that resist systemic change. Conventional materials often remain in landfills long after buildings have been demolished, contributing nothing to ecological recovery and in many cases leaching harmful substances into the environment. This points to an urgent need for alternative material strategies and design approaches that rethink the end of a building's life not as waste, but as an opportunity for regeneration.

Urbanisation

Urbanisation not only generates a great amount of construction and demolition waste but also drives significant ecological loss. As cities expand, natural habitats and nature are cleared or partially destroyed, leaving little room for natural ecosystems to thrive. In New Zealand, urban growth has replaced large areas of wetlands, forests, and coastal margins with impervious surfaces such as roads and housing (Ministry for the environment, 2024; Landscape Architecture Aotearoa, 2024). This transformation severs ecological corridors, reduces biodiversity, and places pressure on species already vulnerable to climate change and human activity.

The loss of ecological land is not simply a matter of disappearing "green space"; it disrupts entire systems of water filtration, soil regeneration, pollination, and carbon storage (Ministry for the environment, 2024). Native flora and fauna are often displaced or forced to adapt to degraded edge conditions at the urban boundary. Over time, this creates landscapes that are dominated by impervious surfaces and monocultural plantings, offering little of the complexity that supports resilient ecosystems.

Within this context, architecture is implicated as both a driver of ecological loss and a potential solution of repair. Conventional development treats land as a neutral surface for construction, stripping away ecological value in favour of permanence and expansion. The challenge, then, is to rethink how buildings might not only minimise harm but actively participate in ecological regeneration, extending habitats, supporting biodiversity, and softening the threshold between built and natural environments.

1.2 Thesis Scope

This thesis was undertaken within the Material Cultures Lab, a research space exploring the intersections between materials, culture, and architectural design. While the lab embraces both material and cultural dimensions, this project focused primarily on materiality — investigating the temporality of biomaterials, their decomposition processes, and their potential to support ecological regeneration within architectural contexts.

Although frameworks such as the Te Aranga Principles informed the research at a surface level, deeper engagement with Māori perspectives was beyond the scope of this project and author's ability. Indigenous understandings of stewardship, temporality, and reciprocity could have meaningfully enriched the discussion, particularly alongside the posthuman feminist ideas explored later. As such, the research relies primarily on Western academic and material/practice-driven approaches and does not claim to represent or replace Indigenous knowledge. Future work should involve collaboration with mana whenua to integrate both Indigenous and Western ecological frameworks.

A key limitation was the balance between theory and experimentation. Due to the one-year timeframe of this thesis and the research questions complexity, the project was primarily research-based, relying heavily on literature, precedent analysis, and conceptual design methods rather than long-term material testing. While small-scale experiments/models were conducted, further empirical work, such as monitoring decomposition or soil interactions over time, would provide valuable data and strengthen future interdisciplinary research between architecture, ecology, and material science.

The scope of this thesis remains intentionally conceptual and speculative rather than conclusive. Biomaterials are complex systems shaped by climate, soil chemistry, and treatment. The project does not aim to offer fixed solutions but instead frames decomposition and temporality as design opportunities, rethinking how architecture might transition from permanence to regeneration. These limitations also open pathways for future directions for combining cultural, ecological, and scientific knowledge to advance the possibilities of regenerative design.

1.3 Aims & Objective

This thesis aims to explore how materials can participate in processes of transformation, decay, and regeneration, positioning them as active agents that shape relationships between humans, nonhumans, and the environment. The research ultimately questions:

Objectives:

- Analyse architectural case studies and theoretical frameworks that inform alternative approaches to temporality, decay, and ecological regeneration.
- Identify a range of sustainable and biodegradable biomaterials suitable for architectural applications in New Zealand.
- Analyse in depth the life cycles of these materials, focusing on how they break down at end-of-life and their potential ecological contributions towards nature and wildlife.
- To develop speculative design strategies, such as diagrams, timelines, and representational experiments, that explore how biomaterials might transition from construction to decomposition.
- Apply the findings in a speculative architectural design for a small home that tests how buildings can be designed to return to the earth and extend native ecologies into suburban contexts
- Reflect on how such practice-led design approaches can support broader goals of climate adaptation, carbon storage, and urban ecosystem revitalisation.

1.4 Research Question

How can architectural design embrace material temporality with biomaterials and decomposition to create a continuous cycle of life between built environments and natural environments?

Figure 3. Biomaterial Building Collage

1.5 Methodology

This thesis adopts a practice-led methodology, where design practice itself operates as the primary mode of inquiry. Rather than treating design outputs as illustrations of research, the act of designing, through drawing, diagramming, speculative architectural proposals and research, is used as the means of producing new knowledge.

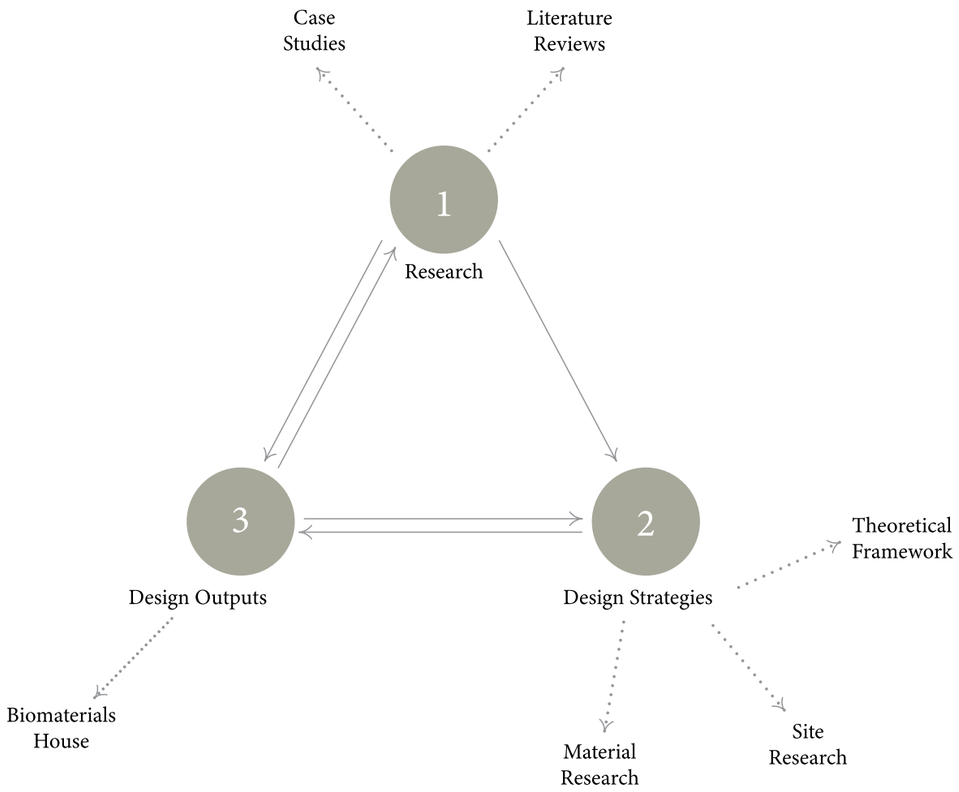

Figure 4. Methodology Diagram

Stage one, Research, is documented in chapter two. This stage establishes the conceptual and theoretical grounding for the project. It involves case study analysis, literature review, and theoretical ideation, with a focus on biomaterials, temporality, and ecological regeneration. The aim is to situate the project within wider discourses of sustainability and regeneration, while clarifying how architecture might extend beyond human-centred concerns to actively participate in ecological cycles.

Stage two, Design Strategies, is shown in chapters three and five. This stage combines extensive material research with speculative design methods — including diagrams, timelines, site mapping, and conceptual design — to speculatively test how biomaterials might behave over time. Instead of physical material prototyping, the focus is on conceptual experimentation. The goal is to understand not just the technical properties of these materials, but also their environmental implications and potential to return nutrients to the earth to support plant life. This phase of the investigation drew on a range of secondary scientific sources, including material performance, environmental impact studies, and life cycle analyses. These insights then required further analysis and synthesis to translate the scientific data into formats that are relevant to architectural thinking, ensuring alignment with the project's ecological and design focus.

Lastly, stage three, Design Output, is presented in chapter six. This final stage translates material knowledge into architectural form. This stage synthesises prior research and design explorations into a conceptual architectural proposal. The design imagines a temporary, biodegradable home that eventually decomposes and returns to the land, extending the forest edge into the community. This stage applies speculative drawings, timeline studies, site and detail drawings to envision buildings that do not end as waste but integrate into living systems.

Throughout the process, the role of the author is not only to analyse and design but also to reflect critically on practice as a mode of knowledge-making. Practice-led methodology utilised drawings and speculative designs as a way of thinking and discovering, not just as a way of visual presentation. This iterative methodology enables a more holistic investigation of biomaterials, seeing them not only as building materials but as active participants that shape relationships between people, wildlife, and the natural environment. It also reflects the regenerative design aspect of the thesis, where the material is not merely a passive element but an active agent in shaping sustainable, life-supporting architectural futures.

Chapter Two – Context

This chapter unpacks the context that shapes this research, moving beyond anthropocentric ideas of a human-dominated future toward more relational and interdependent modes of design thinking. It begins by addressing the stigmas surrounding biomaterials, examining the structural, economic, and cultural barriers that have limited their use despite their ecological potential. It then introduces posthumanism and posthuman feminism, which challenges human-centred design and instead emphasises care, reciprocity, and collaboration between humans, nature, and other living species. Building on this, the chapter explores synanthropic spaces as sites of coexistence, where biodegradable materials and temporal design support biodiversity and create habitats for both humans and nonhumans. Case studies are used to demonstrate how contemporary designers are engaging with biomaterials and degradable design strategies, showing how temporality, ecological collaboration, and material transformation can become key design drivers. The chapter concludes by synthesising these insights into a design framework that positions architecture as an active agent in ecological cycles, setting the stage for design investigations that follow.

2.1 Stigmas of Biomaterials

As environmental challenges grow, the urgency for sustainable materials in architecture increases. Biomaterials, sourced from renewable resources, offer viable alternatives to traditional materials that often end up in landfills. However, their widespread adoption has been slow due to persistent stigmas surrounding their performance, cost, and cultural perception.

Structural and Performance Stigmas

One of the most well-known stories which talks about the stigma of biomaterials is the fable 'The Three Little Pigs', which demonstrated the perceived weaknesses of structures made from natural materials like straw and sticks compared to those built from bricks (Drinkwater, 2021). As noted by Drinkwater (2021), "people often view natural construction materials as weak," a perception that detracts from the Green Building movement and sustainable architecture initiatives. This perception is particularly concerning, as many biomaterials, such as bamboo and rammed earth, possess exceptional structural qualities (Zhang et al., 2024). For instance, bamboo has a tensile strength comparable to steel and exhibits flexibility that allows it to withstand seismic forces, making it an ideal material for construction in earthquake-prone areas (Sil, 2024).

In addition to the structural concerns, biomaterials often face stigma within the construction industry due to rigid building codes and certification processes that are tailored to conventional materials. The lack of flexibility in existing standards makes it difficult and costly to validate the performance of biomaterials, especially when their behaviour differs from that of conventional construction materials. Current testing frameworks rarely consider how the material performance works together with the structural geometry, and design intent, further limiting their acceptance into the building industry (Balasubramanian, 2025).

There are misconceptions surrounding the performance of biomaterials in various climates and conditions. Critics argue that biomaterials may not provide the same durability as conventional materials, leading to challenges regarding maintenance and longevity (Mbiu, 2024). However, research indicates that materials like wheat straw, mycelium, and others have performed excellently in heat and sound insulation fields, contributing to energy efficient buildings and help maintain comfortable indoor environments. Furthermore, mycelium-based composites have shown promise in waterproofing applications, making them suitable for various environmental conditions (Chen et al., 2024).

Economic Stigmas

Beyond structural and performance issues, economic concerns significantly influence the stigma surrounding biomaterials. Many people believe that biomaterials are not economically viable alternatives to traditional materials (Tocco, 2024). This belief stems from the misconception that the production of biomaterials necessitates specialised equipment and processes, thereby leading to increased costs (Aimen, 2024). However, it is important to rectify this misconception, as not all biomaterials require specialised production techniques. Many can be made using standard equipment typically used in conventional construction, or they can be relatively easy to produce by hand.

For instance, materials like bamboo and straw are common biomaterials that can be harvested and processed with basic tools and techniques, making them accessible to a broader range of builders and craftsmen at an affordable cost (Sandak, 2019). Additionally, as demand grows, the cost barriers are likely to diminish. For instance, biomaterials have seen cost reductions as demands increase. With increasing investment, manufacturers have been able to ramp up their production capabilities while lowering their prices, making the range of biomaterials on offer more readily accessible and diverse (Hahn, 2021). This trend suggests that the economic arguments against biomaterials may soon become obsolete as the market matures and demand grows.

Cultural and Perceptual

The resistance faced by biomaterials is not solely a matter of perceived performance and cost; it is also deeply rooted in cultural attitudes and perceptions. The lack of familiarity with these materials leads to misconceptions about their quality and viability in construction (HLM News, 2021). This unfamiliarity can result in a reluctance among stakeholders, including architects, users, and builders, to adopt biomaterials in their projects. The limited lifespan of materials could also deter users from incorporating biomaterials into buildings. For example, while mycelium possesses excellent insulating properties, it is often overlooked, not only because it is relatively unconventional, but also due to its relatively short lifespan of approximately 20 years (Ross, 2014). Comparing that to the fibreglass, insulation which is most commonly used in New Zealand homes, lasts around 80-100 years (Horovitz, 2019). Aesthetic preferences also play a role in shaping material choices. Many biomaterials exhibit a unique and organic aesthetic, which may not appeal to everyone (Hales, 2025), such as seaweed or eggshells. While some clients and designers may take a liking to those tactile qualities, others may prefer the consistency and uniformity of conventional materials. Drinkwater (2021) emphasises the necessity of shifting these perceptions by demonstrating the benefits of using natural materials, such as the ability to significantly reduce climate change impacts. The absence of awareness about the benefits of biomaterials prevents acceptance of the use in design, further continuing a cycle of scepticism (Tocco, 2024)

Case Studies

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For details, refer to the Figure List in this thesis.

Figure 5. Typha-House Pavillion

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Figure 6. SargaBlock Bricks

Several projects demonstrate the potential of biomaterials. The Typhahouse Pavilion at EXPO 2015 in Milan used wetland plants to highlight their structural and insulating potential in an aesthetic way (Architizer, 2016). Similarly, SargaBlocks, made from sargassum seaweed, transforms an environmental problem into a valuable construction material, addressing both ecological and public health challenges (Barberton, 2023).

While stigmas remain barriers to mainstream adoption, these examples illustrate how biomaterials can achieve both performance and beauty. Greater awareness, education, and regulatory adaptation are crucial to normalising their use and fostering a more sustainable built environment.

2.2 Posthumanism & Posthuman Feminism

The Anthropocene marks a shift in how humanity understands its relationship with the Earth, revealing how human activity has become a dominant, often harmful geological force (Dalziel, 2022). Climate change, resource depletion, and ecological collapse call for new ways of thinking about design and construction. Posthumanism challenges anthropocentrism, decentring the human in design, while posthuman feminism extends this by addressing how gendered and marginalised experiences intersect with ecology (Braidotti, 2015). Together, they promote inclusivity and sustainability through materials and methods that respond to both human and environmental needs.

Posthumanism

Posthumanism critiques the belief that humans are the most important beings in the universe, rethinking relationships with animals, technology, and the environment (Ciobanu & Juhlin, 2022). In architecture, posthumanism prompts a re-evaluation of design processes and spatial experiences that include diverse perspectives and entities beyond human inhabitants (Dalziel, 2022).

Many designers fall into what Harrison (2017) calls the “Greenwashing Pitfall”, adding green walls or roofs as superficial gestures toward sustainability. Such design tactics reinforce anthropocentric ideologies by treating nature as an aesthetic layer rather than an essential part of the built environment. As Dogan (2024) argues, this calls for a genuine understanding of how nature works and recognises our connections with non-human beings. The increasing discussions around posthuman approaches are especially relevant in today's context, where the boundaries between human and non-human entities continue to blur. This shift demands a transformation in architectural practices, moving away from the idea that humans are the most important part and looking for new ways to coexist with other life forms.

Designers like Pascal Leboucq, who designed the ‘Growing Pavillion’ made of mycelium, demonstrates the potential of these materials to promote sustainable practices that align with the principles of posthumanism (Dutch Design Foundation, 2019). Similarly, the Degradation Movement Manifesto introduced at the Kochi Muziris Biennale used mycelium to represent life cycles and provoke discussion about decay and temporality in architecture (Areddia, 2017). These examples show that designing with degradation and local materials can foster ecological responsibility and challenge permanence as an architectural ideal.

The posthuman discourse is not simply about reducing the role of human agency but rather working in tandem to nonhuman entities as equals. As Harrison (2017) articulates, this reconfiguration invites architects to engage with various species in their designs, expanding the notion of who architects design for and acknowledging the diverse lives shaped by the built environment.

Post Human Feminism

Posthuman feminism builds on the ideas of posthumanism by addressing how gender, race, and colonial power structures shape architectural practices. While posthumanism seeks to decentralise humans, posthuman feminism extends this by emphasising inclusivity and relationality among humans and non-human entities (Braidotti, 2015). In this case, nature is seen not as a resource but as a design collaborator. Scholars like Braidotti (2015) and İbrişim (2024) emphasise the importance of multiplicity, interconnection, and care, encouraging architectural approaches that recognise the fluidity of identities and the deep entanglement of all living systems (Harrison, 2017).

This approach also aligns with Indigenous worldviews that emphasise interconnectedness. Concepts like Two-Eyed Seeing (Bartlett et al., 2012) demonstrate how combining Indigenous and Western knowledge systems can strengthen ethical, ecological, and culturally grounded design practices. Through this lens, biomaterials and community-led construction become ways to empower marginalised groups, support local stewardship, and embed cultural values within the built environment. Since the environment cannot advocate for itself, architects have a responsibility to act as its voice, designing in ways that protect, sustain, and collaborate with the more-than-human world.

Integration into Architecture

Integrating posthumanism and posthuman feminism into architectural practice encourages designers to move beyond anthropocentric design towards more relational, regenerative ways of thinking. These frameworks promote interdisciplinary collaboration across ecology, sociology, indigenous knowledge and material science to develop regenerative, inclusive spaces (İbrişim, 2024). They also emphasise participatory processes that empower marginalised communities and broaden who architecture is designed for (Braidotti, 2015).

By recognising the agency of materials and nonhuman life, architects can reimagine buildings as active participants in ecological cycles rather than static, permanent objects. This shift supports more inclusive, adaptive, and ecologically responsive forms of architecture fit for a posthuman future.

2.3 Synanthropic Spaces

The concept of synanthropic spaces refers to environments where human and non-human species coexist in human-altered areas and benefit from shared surroundings (Baumann, 2023). Contemporary design increasingly acknowledges the value of cohabitation, particularly in urban contexts where human development intersects with natural systems. These spaces raise important questions about how architecture, particularly those using biodegradable and sustainable materials, can support or enhance biodiversity and promote an equitable relationship with nature.

Historically, architecture has prioritised human needs over ecological cohabitation (Grobman et al., 2023). Synanthropic species such as birds, insects, and small mammals were often dismissed as pests or passive occupants. However, recent literature (Gunawan, 2015) reframes built environments as dynamic habitats that can support biodiversity. This perspective argues that architecture is not just a static form but an evolving ecological node that shelters both humans and non-humans.

Materiality plays a key role in creating synanthropic interactions. Biodegradable materials such as mycelium, hempcrete, straw, and cork create porous conditions that can host microbes, insects, and plants during and after habitation. As materials like timber or adobe decay, they become nutrient sources and shelters for new life. Philosophers such as Jane Bennett (2010) expands this idea, suggesting that materials are not inert but active participants in ecological processes. When designed with this in mind, material breakdown becomes a productive ecological act, enriching soil and supporting habitat creation.

Scholars such as Bruno Marques (2014) and Ângela Pinto (2014) similarly describe architecture as a temporal practice, one that adapts and evolves within ecological rhythms. From this perspective, biodegradable architecture becomes a transitional habitat, gradually transforming into fertile ground for vegetation and wildlife.

Integrating synanthropic thinking into design shifts architecture from a static model to a cyclical, regenerative one. Temporal buildings built from biomaterials can extend their usefulness beyond human occupation by supporting wildlife and nurturing biodiversity, ensuring that the end of a building's life marks the beginning of new ecological growth.

2.4 Ancient Ruins

The design of this project finds a compelling parallel in the decay of ancient ruins, from the Mayan cities of Mesoamerica to the temples of Angkor Wat, where once-inhabited spaces have been gradually reclaimed by the jungle. These sites are romanticised for their mysterious beauty, where vines and roots weave through stone and monumental structures transform into habitats for plants, birds, and insects. Their allure lies not just in the architecture, but in nature's reclamation, a merging of human and nonhuman worlds.

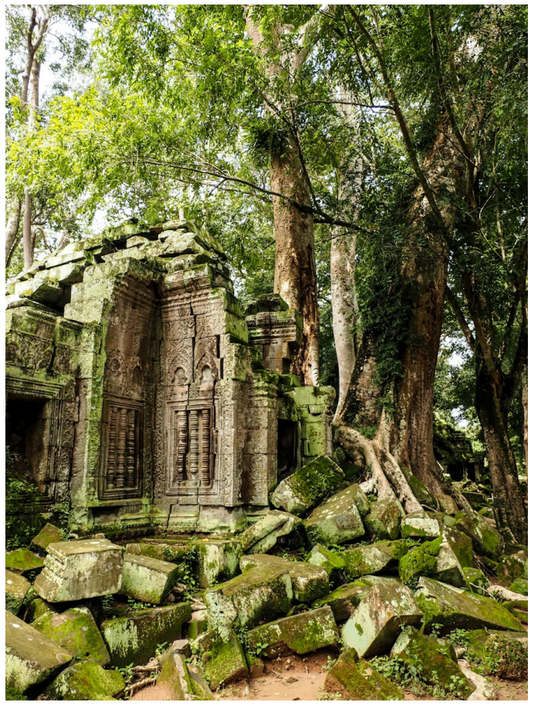

Figure 7. Angkor Wat Ruins

This fascination with overgrown ruins reveals a cultural tendency to aestheticise certain kinds of decay not as catastrophic, but poetic (Nevlyutov, 2019). Unlike the negative perception of a rotting house, the ruin's beauty lies in its transformation. This perspective resonates with the idea that buildings need not be eternal; its decline can instead form part of a larger ecological cycle (Ling, 2018). For this thesis, the ruin becomes a metaphor, suggesting that temporary biomaterial architecture can also embrace impermanence, decomposition, and transformation from the outset.

Just as ruins create atmospheres where cultural history meets ecological succession, this thesis explores new forms of beauty, meaning, and ecological participation. It reimagines architecture not as a permanent mark on the land, but as a living, temporal agent within wider ecosystems, where decay and regeneration coexist.

By linking biomaterial design with the imagery of ruins, the project envisions architecture as a symbiotic act; one that becomes more poetic as it is reclaimed by plants and wildlife (Nevlyutov, 2019). In this merging of ruin and renewal, architecture becomes porous, temporal, and deeply entangled with the living world.

2.5 Case Studies

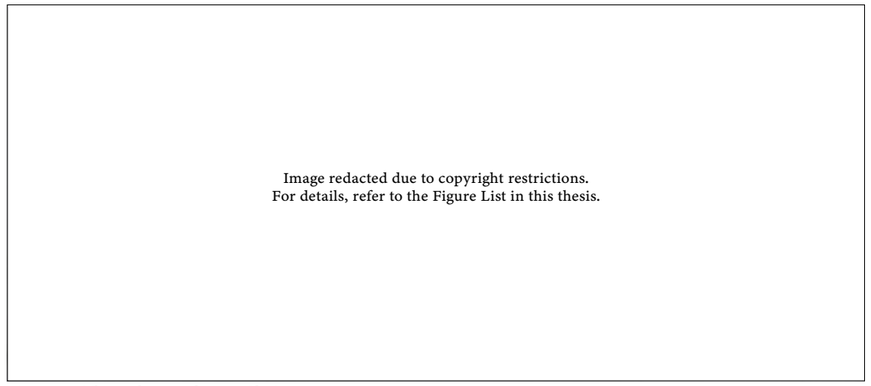

Figure 8. The Ephemeral Icon Chair

Case Study One: The Ephemeral Icon Chair by Officina Corpuscoli

The Ephemeral Icon chair, designed by Maurizio Montalti of Officina Corpuscoli, is a biodegradable seating object made from mycelium and other organic matter. Over time, the chair is designed to naturally degrade and reintegrate into the soil, demonstrating how furniture can be conceived not as waste, but as a nutrient source. Its form and lifecycle challenge the traditional values of durability and permanence in product design, instead celebrating entropy and transformation. As a speculative design, it invites users to reconsider their relationship with objects, not as lasting possessions but as participants in larger ecological cycles.

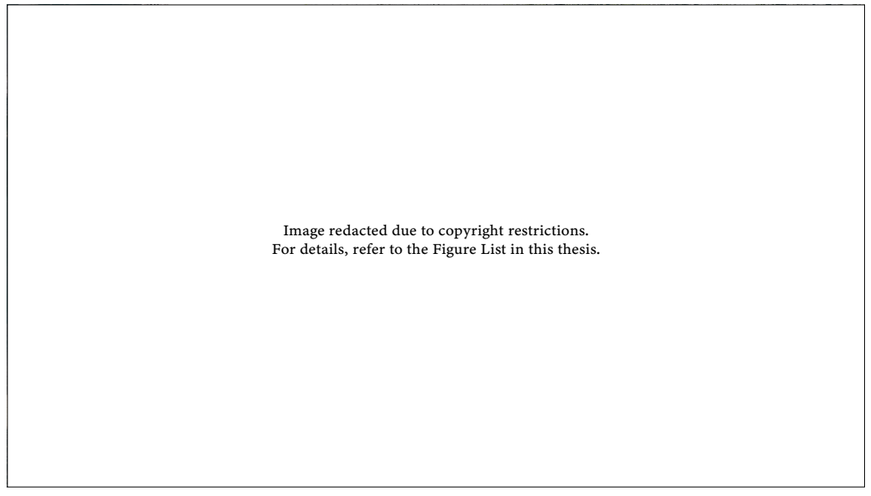

Figure 9. Shell Mycelium Installation

Case Study Two: Shell Mycelium Installation, Fort Kochi (The Degradation Movement)

The Shell Mycelium installation, exhibited at the Kochi-Muziris Biennale in India, was developed as part of the Degradation Movement—a collective advocating for biodegradable, performative architecture. The "Degradation Movement" embraces material impermanence as an act of resistance against industrial permanence – highlighting a concept that stresses the need for temporality. The installation utilized mycelium to form undulating, shell-like structures that decayed over the course of the exhibition. This temporal architecture

was intentionally designed to host environmental forces, microbial life, and eventual breakdown, serving as both a shelter and a living experiment. The project questions the notion of architectural endurance and invites new narratives around collaboration with fungi, climate, and time.

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For details, refer to the Figure List in this thesis.

Figure 10. Decomposition Farm

Case Study Three: Decomposition Farm: Stairway by Yong Ju Lee Architecture

The Decomposition Farm: Stairway by Yong Ju Lee Architecture is a provocative exploration of architecture as a living, degradable system designed to interact with both humans, plant life and insects. Constructed using carved polystyrene foam, the installation incorporates drilled holes to house mealworms, the larval stage of beetles, which are known for their ability to consume and digest polystyrene. Researchers have found that mealworms can metabolise this plastic material and excrete a substance safe enough to grow crops. In this installation, the mealworms play a crucial role: as they digest the polystyrene, their faeces feed moss and other vegetation intentionally attached to the foam structure. Over time, this creates a feedback loop in which waste becomes nourishment, transforming an artificial architectural object into a micro-ecosystem. Though functional for humans, the structure is primarily designed for wildlife and nature, acting as an active habitat, hosting insects, supporting moss growth, and eventually integrating seamlessly into the natural environment. This case study exemplifies how architecture can be co-designed with non-human species to foster regenerative material cycles and support biodiversit.

2.6 Theoretical Framework

To improve the ecological resilience of our built environments and strive for a more-than-human future, it is essential to adopt a holistic approach, one that looks beyond human-centred design and anthropocentric priorities. Modern design frameworks predominantly focus on human wellbeing and living, often neglecting the needs of nature and wildlife. However, critical frameworks such as posthumanism, posthuman feminism, and synanthropic ideation have long recognised the importance of coexistence, advocating for the inclusion and prioritisation of non-human beings alongside human ones.

This research seeks to move past the anthropogenic eros of a human dominated future and instead embrace more relational, interdependent modes of thinking. By recognising the role of materials as active agents in ecological systems, rather than inert resources, we can begin to formulate responses that align more closely with posthuman feminist and synanthropic values. The following framework outlines approaches for integrating these principles into architectural design, fostering environments that support all forms of life.

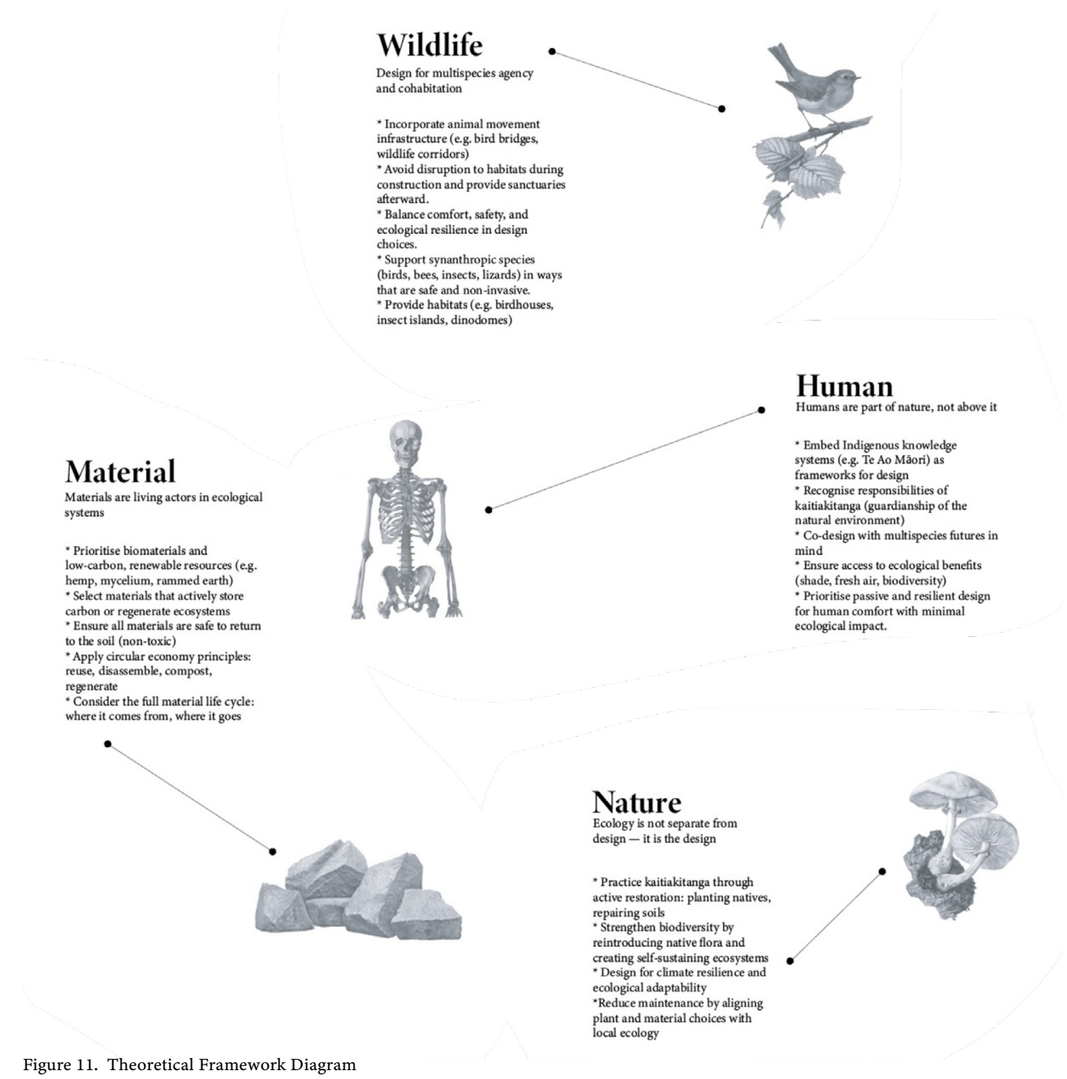


Figure 11. Theoretical Framework Diagram

Conclusion

This chapter has shown that the integration of biomaterials into architecture is shaped by both obstacles and opportunities. While stigmas persist, emerging research and case studies demonstrate that these materials have the potential to reshape architecture when reframed through ecological and posthuman perspectives. By recognising materials as active participants in cycles of growth and degradation, architecture can move beyond permanence and efficiency toward practices that embrace temporality and regeneration.

The theoretical frameworks of posthumanism, posthuman feminism, and synanthropic design provide critical tools for this shift, challenging anthropocentric ideation and advocating for inclusive, multispecies futures. These insights establish the conceptual context for this thesis, guiding the design research that follows and grounding its exploration of architecture as a temporal, ecological, and relational practice.

Chapter Three – Living Matter & Living Systems

Figure 12. Insects on Straw Roof

Buildings are made from matter that was once alive, and once built, they continue to participate in living systems. This chapter brings together two strands of research: the material behaviour of biomaterials, and the ecological relationships between buildings and their nonhuman inhabitants. By merging these investigations, the chapter examines not only what materials are but what they do once placed into an architectural and ecological context.

The first part of this chapter focuses on understanding biomaterials within a New Zealand climate — their chemical behaviour, lifespan, carbon storage, sourcing, and their potential contribution to soil health at the end of life. These materials are evaluated not just for their performance while a building stands, but for how they transform as they break down and re-enter ecological cycles.

The second part shifts toward the organisms (insects, birds, rodents, fungi, mosses) that interact with these materials. Their presence is typically framed as a problem in conventional architecture, where durability and cleanliness are prioritised. In this thesis, organisms are understood as active collaborators in decomposition, nutrient cycling, and ecological regeneration. Their behaviours reveal how materials decay, how buildings become porous, and how structures transition into living habitats over time.

Together, these two themes outline a shift from thinking about architecture as a static object towards understanding it as part of living systems where materials, organisms, and ecological processes overlap, interact, and co-produce new environments over time.

3.1 Chemical Impacts

When buildings reach the end of their life, their materials inevitably degrade –- whether through demolition, weathering, or natural decay. What those materials leave behind can either support or harm the ecosystems they re-enter. While sustainability discussions often focus on whether a material is recyclable or biodegradable, far less attention is given to the chemicals embedded within them. The chemicals determine whether decomposition enriches soil or contaminates it, making chemical awareness essential for regenerative architecture

Conventional Materials and Harmful Chemicals

Many conventional materials are chemically engineered for durability, fire resistance, or weatherproofing. These treatments extend lifespan but create significant ecological pollution, not just during their production process but their end-of-life stage as well. Treated timber contains preservatives like copper, chromium, and arsenic that leach into soil (Safa et al., 2020). Concrete presents similar challenges: when crushed, they release dust and fine particles that can pollute air and waterways, while their strong alkalinity makes them unsuitable for reintegration into soil systems (Hopkins et al, 2024). Synthetic insulation, adhesives, and paints often emit VOCs and petrochemical residues that disrupt microbial processes (Building Performance, 2023). In many cases, the chemical afterlife of these materials is more damaging than their physical decay.

Biomaterials and Chemical Concerns

Although biomaterials are renewable and biodegradable they are not inherently soil-safe. Even natural materials can be compromised by the chemicals added to improve their performance. Untreated timber, for example, decomposes into carbon-rich organic matter, but once painted, stained, or chemically preserved, it introduces synthetic compounds into the soil (Safa et al., 2020). Likewise, natural fibres such as hemp, flax, or wool may be processed with bleaches, dyes, or fire retardants that linger in the soil long after the fibres themselves have broken down.

Bioplastics like polylactic acid (PLA), derived from renewable crops, are frequently marketed as biodegradable, yet in practice they often require industrial composting conditions to degrade safely (Ahsan et al., 2023). In natural soils they decompose far more slowly, and when blended with additives or stabilisers, can leave behind microplastics or other persistent residues (Liu et al., 2023). Many biomaterials are therefore promoted as recyclable or renewable rather than truly compostable, and these examples demonstrate that “biodegradable” does not necessarily equate to “soil-safe.”

Beneficial Chemical Contributions of Biomaterials

In their pure, untreated forms, many biomaterials positively support soil health. Straw, rice husks, and other plant-based residues release organic carbon and improve soil structure, helping retain moisture and support root growth (Ninkuu, 2025; Gouertoumbo, 2022). Wool slowly releases nitrogen as a natural fertiliser (Camilli et al., 2025), and lime-based materials like hempcrete can balance acidic soils (Manderson, 2024). Even slow-decaying cork improves aeration over time (Rompato, 2024).

Material breakdown is both physical and chemical. For architecture to function within regenerative ecological cycles, materials must be chosen not only for their ability to biodegrade but for the quality of what they return to the soil. Pure, minimally treated biomaterials offer the greatest potential to enrich ecosystems rather than contaminate them.

3.2 Materials in New Zealand Climate

New Zealand’s temperate maritime climate is characterised by mild winters, cool summers, and high levels of rainfall, with conditions strongly influenced by the surrounding ocean. Auckland, the site of this project, experiences a subtropical climate, with warm, humid summers and mild, wet winters (Chappell, 2014). These conditions make material selection critical, as moisture, humidity, and seasonal variability can significantly impact durability, performance, and maintenance requirements

Timber

Timber has long been central to New Zealand’s construction industry, particularly the introduced species Radiata Pine, which is grown commercially in New Zealand (Red Stag, n.d). Timber exposed to sun and rain can split, check, or discolour, requiring protective coatings or regular upkeep (Building Performance, 2023). Despite these challenges, its abundance and versatility make it one of the most suitable materials for the Auckland context.

Straw

Straw construction offers excellent insulation and very low embodied carbon, making it a strong ecological choice. However, in Auckland's humid climate, its success relies on careful design to protect against moisture. Features like wide eaves, elevated foundations, breathable plasters, and meticulous detailing are crucial to prevent water infiltration and ensure durability (Black Pine Architects, 2021). While straw works best in drier climates, successful examples from similar wet regions, such as England, show that it can thrive in Auckland with proper management. When well-protected, straw construction can offer both thermal comfort and ecological benefits.

Cork

Cork performs well across a range of climates due to its thermal resistance, breathability, and ability to resist rot (Fernandes, 2025). However, it is not waterproof, and in humid conditions, installation and ventilation become critical to avoid condensation. While cork is not locally grown in New Zealand and is typically harvested and imported from Portugal and Spain, its performance characteristics make it a viable option. With correct application, cork cladding could be highly suitable in New Zealand.

Bamboo

Bamboo thrives in warm, humid climates but performs poorly under long-term wet exposure, where cracking and splitting are common (Kramer, 2016). Furthermore, in Auckland, some species are classified as invasive, excluding them from responsible architectural use (Urban Arborist, 2024). While structurally strong, bamboo is not recommended in this climate given the risks of degradation and ecological impact.

Mycelium

Mycelium composites offer low-carbon insulation benefits but are highly vulnerable to humidity. In Auckland’s damp, temperate conditions, they are prone to mould and fungal growth, leading to rapid deterioration (Protopapadaki & Kalika, 2018). While promising in arid conditions, mycelium insulation and bricks would deteriorate rapidly in Auckland’s climate and are not recommended for long-term application.

Hempcrete

Hempcrete is highly compatible with Auckland’s conditions due to its hygroscopic qualities, allowing it to regulate indoor humidity by absorbing and releasing moisture (Hemp Building Association NZ, n.d). Its thermal mass and insulation capacity make it effective in both hot and cold weather, and its resistance to humidity positions it as one of the most appropriate materials for Auckland's climate.

Rammed Earth

Rammed earth walls are durable and can perform well in humid climates, though they require additional protection from driving rain. While durable, its porosity means that Auckland's high rainfall would necessitate additional insulation and protection (Downton, 2013). It may not be the most efficient choice compared to more moisture-resilient materials.

Limestone

Limestone is highly durable and weather resistant, the density of limestone also allows it to be resistant to harsh weather conditions like heavy moisture and fluctuating temperatures. However, limestone is vulnerable to gradual weathering, particularly from acidic rain, which can erode its surface over time (U.S. General Services Administration, n.d). Despite this, its track record suggests it can perform well in Auckland with proper care and maintenance.

Adobe

Adobe is traditionally suited to hot, arid climates and is less durable in wet, humid conditions. In Auckland's conditions, adobe would require frequent maintenance to prevent cracking and erosion and is likely to deteriorate faster than in drier regions (Wright, 2025). Although feasible, its performance would be limited, making it less ideal for this climate.

Rice Husk

Rice husk composites are naturally resistant to rot, pests, and water due to their silica content (Modern Mill, 2024; Rodell Design, n.d). This makes them ideal for cladding systems, composite decking, and brickwork, where durability and moisture resistance are essential. Products like Resysta show how rice husk can be combined with polymer binders to create recyclable exterior cladding that mimics timber while being fully recyclable. These features make rice husk particularly suitable for Auckland's humid climate as a low-maintenance material.

Sheep Wool

Sheep wool insulation is an ideal fit for New Zealand's climate. Its hygroscopic capacity allows it to absorb up to one-third of its weight in moisture without losing thermal efficiency (Ecomerchant, n.d). With established local supply chains, such as Terra Lana, wool is both sustainable through high-performance, certification and minimal environmental transport costs, but also contextually appropriate.

3.3 Material Lifespan

The durability of building materials is a critical factor in architectural design, yet within the context of biodegradable and regenerative construction, lifespan must be understood differently. Unlike conventional materials that are designed to resist decay for as long as possible, biodegradable materials must be understood through their temporality: how long they perform their function, and how they eventually return to the earth. Understanding the lifespans of biomaterials highlights both their potential and their limitations in regenerative design.

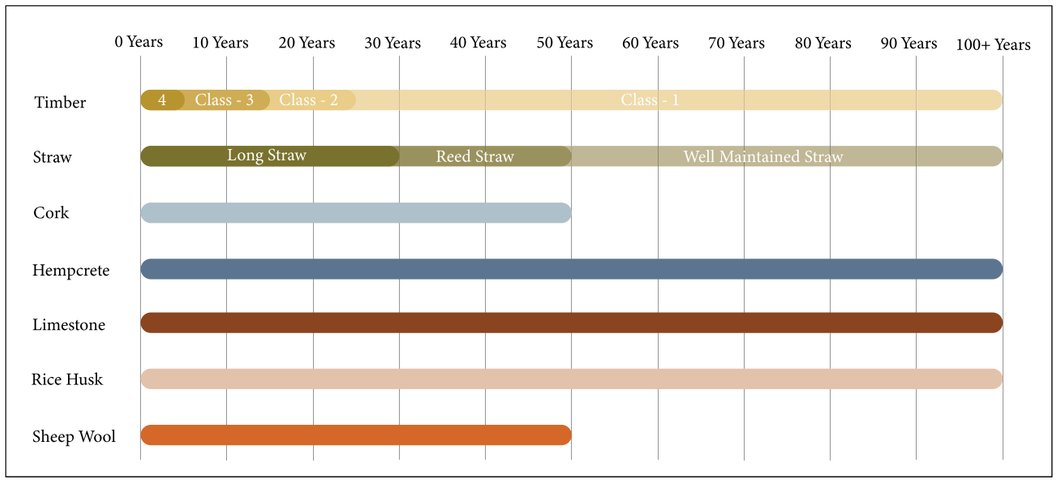


Figure 13. Material Lifespan Bar Chart

Timber

Timber is one of the most established construction materials in New Zealand, valued for its availability and durability. Its lifespan depends on treatment, maintenance, and exposure to weather. The natural durability of timber also varies between species and its durability classes; for instance, Totara and Eucalyptus cladocalyx rank high in durability (Class 1–2), while Macrocarpa and Silver wattle fall lower (Classes 3–4) and are more susceptible to moisture and pests (Page & Singh, 2014). Untreated timber can degrade in months to a decade (Satchell, 2014). However, some untreated wooden facades in Sweden have lasted hundreds of years without significant degradation (Bahrami, 2023). Importantly, only untreated timber fully biodegrades since it does not contain harmful chemicals unlike treated wood.

Straw

Straw can also be long-lasting if kept dry. Well-maintained straw constructions can exceed 100 years, while poorly maintained thatched roofs last 15–30 years for long straw and 40–50 years for water reed (Becker et al., 2020). Early examples from the late 1800s in the Great Plains of America illustrate straw's durability when protected from moisture (Arkin Tilt Architects, 2014). With proper design to prevent water ingress, straw bale walls can offer century-long service while remaining fully biodegradable (BRANZ, 2015).

Cork

Cork typically lasts 30–50 years without significant decay as cladding or insulation, provided it is installed and ventilated properly (Market Timbers, 2025; Silvestre et al., 2016). Though less durable than timber or hempcrete, cork is resilient to decay and pests, allowing for reliable performance during its lifespan, after which it can be recycled or decomposed. While it is resistant to decay, it means it will take longer to break down.

Hempcrete

Hempcrete is one of the most durable bio-based materials, with lifespans exceeding 100 years when constructed properly (Ansari et al., 2025; Arehart et al., 2020). Resistant to pests, fire, and mould, it retains its structural and insulating properties over time (Ansari et al., 2025). As a composite, its lime binder further stabilises performance, making hempcrete one of the most robust biodegradable materials.

Limestone

Limestone has long symbolised permanence in construction, with many New Zealand examples, such as Auckland's townhall that was constructed in 1911 still standing after more than 100 years (National Group, 2019). Properly maintained, limestone can endure centuries, although it is vulnerable to acid rain. Tiles and cut stone may last 50–100 years but can last longer (Wilhelm et al., 2021). Unlike other materials, limestone does not decompose into nutrients but erodes gradually, limiting its ecological role while still benefiting soil by neutralising acidity.

Rice Husk

Rice husk is mainly used as composites for cladding and concrete systems. Its silica content makes it resistant to rot, pests, and water. In structural uses, rice husk materials can last 70–100 years (Henry & Lynam, 2020), making them suitable for humid climates like Auckland.

Sheep Wool

Sheep wool insulation demonstrates both performance and longevity. Terra Lana (2024), a New Zealand supplier, guarantees a minimum lifespan of 50 years, though some studies suggest it can remain effective for 60 years or more. Its hygroscopic properties help maintain performance over time. Commercial wool insulation typically contains a small proportion of polyester fibres to help it maintain structure and prevent slumping, which helps its longevity ended (Building Performance, 2023); however, pure sheep wool, without synthetic binders, is more sustainable and can fully biodegrade, even serving as mulch once its insulating life has but has a shorter lifespan. As a biodegradable material sourced locally, it offers durability comparable to conventional insulations while remaining regenerative at the end of life.

This material timeline showcases a range of durability: from shorter-lived elements like thatched straw roofs made with long straw (15–30 years) to long-lived materials such as hempcrete and limestone (over 100 years). The selected biomaterials show how, with proper maintenance, biomaterials can have extended lifespans. This range highlights strategic applications in architecture: intentionally short-lived components can promote ecological succession, while others provide longer-term stability. Together, these varied lifespans emphasise the theme of temporality, designing with cycles of durability, decomposition, and regeneration in mind

3.4 Carbon Storage of Materials

New Zealand's temperate maritime climate is characterised by mild winters, cool summers, and high levels of rainfall, with conditions strongly influenced by the surrounding ocean. Auckland, the site of this project, experiences a subtropical climate, with warm, humid summers and mild, wet winters (Chappell, 2014). These conditions make material selection critical, as moisture, humidity, and seasonal variability can significantly impact durability, performance, and maintenance requirements

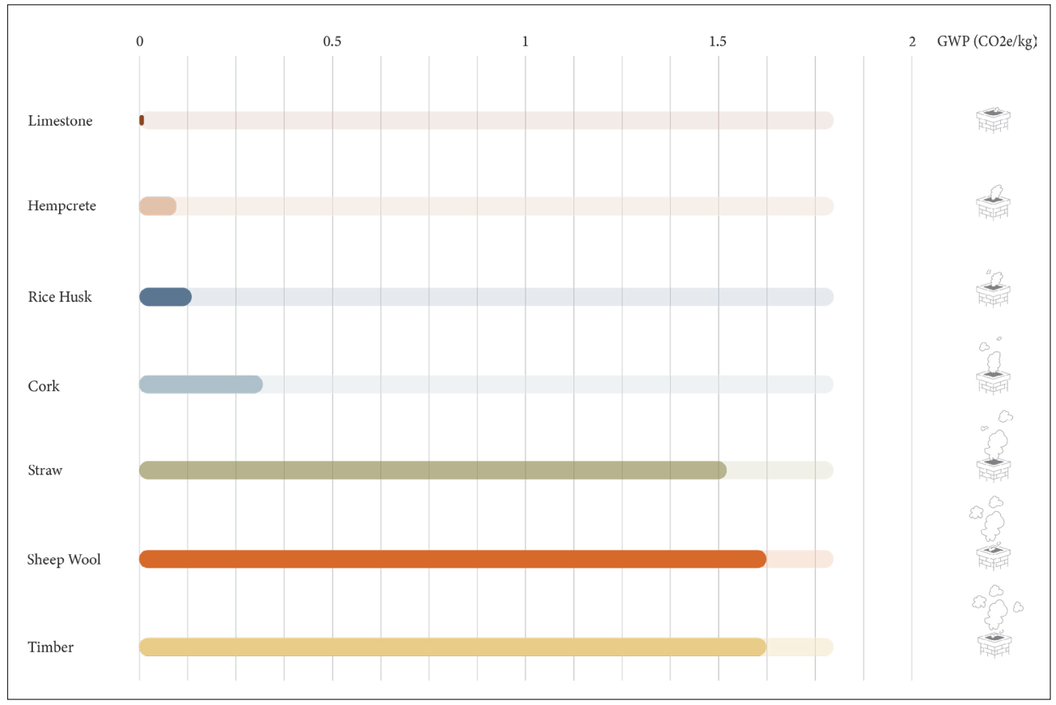


Figure 14. Material CO2e/kg Bar Chart

Timber

Timber plays a significant role as a carbon sink, with approximately 450–500 grams of carbon stored per kilogram of wood. This equates to around 1.65–1.80 kg of CO_2 sequestered per kilogram of timber (Red Stag, n.d). However, its eventual decomposition or combustion releases this carbon, contributing to emissions unless carefully managed through reuse or regenerative design strategies.

Straw

Like timber, straw captures atmospheric carbon during growth, storing about 1.69 kg of CO_2 per kilogram of dry straw, making it one of the most effective agricultural byproducts for carbon sequestration (Leppäkoski et al., 2022).

Cork

Cork has a lower storage capacity compared to timber or straw, at 0.358 CO_2e/kg (Corticeira Amorim, 2020). Nonetheless, cork is harvested without felling trees, making it a renewable material that can be replenished over time, while still contributing to carbon storage.

Hempcrete

Hempcrete stands out for its carbon-negative potential. Studies show that 1m³ of hempcrete can sequester around 470 kg of CO_2, equivalent to a footprint of –0.15 CO_2e/kg. This results from both the rapid growth cycle of hemp, which absorbs carbon, and the carbonation process of the lime binder, which continues to absorb CO_2 over time (Muhit et al., 2024).

Limestone

Limestone contributes minimally to sequestration, with 0.02 CO_2e/kg. Its role is less about storing carbon and more about durability, as it erodes rather than biodegrades. In the context of regenerative design, limestone is less effective than plant-based biomaterials.

Rice Husk

Rice husk offers a moderate storage potential at 0.105 CO_2e/kg (Ahiduzzaman, 2007). Due to its high silica content, it is resistant to rot and pests, allowing it to retain stored carbon effectively in humid climates like Auckland.

Sheep Wool

Wool insulation can store approximately 1.8 kg of CO_2 per kilogram of clean fibre, comparable to timber (The Woolmark Company, 2019). Its hygroscopic qualities also improve indoor comfort, but like other organic materials, its stored carbon may be released if not composted or reused sustainably at the end of its lifecycle.

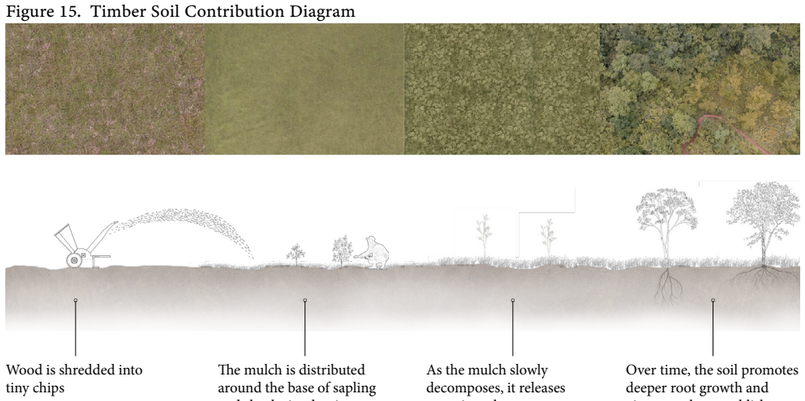
3.5 Material Contributions in Soil

Figures 15 through 21 illustrates how biomaterials suitable for New Zealand's climate, when manually broken down into smaller particles such as mulch or compost, can contribute to the growth of vegetation. This early-stage research examined the immediate ecological potential of these materials once returned to the soil. By comparing how materials such as timber, straw, and sheep wool behave when reintroduced into soil systems, the diagram highlights their ability to enhance soil fertility, structure, and moisture retention. Including this analysis broadens the understanding of each material's regenerative capacity, positioning them not only as building components but as active agents in sustaining new vegetation and completing the ecological cycle.

Timber

Decomposes into carbon-rich mulch, improving soil texture and water retention

Figure 15. Timber Soil Contribution Diagram



Wood is shredded into tiny chips

The mulch is distributed around the base of sapling and shrubs in planting areas

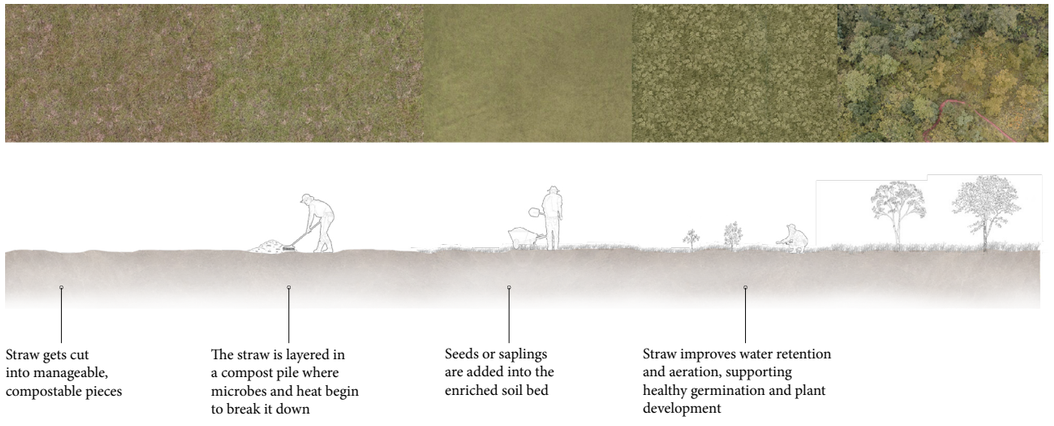
As the mulch slowly decomposes, it releases organic carbon, suppresses weeds, and retains water in the soil

Over time, the soil promotes deeper root growth and vigorous plant establishment

Straw

Adds carbon, increases aeration, and supports microbial activity

Figure 16. Straw Soil Contribution Diagram



Straw gets cut into manageable, compostable pieces

The straw is layered in a compost pile where microbes and heat begin to break it down

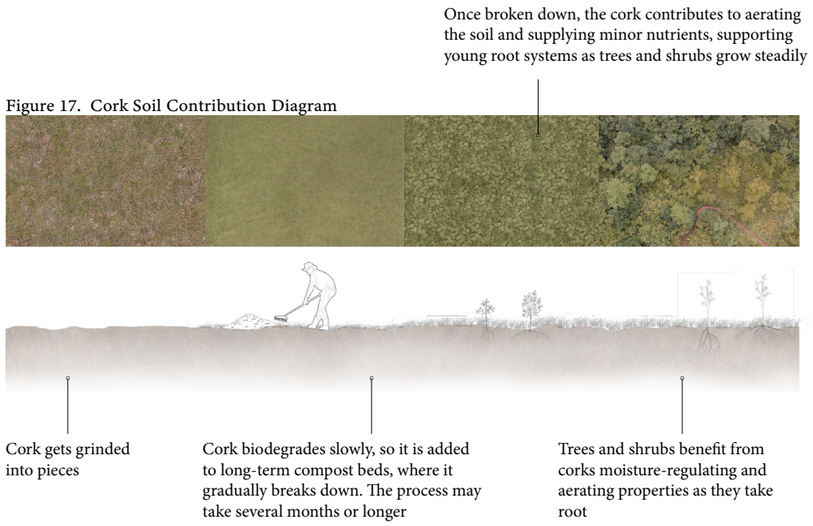
Seeds or saplings are added into the enriched soil bed

Straw improves water retention and aeration, supporting healthy germination and plant development

Cork

Slowly decomposes, providing long-term aeration and organic matter

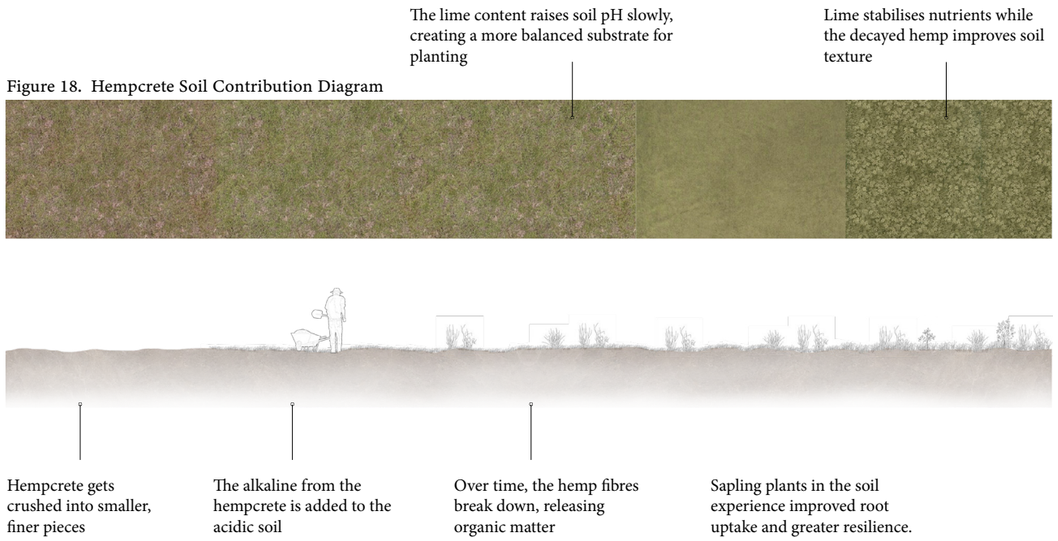
Figure 17. Cork Soil Contribution Diagram



Hempcrete

Limestone neutralises acidic soil; hemp fibres add organic content over time

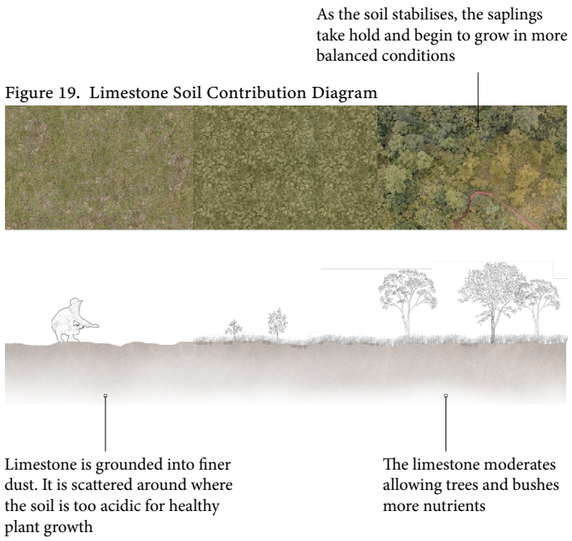
Figure 18. Hempcrete Soil Contribution Diagram



Limestone

Raises pH in acidic soil, and adds calcium

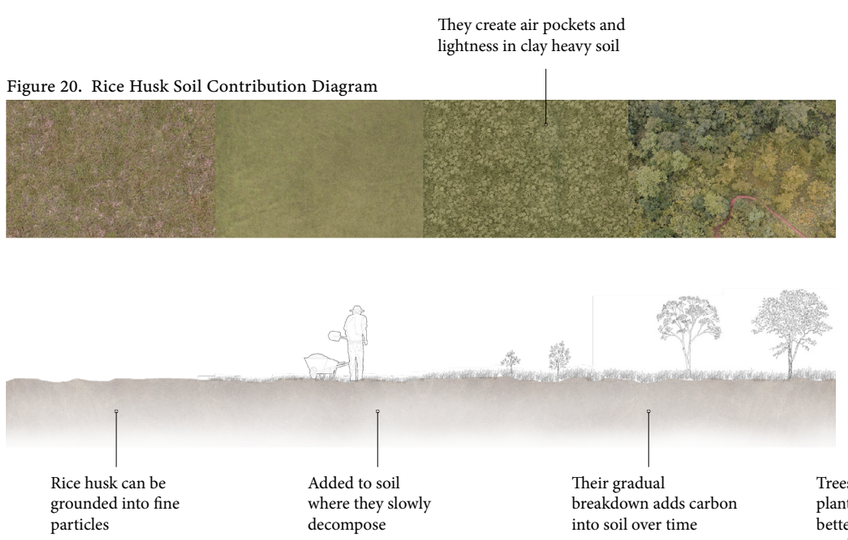
Figure 19. Limestone Soil Contribution Diagram



Rice Husk

Improves aeration and water retention, high is silica

Figure 20. Rice Husk Soil Contribution Diagram



Sheep Wool

Adds nitrogen and keratin, acts as a slow-release fertiliser

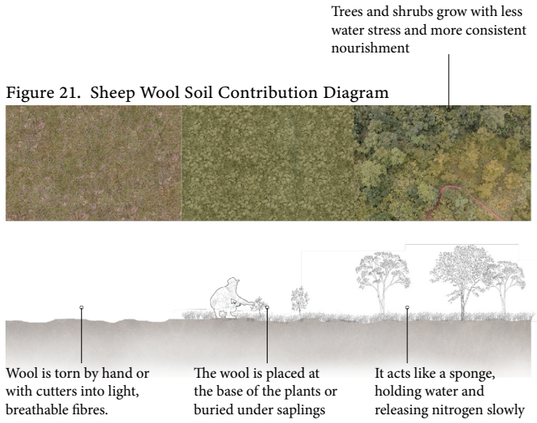


Figure 21. Sheep Wool Soil Contribution Diagram

3.6 Sourcing Materials in New Zealand

Figure 22 illustrates the some of the locations in New Zealand where materials can be commercially sourced, as well as options for sourcing some materials from abroad that aren't available locally.

Timber
New Zealand's plantation forests are located in the regions of Northland, Waikato, Bay of Plenty, Gisborne district, Hawkes' Bay, Tasman / Nelson, Otago / Southland, with Kaingaroa Forest one of the largest suppliers.

Straw
Most of New Zealand's straw comes from the South Island, particularly Canterbury, with additional supply from Southland and Otago. Smaller quantities are also grown in Hawke's Bay, Manawatū, and Gisborne.

Cork
Cork used in New Zealand is not locally produced but imported, primarily from Portugal and Spain, where it is harvested.

Limestone
The Parkside Quarry in Ōamaru, North Otago, is New Zealand's sole source of building-grade limestone, supplying the stone used in heritage and contemporary projects nationwide.

Hempcrete
Hemp crops for seeds and fibres are cultivated in several regions, including Canterbury, Bay of Plenty, Manawatū-Whanganui, Nelson, Hawke's Bay, and Wairarapa.

Rice Husk
Since New Zealand does not grow rice at scale, rice husk for potential building applications is imported mainly from Australia, India, Thailand, and Vietnam.

Sheep Wool
Terra Lana sources its insulation wool from Banks Peninsula farms near Christchurch, supporting family-owned sheep farmers in the South Island while supplying sustainable building products.

Figure 22. Material Sourcing Map

3.7 From Living Matter to Living Systems

The boundary between material and organism is not fixed but fluid (Bennett, 2010). Many of the biomaterials studied in this project originate from once-living systems, from the cellular structures of plants to the fossilised remains of marine organisms. Materials such as timber, straw, hemp, and wool carry the biological signatures of where they come from, each retaining traces of the life processes that formed them: growth, photosynthesis, and carbon storage. Even materials that appear inert, such as limestone, emerge from biological origins which composed largely of the compressed shells and bones of microscopic marine creatures. Once part of living ecosystems, these materials continue to act as living agents in architectural and ecological contexts, capable of supporting and sustaining new forms of life as they return to the earth, as Stickney (2023) put it, "All buildings must die, but their material by-products do not need to be wasted".

When these materials are reintroduced into natural cycles through weathering or decomposition, they do not simply disappear; they transform. Mycelium, for instance, is a living organism, it's a network of fungal threads that actively grow, digest, and regenerate (Elsacker et al.,2020). When used in architecture, it literally bridges the divide between structure and organism. Similarly, untreated timber, straw, and wool become habitats for insects, moss, and fungi as they degrade, continuing to host biological activity long after their human use has ended. Even non-organic materials such as limestone participate in these cycles, slowly eroding to enrich soil pH and provide mineral nutrients that sustain plant growth (Olego et al., 2021).

This interconnection between material and organism forms a circular ecology, a continuous exchange between what was once alive, what is currently alive, and what will become life again. In this sense, materials that make up a building and the organisms that occupy are not separate subjects but part of a shared system of transformation. Materials act as both the foundation and the habitat for nonhuman life, while inhabitants accelerate decomposition and regeneration. Together, they blur the distinction between architecture and ecology, showing how buildings can become living systems in themselves as dynamic participants in the cycles of decay, growth, and renewal that define the natural world.

During the decomposition process, these two living systems — materials and organisms — interact symbiotically. As materials begin to decay, they release nutrients, moisture, and shelter that attract organisms such as insects, mosses, fungi, and small animals. In turn, these inhabitants accelerate the breakdown of materials through biological activity: burrowing, consuming, nesting, and spreading spores. This mutual relationship transforms architecture into an evolving ecosystem where decay fuels new growth. In the final stages, the once-constructed environment becomes indistinguishable from the landscape, its biological and material processes merging to support the regeneration of native vegetation and the return of biodiversity

3.8 Attracting Organisms

Organisms are drawn to structures and landscapes through combinations of food, shelter, water, and environmental cues. As biodegradable buildings begin to break down, they create microhabitats offering warmth, refuge, and nutrients. While conventional architecture treats such organisms as pests, in this project they are understood as participants in ecological succession and degradation. Understanding these attractants helps to anticipate how organisms might participate in both the degradation and re-inhabitation of buildings.

Birds are attracted to accessible food sources such as seeds, nectar, insects, and fruit. Mulch, leaf litter, and planting provide foraging grounds (Auckland Council, 2019). Water features further increase attraction. As materials decay, cavities and crevices can become nesting niches (Mainwaring, 2015). Their foraging and nesting help disperse seeds and organic matter, strengthening succession cycles.

Insects are highly responsive to food, light, and moisture. Ants, flies, and cockroaches seek organic scraps, while moths and beetles are drawn to artificial lighting (Buiano, 2024). Moist humid microclimates attract mosquitoes (Lauren, 2024), while plants support pollinators and herbivores. In biodegradable structures, species such as termites and cockroaches aid in breaking down fibres like timber, straw, and wool, accelerating decomposition. Night lighting, gardens, and water create productive foraging grounds, while rafters and small crevices mimic the hollows they use in the wild (Department of Conservation, n.d).

Bats are indirectly attracted through insect abundance. Night lighting, gardens, and water create productive foraging ground. Structurally, they prefer small crevices, rafters, attics, and chimneys, where conditions are dark, warm, and protected. These spaces mimic the hollows of old trees, which bats also use as breeding and resting grounds (Department of Conservation, n.d).

Rats, however, require a different framing. While they are drawn to warmth, food, and sheltered cavities, the most common rat species in New Zealand are introduced and pose serious threats to native birds, insects, and lizards (Topbest Pest Services, 2024; Department of Conservation, n.d). While their presence in decomposing structures may contribute to physical breakdown, they also pose ecological risks. Their role is therefore understood not as inherently "negative," but as a reminder that not all organisms drawn to biodegradable architecture are beneficial for local ecologies, and that design must consider both invited and uninvited species.

Mosses and fungi are often the earliest colonisers of damp, shaded surfaces. Moss thrives on porous materials, creating micro-habitats for insects (Wassilieff, 2009), while fungi flourish on decaying organic matter, recycling nutrients and preparing surfaces for plant germination (Oppliger & Duquenne, 2016). Their networks not only recycle nutrients into soil but also create fertile micro-environments for seeds to germinate. These organisms act as mediators between material breakdown and new plant life, transforming buildings into living substrates, accelerating decomposition while laying the groundwork for new plant life to take hold.

The organisms drawn to biodegradable structures rarely exist in isolation. Insects attract birds and bats; mosses and fungi create shelter for invertebrates; decomposing materials provide nutrients for soil. Over time, small entries, such as spores on damp timber, insects in cavities, expand into a web of interdependent life. In this project, these presences are understood not as pests but as part of a transformative process. Degradation becomes a pathway toward ecological succession, where diverse organisms collectively reshape buildings into evolving habitats.

3.9 Affect on Buildings Lifespan

The lifespan of a building is shaped not only by its materials and construction but also by the organisms that interact with it. Each organism influences how structures deteriorate, sometimes accelerating decay, sometimes transforming it into ecological succession. While conventional architecture sees these organisms as threats, in biodegradable design their impacts can be reframed as part of a building's intended lifecycle.

Birds affect buildings physically and chemically. Nesting in roof cavities or wall gaps can dislodge tiles and strain joints, while claws and beaks slowly abrade soft materials like timber or plaster. Their droppings are acidic and corrosive, wearing away stone and metal and contributing to hidden structural decline (Elizalde, 2022).

Insects act both as degraders and decomposers. Termites and carpenter ants hollow timber and weaken structural elements (Kalleshwaraswamy et al., 2022), while moths and beetles target natural fibres in insulation (Medha et al., 2021). In biodegradable buildings, insects also fragment straw, timber, and plant fibres, assisting fungi and microbes in further decomposition (Zou et al., 2023). They accelerate material decay even as they assist ecological processes.

Bats do not physically damage structures, but their guano is corrosive, containing salts and uric acid that degrade timber, stone, and metals (Voigt, 2015). Moist, accumulated droppings encourage fungal growth and wood decay, while ammonia-rich residues stain and erode interior surfaces (Wallace, 2022).

Rodents are among the most aggressive contributors to degradation. Their gnawing compromises timber, insulation, wiring, and pipes, leading to structural weakening, electrical hazards, and water damage (Witmer, 2022). Burrowing through soil, foundations, or drainage systems, they can weaken the ground beneath structures, compromising stability (Red Tail Pest Control, 2024). In biodegradable buildings, this activity rapidly increases porosity and accelerates collapse.

Mosses and fungi degrade structures more quietly. Moss traps moisture against materials, promoting rot and softening surfaces (Wassilieff, 2009). Fungi, through their mycelial networks, break down cellulose and lignin in timber and straw (Srivastava et al., 2013). Wood-decay fungi can hollow beams until failure, while moulds spread across cladding and insulation. Together, moss and fungi act as early colonisers that both signal and accelerate decomposition, shortening a building's lifespan while enabling ecological succession.

Together, these organisms form an interlinked system: rodents create openings for insects; insects fragment materials for fungi; moss maintains dampness that supports microbial growth; bird and bat droppings alter the chemistry of surfaces. What conventional architecture sees as deterioration becomes, in this project, part of a designed temporal process where organisms are understood not as threats but as collaborators in decomposition, succession, and ecological regeneration.

3.10 Visitors, Not Tenants

While biodegradable structures invite wildlife to interact with architecture, most organisms do not seek to permanently "live" in human-made spaces. Their presence is usually opportunistic, driven by food, warmth, moisture, or shelter rather than a true preference for built environments. In this sense, they are visitors moving through, not tenants settling in.

Birds may occasionally use birdhouses or cavities in buildings, but only as substitutes when natural habitats are lacking. Small species like Grey Warblers or Silvereyes may adopt open boxes, while larger birds such as Kererū and Fantails continue to prefer trees, branches, and forest canopies (Department of Conservation, n.d.; Kohab, 2021). Even species like Morepork, which sometimes occupy artificial hollows, still favour old tree cavities when available. These preferences remind us that even when architecture offers shelter, birds often prefer natural habitats unless necessity or opportunity compels them otherwise.

Bats and insects behave similarly. Bats roost in attics or rafters only when hollow trees are scarce (O'Donnell, 2024). Their true preference remains old-growth forests, where cavities provide insulation, protection, and proximity to insect populations. Insects enter buildings in search of food, warmth, or light, yet most cannot thrive indoors and eventually return to soil, vegetation, or outdoor microhabitats. Cockroaches, ants, and flies may scavenge for scraps or shelter in damp corners, but they remain dependent on soil, leaf litter, or garden habitats where moisture and organic matter sustain them (Illinois Department of Public Health, n.d). Their presence signals environmental opportunity, not long-term cohabitation.

Unlike the other organisms, rats do not simply come and go. If they find a house with available food, water, and shelter, they will establish residency, build nests, and form a growing colony. A single rat sighting is often an indication of an established or developing infestation (Pest Management Association of New Zealand, 2023).

Mosses and fungi differ in that they willingly settle once decay begins. They are more inclined to remain and spread once conditions are favourable. Moss establishes itself on damp, shaded, porous surfaces, particularly when a building's protective layers have already begun to fail (Jang & Viles, 2021). Similarly, fungi colonise timber or straw only when moisture levels are high and decomposition has already begun (Schmidt, 2006). In this sense, buildings mimic ecological niches that mosses and fungi would normally occupy elsewhere.

These examples highlight that wildlife does not truly desire to "live" in human homes. They may take advantage of shelter or resources when offered, but their ecological niches lie elsewhere in trees, soil, and open habitats. In this project, this is not framed as infestation but as ecological participation: the building becomes part of a living landscape, dissolving into habitats as the boundary between human and nonhuman space softens.

3.11 Native Flora & Fauna

While this project frames nonhuman inhabitants as participants in decomposition and ecological succession, it is also important to recognise that not all organisms contribute positively to New Zealand's ecosystems. Many introduced species interact with native flora and fauna in ways that disrupt ecological balance, reminding us that the transformation of buildings into habitat occurs within a wider, fragile environmental context.

Species such as rats, stoats, and possums, now widespread in disturbed and urban landscapes, pose significant risks to native wildlife. These mammals' prey on eggs, chicks, reptiles, and invertebrates, impacting species that evolved without mammalian predators and therefore lack defences ((Department of Conservation, n.d.). Their presence within or around degrading structures may accelerate ecological processes, but they simultaneously threaten the broader ecosystems that those structures ultimately rejoin.

Larger introduced animals, including deer, goats, and pigs, cause extensive damage to native forests and wetlands. By consuming seedlings and disturbing soil through trampling and rooting, they inhibit forest regeneration and damage the structural layers that support native biodiversity (Department of Conservation, n.d). Over time, this degradation affects the ecological processes that maintain healthy forest systems, reducing the habitat's capacity to support both native species and broader environmental functions.

Competition for food and shelter also pressures native species. Small mammals and insects may occupy niches once held by native fauna, while some introduced species act as vectors for disease (Department of Conservation, n.d). These interactions demonstrate that not all forms of inhabitation support ecological resilience.

The impacts extend to larger environmental processes: when pests suppress forest regrowth, ecosystems lose their ability to store carbon and maintain biodiversity. In this way, introduced species complicate the transition from decomposing buildings to regenerating landscapes. Although this project does not directly address pest management due to its conceptual and speculative nature, acknowledging these dynamics remains essential. They remind us that designing for ecological succession requires confronting the realities of invasive species, acknowledging both the opportunities and risks that arise when architecture becomes part of living systems.

Conclusion

The research presented in this chapter demonstrates that materials and organisms cannot be meaningfully separated within a regenerative architectural framework. Biomaterials carry specific chemical, climatic, and temporal qualities that shape how they perform during occupation and equally, how they behave as they break down. Their decomposition is not a neutral end point, but an ecological event that influences soil health, nutrient cycles, and the succession of plant life.

At the same time, the organisms drawn to biodegradable architecture are not simply threats to durability. Birds, insects, moss, fungi, bats, and rodents alter buildings in ways that conventional architecture frames as damage, yet their presence is essential to decomposition. Their foraging, burrowing, nesting, and microbial activity accelerate material breakdown, redistribute nutrients, and lay the groundwork for plant succession. Their interactions reveal architecture as a site of continual exchange: a temporary shelter for humans that later becomes a scaffold for new forms of life.

By integrating both material behaviour and ecological inhabitation, this chapter reframes degradation as a productive and necessary part of architectural life. This chapter emphasises that degradation is not a failure, but a mode of transformation; that inhabitation is not exclusive to humans; and that buildings participate in ecosystems long after they cease being functional structures.

Together, these insights set the foundation for the speculative design work that follows, where architecture is imagined as a living system that is designed to transform, break down, and nourish the environments it will one day become. By foregrounding both materials and organisms, the chapter establishes a framework for designing buildings that are not only sustainable, but symbiotic, regenerative, and deeply embedded within the living cycles of their sites.

Chapter Four – Site

This chapter introduces and analyses the proposed site in Glen Eden, Auckland, along with the nearby Waitākere Ranges, to provide the geographical and ecological context for the project. The site selection process began early in the research, with the intention of establishing a strong site-specific rationale for the design.

Glen Eden lies at the threshold between suburban Auckland and the native bush of the Waitākere Ranges. Its location highlights the tension between urban expansion and the preservation of natural ecosystems (Haigh et al., 2017). The site presents an opportunity to explore how architecture might engage with this threshold in a regenerative way. The project proposes temporary homes made from biodegradable and regenerative biomaterials. While serving as housing during their lifespan, these structures are designed to eventually decompose back into the earth. As these materials break down, they enrich the soil, providing fertile conditions for native plants to grow, extending the forest edge, and supporting biodiversity. In this way, architecture is reframed not as a permanent imposition but as part of a cyclical process, supporting biodiversity, enhancing ecological connectivity, and extending the forest edge further into the community.

The analysis in this chapter moves from a macro-scale understanding of Auckland and the Waitākere Ranges to a micro-scale investigation of Glen Eden, focusing on land use, soil conditions, and ecological context. Together, these layers of analysis establish the environmental and contextual framework within which the design operates.

Figure 23. Waitākere Ranges Looking Out to Auckland City

4.1 Site Maps

The selected site for the development is in Glen Eden, on the border of the West Auckland suburb and the native bush of the Waitākere Ranges, known to Te Kawerau ā Maki as Te Wao Nui ā Tiriwa (The Great Forest of Tiriwa). It is located on the rural–urban boundary (RUB). A rural–urban boundary defines the edge of an urban area, separating land designated for future urban development from areas intended to remain rural.

The surrounding land use is predominantly residential, with pockets of grass and mature trees. To the east, the landscape is predominantly suburban, composed of medium-density housing, paved roads, and small private gardens typical of Auckland's residential fringe. Moving westward toward the Waitākere Ranges, the land transitions into rural and semi-rural zones characterised by pasture, lifestyle blocks, and remnants of regenerating forest. Beyond these lie dense tracts of native bush dominated by kauri, rimu, tōtara, and ponga, which form part of the Waitākere Ranges Regional Park (Griffiths et al., 2023). These forests are ecologically significant, and important to protect as they support native bird species such as tūī, kererū, and pīwakawaka, as well as extensive understorey vegetation including ferns and mosses (Lovegrove & Parker, 2023).

As seen in Figure 24, the red border indicates the extent of the Glen Eden urban suburb, while the light green area to the west represents the rural zone. The dark green region marks the beginning of the Waitākere Ranges, highlighting the gradual transition from suburban development to native forest. This visual distinction reinforces the site's position along a sensitive ecological threshold.

These green fragments suggest both the ecological potential of the area and the threat posed by suburban intensification. By situating speculative architecture here, the project engages with the challenge of reconciling urban growth with ecological regeneration

Figure 24. Map of West Auckland

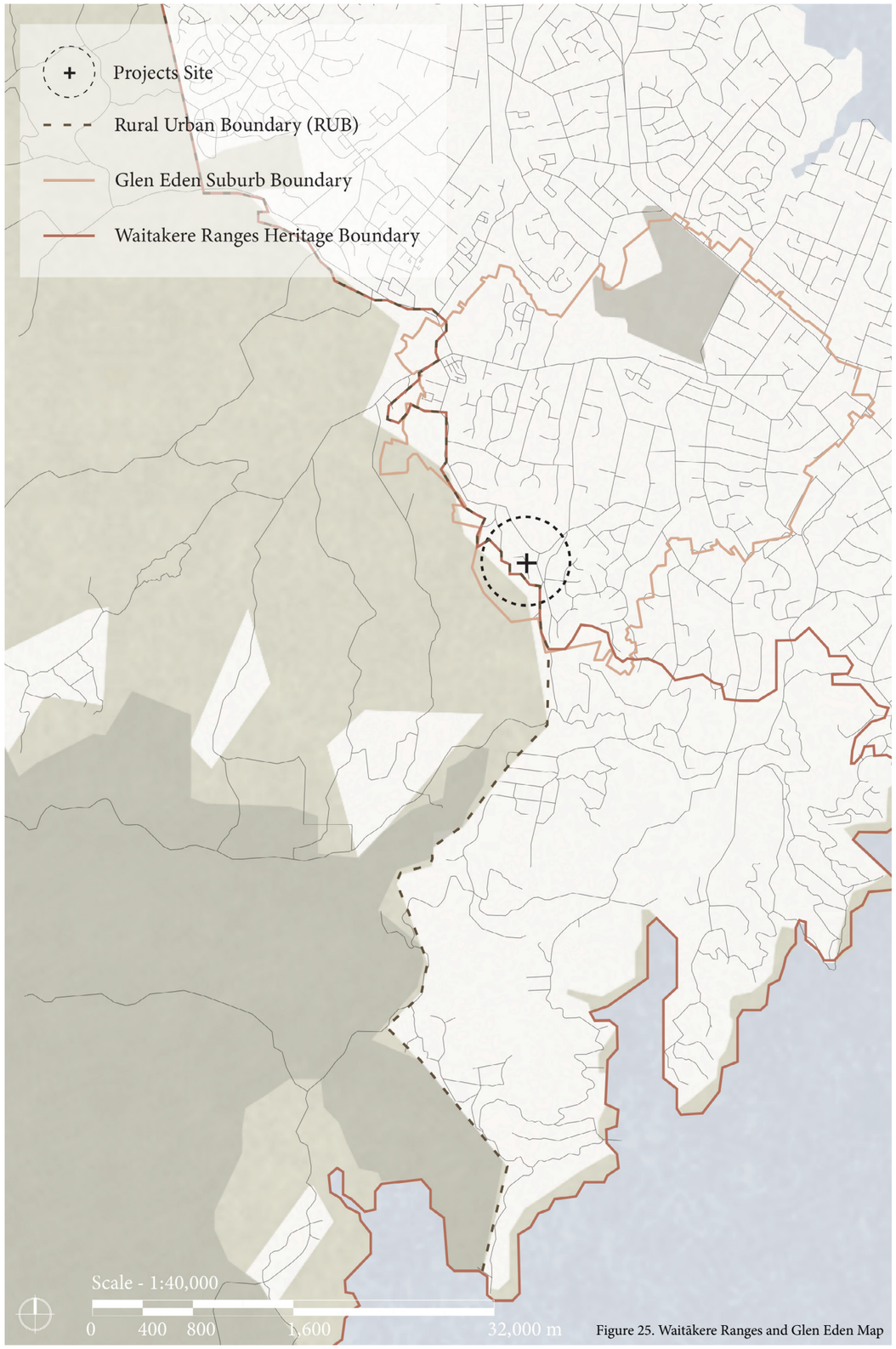


Figure 25. Waitākere Ranges and Glen Eden Map

Figure 26. Oratia Drive Site Map

Figure 27. Aerial View of Site

Figure 28. Oratia Drive — Google Earth Street Photos

4.2 Site Context

Analysing the suburban context of Glen Eden is important because it helps reveal the ecological and architectural issues this project responds to. Like many parts of Auckland's outer suburbs, Glen Eden is made up of detached houses, front and or backyards, and a limited variety of plants. While these areas might look green at first glance, they often have low biodiversity. The dominance of empty or sparse lawn grass creates monocultures that support few insects or native birds, while decorative planting often prioritises aesthetics over ecological value (Ministry for the Environment, 2024).

These fragmented patches of greenery, such as lawns, isolated trees, and fenced gardens, interrupt rather than support ecological connectivity. For native wildlife like birds, lizards, and insects, the suburban environment can feel more like a barrier than a habitat, reducing ecological connectivity (MacKinnon et al., 2023). The separation of green spaces by roads, driveways, and housing boundaries limits wildlife movement, reducing the potential for ecological corridors that link suburban areas to nearby ecosystems like the Waitākere Ranges.

Architecturally, the built fabric reinforces this separation between human and natural systems. Most houses are built with long-lasting, non-degradable materials such as treated timber, concrete, and synthetic claddings — materials designed to resist decay rather than participate in natural cycles. When these buildings reach the end of their lifespan, they are demolished and sent to landfill rather than reintegrated into the environment. This reflects how modern construction often treats decay as a failure and nature is treated as something to be kept outside the home, managed, or controlled (Candy, 2025).

This project takes the opposite approach. By using biodegradable and regenerative biomaterials, it imagines the suburban home as something alive, as a structure that can break down, feed the soil, and support new ecological growth. Empty lawns are replaced with native planting that benefit wildlife, and materials that decay naturally create new habitats as they break down. In doing so, the project challenges the typical suburban model and explores how homes could exist alongside nature rather than separate from it.

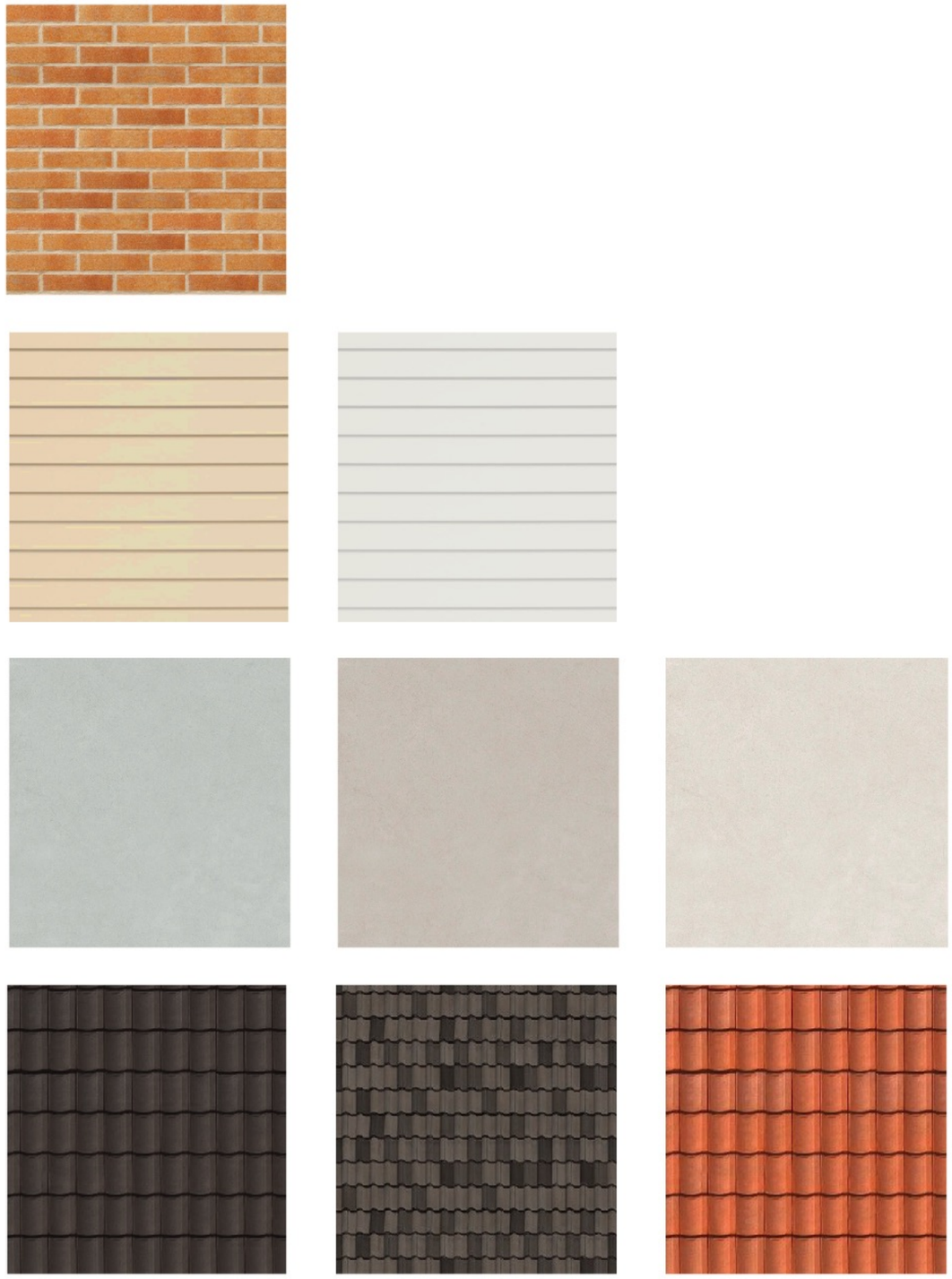


Figure 29. Materials of Houses Around the Site Collage

4.3 Soil Analysis

This soil pH map provides important contextual information about the general soil conditions influencing the Glen Eden site. While direct data for Glen Eden is limited, the Waitākere Ranges share similar geological and ecological characteristics, offering a reliable reference point. Understanding soil characteristics is important for assessing how biodegradable materials and planting species will interact with the ground, particularly in terms of nutrient absorption, fertility and ecological regeneration potential.

As seen in figure 31, it is seen that Orthic Granular soil is the most predominant soil type. Mapping the region shows that the soils are predominantly moderately acidic, ranging from low pH (4.9–5.4) to moderately acidic (5.5–5.7) and slightly acidic zones (5.8–6.4). Among the various soil types, including Rocky Raw and Sandy Recent soils, orthic granular soil is the most widespread. This soil type typically exhibits a moderately acidic pH (5.5–5.7), which influences drainage, nutrient availability, and plant growth. The Glen Eden site lies along the transition between suburban land and the volcanic, clay-rich soils of the Ranges, meaning it is likely underpinned by similar Orthic Granular conditions. Such soils offer strong potential for supporting native vegetation and regenerative planting, although their acidity may benefit from amendments such as limestone to improve nutrient availability (Olego, 2021).

Figure 30. pH Soil Levels Map of Waitākere Ranges

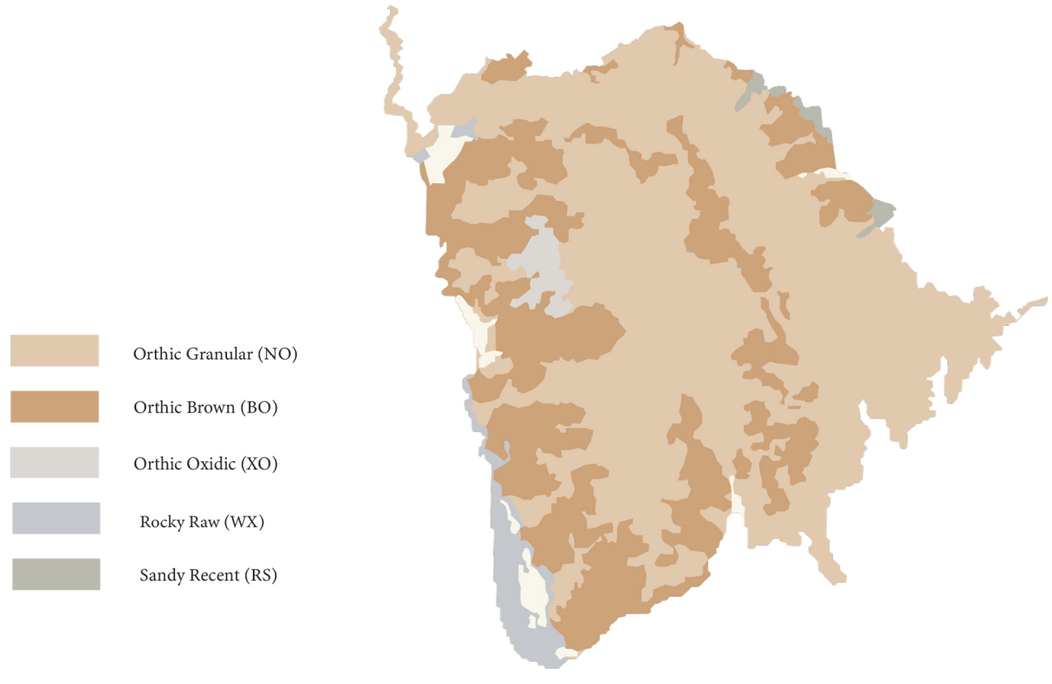
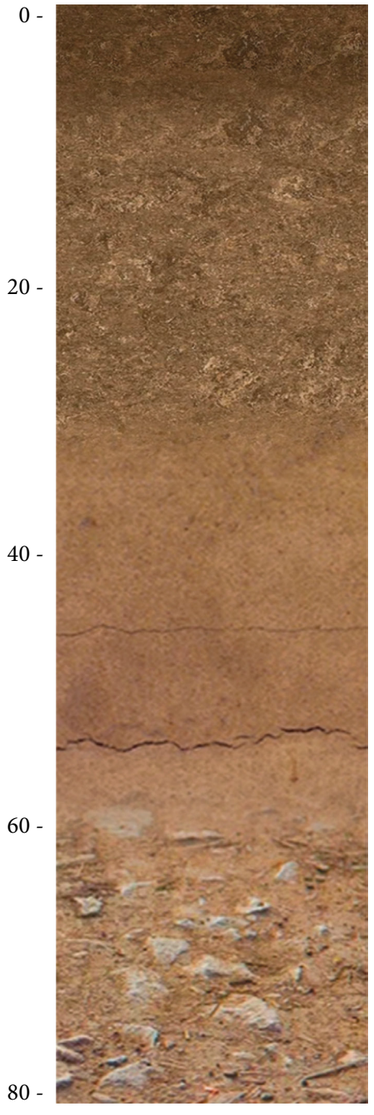


Figure 31. Soil Type Map of Waitākere Ranges



Ap (Topsoil)
Rich in organic material and typically dark in colour, this layer supports most plant life and biological activity.

AB (Transitional Layer)
A mix of topsoil and subsoil characteristics

Bt (Subsoil)
Characterised by clay accumulation and a denser texture, influencing drainage and root penetration.

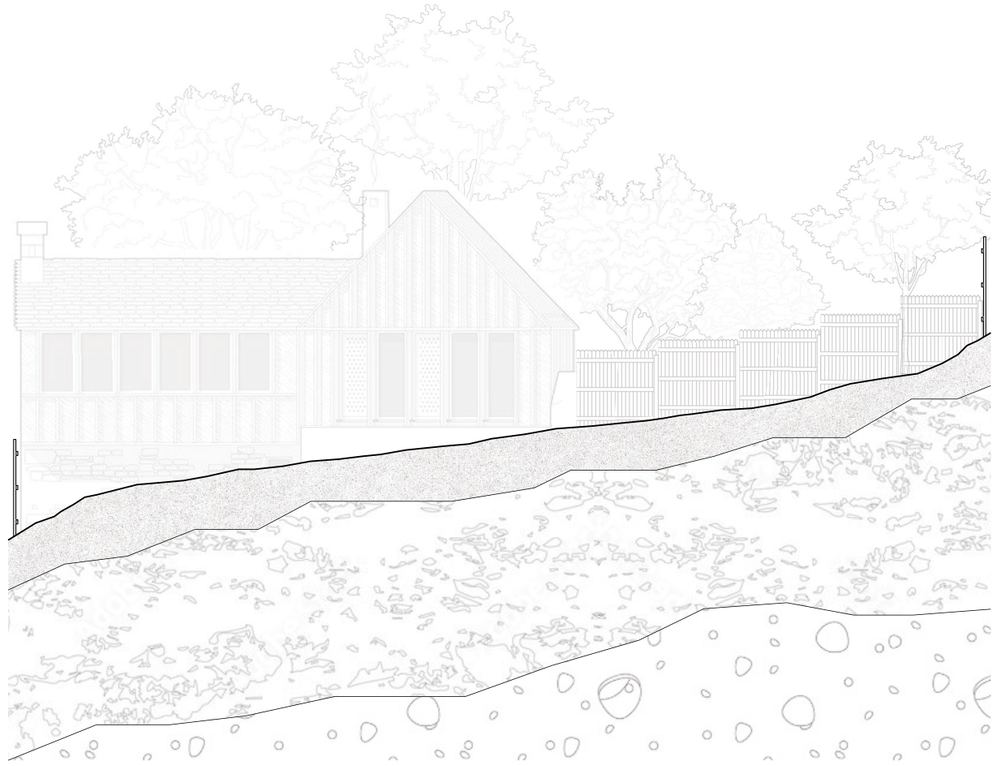
C (Parent Material)
The unweathered base layer from which the upper soil levels develop.

Orthic Granular Soil, commonly found in the North Island of New Zealand, is moderately easy to cultivate but requires careful management due to its clayey composition. While historically productive in horticulture, its slow permeability can lead to poor drainage and occasional waterlogging if not managed properly.

For agriculture and gardening, this soil type is well-suited to crops that thrive in well-drained conditions. In landscaping, its stability and nutrient-rich composition make it ideal for supporting a wide range of vegetation, including grasses, herbs, and some woody plants.

Orthic Granular soils are often nutrient-rich making it quite fertile, supporting diverse vegetation, inclusing grasses, herbs and some woody plants

Figure 32. Orthic Granular Soil Section



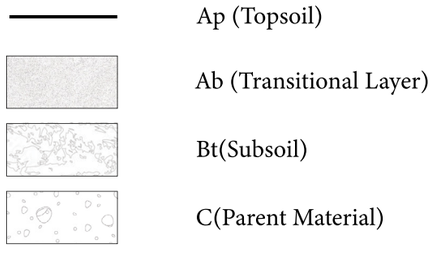


Figure 33. Section A-A Soil Analysis

4.4 Ecology & Wildlife

Figure 34. Waitākere Ranges Wildlife and Ecology Collage

The sites close proximity to the Waitākere Ranges offers a rich biodiversity that can be integrated into the design. Native fauna, such as birds and insects, play a crucial role in pollination and seed dispersal. Some of which are seen in Figure 34. Protecting and enhancing habitats for these species is essential in maintaining biodiversity.

The ecological edge condition of the site creates opportunities for planting strategies that extend natural habitats into suburban areas. By allowing biodegradable homes to transition into soil and nutrients over time, the project envisions architecture that actively contributes to these ecological networks.

4.5 Site Opportunities & Constraints

Opportunities:

- Agricultural Potential: The moderately acidic and well-draining orthic granular soil is suitable for cultivating a variety of native plants and crops, supporting biodiversity and resilient ecosystems.
- Ecological Restoration: The project presents an opportunity to restore and enhance local ecosystems by planting native species and creating habitats for wildlife.
- Sustainable Practices: These soil conditions support organic growing and sustainable landscaping practices, reducing dependence on chemical inputs.
- Ecological edge condition: The site sits between suburban development and native bush, making it an ideal place to test regenerative, biodegradable housing that can transition into forest over time.
- Climate suitability: Auckland's mild, wet climate supports plant growth, so when materials biodegrade, they can quickly contribute to soil enrichment and reforestation.

Constraints:

- Drainage and Erosion: While generally well-draining, Orthic Granular Soil can experience erosion or runoff during heavy rainfall, particularly on slopes if not maintained.
- Acidity Management: The moderately acidic pH may necessitate soil amendments for certain crops or non-native plantings, which could increase maintenance efforts. Soil acidity could be fixed through biomaterials such as limestone.
- Nutrient Balance: Long-term management may be needed to maintain fertility if the land is cultivated intensively or planted with non-colonial species.
- Ecological Sensitivities: Any intervention near the Waitākere Ranges must consider biosecurity (e.g., kauri dieback disease) and avoid disrupting existing habitats.

Conclusion

The site's position between suburban Auckland and the native bush of the Waitākere Ranges highlights the pressures of urban expansion and the preservation of natural ecosystems (Haigh et al., 2017), presenting a unique ecological and architectural context for this speculative project. The site analysis demonstrates how its location, shaped by ecological fragmentation, proximity to native bush, and the presence of moderately acidic Orthic Granular soils, creates both challenges and opportunities for regenerative design. These conditions reveal a landscape where biodiversity on site is present but limited – ecological corridors are broken, and conventional built form resists natural cycles.

Understanding the soil, hydrology, and ecology of the area is essential for imagining how biodegradable materials might behave as they decompose. The acidity and clay-rich structure of the soil suggests a role for restorative materials such as limestone or hempcrete, while high rainfall and fertile conditions provide strong potential for vegetation to reclaim the site as architecture decomposes. Proximity to the Waitākere Ranges also demands sensitivity to wildlife patterns and biosecurity concerns, and the need to support rather than disrupt native ecosystems.

Together, these insights establish a framework in which architecture can shift from permanence to participation. The site becomes not only a physical location but an ecological partner, a place where temporary, biomaterial homes can serve their human purpose and then transition back into the land, supporting wildlife and the natural environment – supporting the thesis's goal of designing with, rather than against, living systems.

Chapter Five – Developed Design

This chapter outlines the development of the design, translating the project's research into architectural form. Building on the material studies, site analysis, and theoretical framework established earlier, it explores how biodegradable and regenerative biomaterials can be integrated into a domestic context. Rather than proposing a conventional housing model, the chapter speculates on how architecture might embrace cycles of growth, decay, and renewal.

It begins by testing three housing typologies — modular, tiny, and two-storey homes — to determine which best supports the project's aims. This is followed by a series of floor plan iterations that refine spatial organisation. The chapter then introduces degradation concepts that imagine how the building might break down at the end of its life, supported by a criteria matrix evaluating each approach against the objectives of temporality, regeneration, and ecological integration.

The following sections focus on landscape design and material detailing, considering what vegetation would best support ecological succession and attract wildlife. Roof and wall details then test how the selected biomaterials from Chapter 3 can be applied in practice. The chapter concludes by reflecting on the final crit presentation layout and the design shift that allowed the project to more fully embody its intentions of biodegradability and temporal architecture.

5.1 Concept Diagram

The concept diagram sets the foundation for the design by turning the project's ideas of biodegradability, time, and ecological renewal into one visual system. Instead of showing a fixed architectural proposal, it maps how the building, its biomaterials, and the landscape interact over time. It shows how the structure is meant to grow, break down, and eventually return to the site through cycles of decomposition, soil improvement, and plant succession.

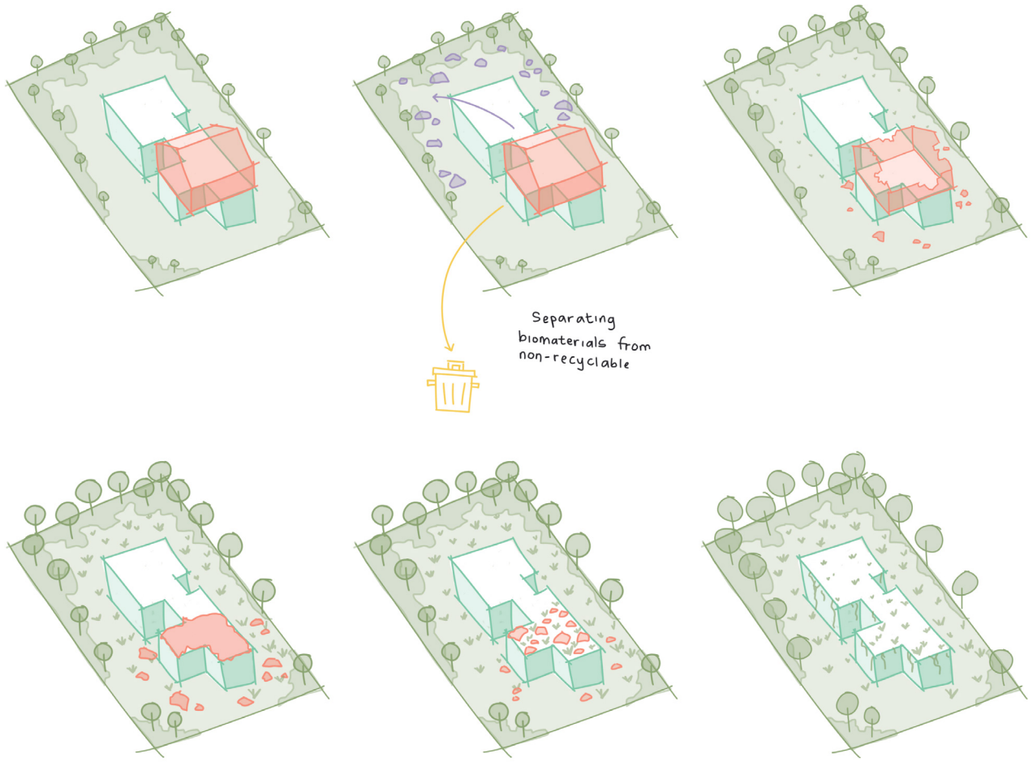


Figure 35. Degradation Concept Diagram

5.2 Initial Concepts

The early design phase explored three potential housing typologies — modular homes, tiny homes, and two-storey homes — each offering different opportunities and challenges for integrating biodegradable and regenerative biomaterials into domestic architecture. These typologies weren't pursued as realistic design proposals, but as speculative frameworks for testing material, spatial, and ecological ideas.

Modular Homes

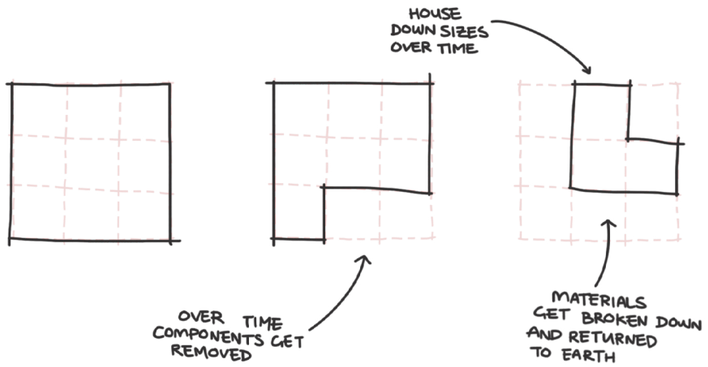


Figure 36. Modular House Concept Diagram

The modular housing concept was initially examined for its sustainable potential through prefabrication and material efficiency. While modular systems minimise waste and support scalability, the typology constitutes a large and complex field of research that would've warranted a whole other research component in on of itself. Exploring it in depth would have diverted focus from the primary project investigation into biodegradability. Their reliance on standardised components also restricts experimentation with irregular biomaterials such as hempcrete, straw, and mycelium. For these reasons, the modular approach was not pursued further.

Figure 37. Compilation of Modular House Floor Plans (Scale 1:200)

Tiny Homes

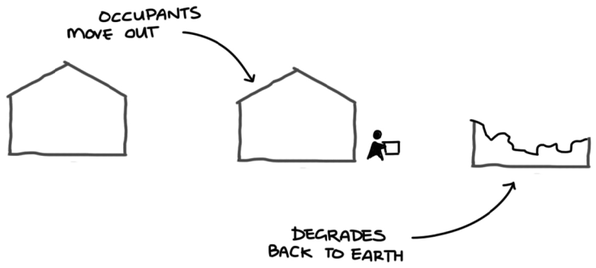
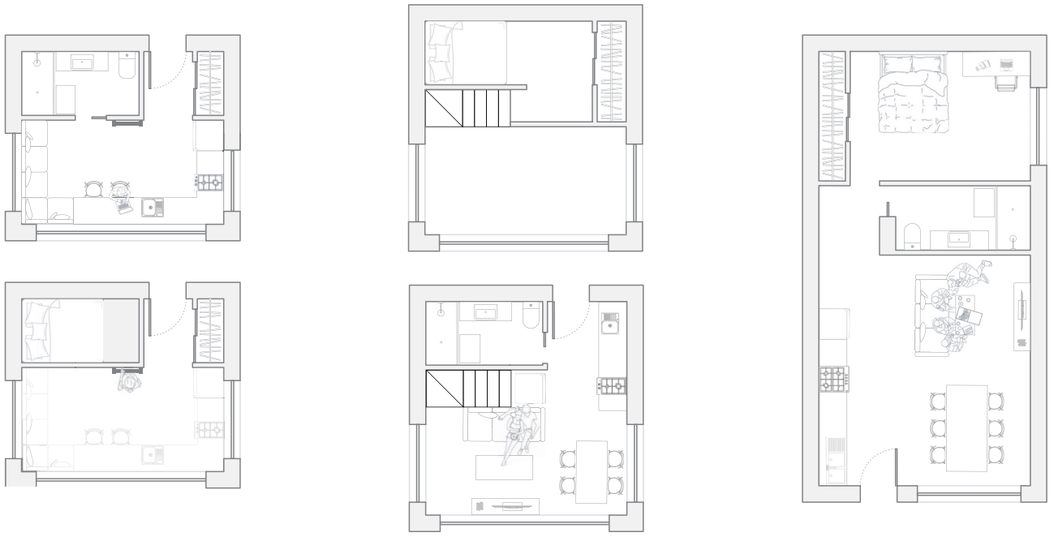
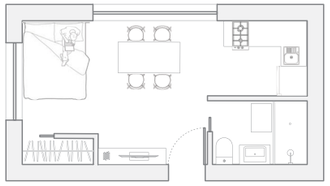
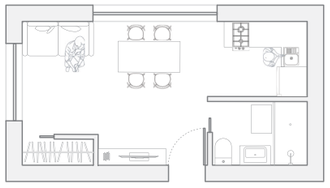


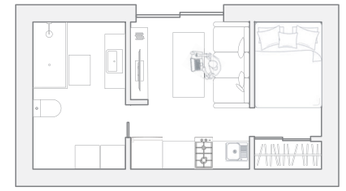
Figure 38. Tiny House Concept Diagram

Tiny homes were considered for their minimal footprint, flexible living, and efficient material use. However, their constrained size limits suitability for long-term residential use and reduces opportunities to test multiple biomaterials across structural, cladding, and insulation systems. As a result, while tiny homes embody sustainable values, the typology lacked the architectural scope required for exploring material temporality and ecological regeneration.









Scale 1:200

Figure 39. Compilation of Tiny House Floor Plans (Scale 1:200)

Two-Storey Homes

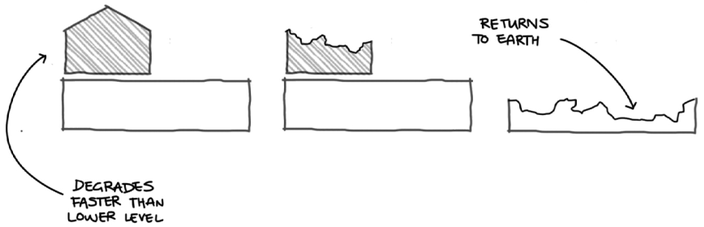


Figure 40. Two Storey House Concept Diagram

The two-storey home emerged as the most appropriate typology. It provides a familiar suburban framework, relevant to contexts like Glen Eden, while allowing more complex spatial and material experimentation. Its vertical organisation accommodates a wider range of biomaterial applications and supports investigation into weathering, exposure, and decomposition. It also offers greater surface area for ecological interaction. Within this typology, the design can remain contextually grounded while testing speculative ideas about temporality, degradation, and regeneration

Decision

Through this iterative exploration, the two-storey home was chosen as the most appropriate typology for this project. It provides a balance between familiarity and experimentation, integrating biodegradable materials within a form that is both recognisable and open to transformation. This typology enables the speculative testing of architectural temporality, decomposition, and ecological renewal, without needing to conform to conventional expectations of permanence or practicality. Ultimately, the project does not aim to propose a buildable prototype, but to reimagine the suburban home as a living, evolving system that participates in cycles of growth, decay, and regeneration.

Figure 41. Compilation of Two House Floor Plans (Scale 1:200)

5.3 Floor Plan Iterations

Through iterative floor plan exploration, the goal was to enhance the occupants' connection to the surrounding environment.

Original Floor Plan

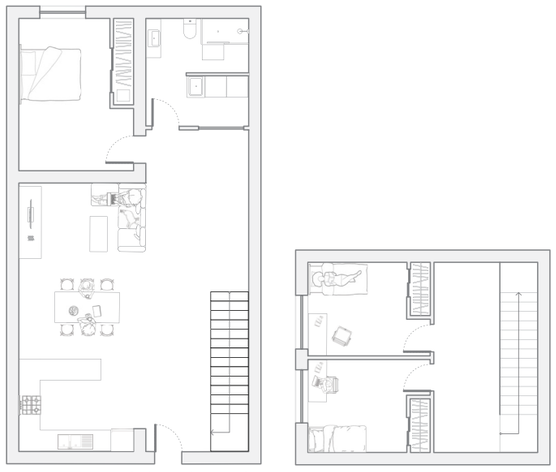


Figure 42. Original Floor Plan (Scale 1:100)

Floor Plan Iteration One

Figure 43. Floor Plan Iteration One (Scale 1:100)

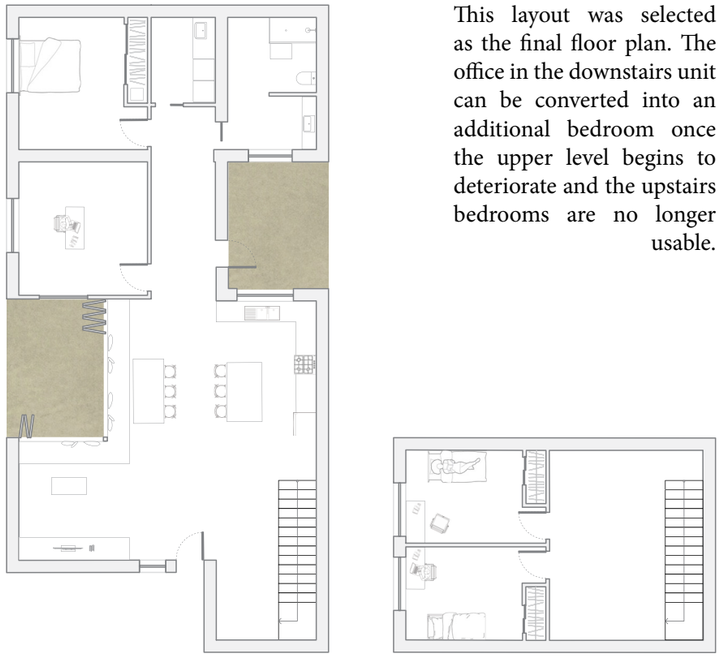
Floor Plan Iteration Two

Figure 44. Floor Plan Iteration Two Scale (1:100)

Floor Plan Iteration Three

Figure 45. Floor Plan Iteration Three (Scale 1:100)

Floor Plan Iteration Four



This layout was selected as the final floor plan. The office in the downstairs unit can be converted into an additional bedroom once the upper level begins to deteriorate and the upstairs bedrooms are no longer usable.

Figure 46. Floor Plan Iteration Four (Scale 1:100)

5.4 Degradation Concepts

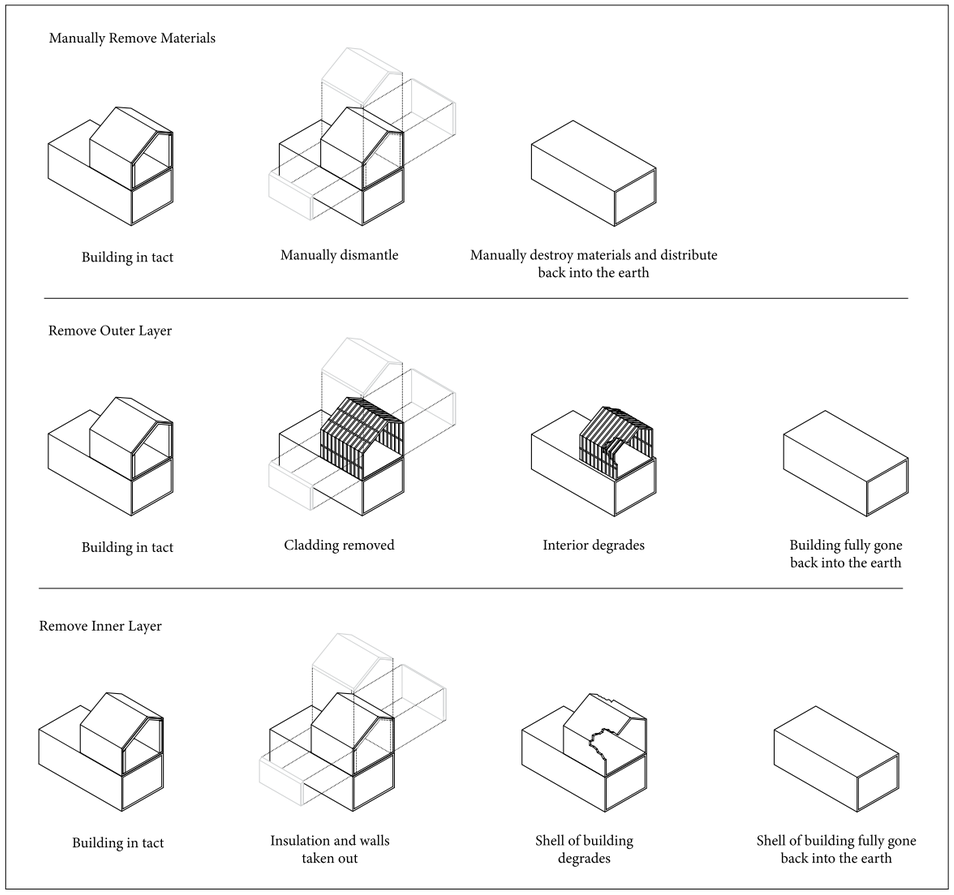


Figure 47. Degradation Concepts

Degradation Concepts

Three speculative degradation concepts were explored: Removing the inner layer, removing the outer layer, and manually removing materials. Each proposes a different way for the building to decay, disassemble, and reintegrate with the landscape.

Removing the Inner Layer

This concept begins degradation from within the structure. Interior elements such as insulation and internal linings are removed first, while the exterior shell remains intact. The house appears whole from the outside as its inner layers quietly break down. Removed materials are redistributed across the site to support ecological regeneration. As the shell degrades, cavities and porous spaces form, allowing moss, fungi, and small organisms to colonise the structure. The building gradually hollows out before fully returning to the soil.

Manually Removing Materials

This concept involves controlled deconstruction, where components are dismantled and returned to the earth through human intervention. While this method ensures precision and reduces waste, it lacks the autonomous, self-degrading qualities central to the thesis and is therefore less aligned with the project's objectives.

Why Not Let It Fully Degrade Without Removing Materials?

Although complete natural decay with no human intervention may seem ideal, not all materials break down safely without guidance. In reality, not all building elements break down evenly or safely without intervention. Elements such as treated materials, paints, fastenings, or insulation may resist decomposition or release toxins if left unmanaged. Selective removal ensures only non-toxic, biodegradable materials remain on site, enabling safe breakdown. It also allows decomposition to occur in stages, fostering ecological succession through gradually forming habitats rather than sudden collapse. In this way, partial removal becomes an act of ecological care, maintaining safety, enhancing soil health, and ensuring that the building's transformation from structure to landscape occurs as a productive and regenerative process rather than uncontrolled ruin.

Criteria Matrix

To determine which degradation concept best aligned with the project's aims, a criteria matrix (Figure 48) was developed using the research question and theoretical framework in Chapter Two. The matrix evaluated each concept across themes of temporality, regeneration, wildlife integration, ecological processes, human participation, and human–nonhuman interaction. These categories assessed how well each approach supported gradual decomposition, ecological succession, and the balance between design intent and natural transformation.

As shown in Figure 48, both options of removing the inner layer and removing the outer layer scored highest, aligning more closely with the project's ecological intentions than manually removing materials. Their scores were identical, as both encourage passive, organic breakdown without requiring full human control; the main distinction is whether degradation begins internally or externally.

Removing the inner layer was ultimately selected. It enables decomposition to start within the structure, reflecting a quiet, gradual transformation rather than abrupt collapse. Interior components, such as insulation or any chemically treated materials, can be removed before degrading, preventing contamination and preparing the building for natural processes. The building's core gets removed and broken down first, supporting soil health and biodiversity, before the outer shell eventually degrades and returns to the earth.

Figure 48. Criteria Matrix

5.5 Landscaping

The landscaping design supports the project's aim of connecting architecture with natural cycles of growth and decay. Research into coloniser plants informed how the site could regenerate as the building breaks down. These hardy, fast-growing species stabilise soil, prevent erosion, and prepare disturbed ground for later ecological succession. These qualities make coloniser plants ideal for this project.

As biodegradable materials decompose, coloniser plants can quickly establish themselves in the enriched soil, initiating succession and providing food and habitat for birds, insects, and other wildlife. This encourages biodiversity as the structure deteriorates.

Potential species include mānuka and kānuka for soil improvement and attracting pollinators; cabbage tree (tī kōuka) for its which grows in many soil types; five-finger (whauwhaupaku) and lemonwood (tarata) for dense foliage and nectar; kōwhai for native birds; pōhutukawa for open areas; and harakeke (flax) for insects and birds.

Additional native plants that are not colonisers but add ecological value, such as karaka for bird food and tussock grasses for ground cover and shelter, further strengthen the planting scheme. Together, these species create a resilient, evolving landscape that gradually reclaims the site as the building decomposes, demonstrating regeneration and coexistence between architecture and nature.

Figure 49. Landscape Map (Scale 1:200)

5.6 Building Details

These building details were made by iteratively experimenting with the materials that were found most suitable in New Zealand's climate from chapter 3.

Roof Details

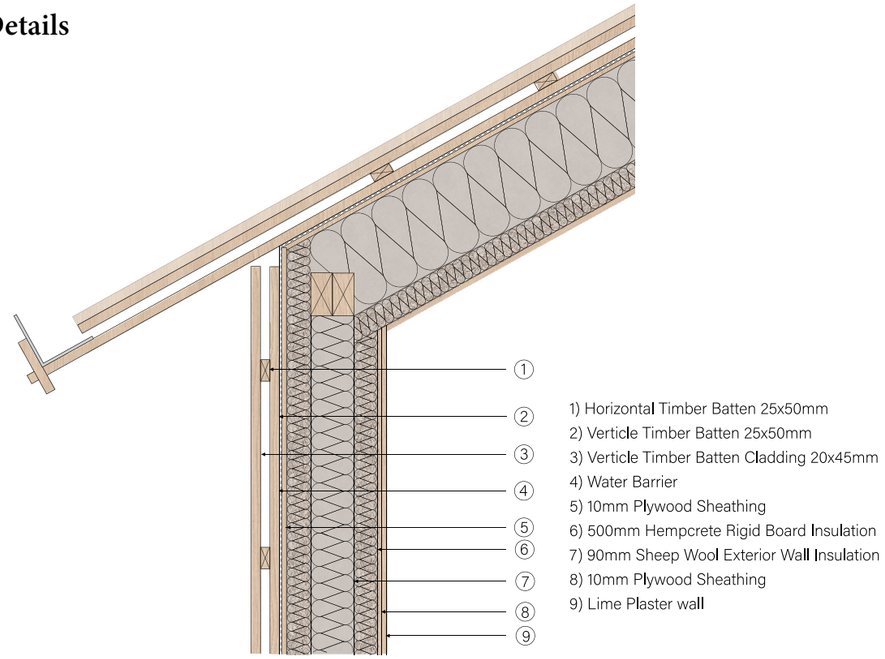


Figure 50. Timber Roof Detail Drawing Version One (Scale 1:200)

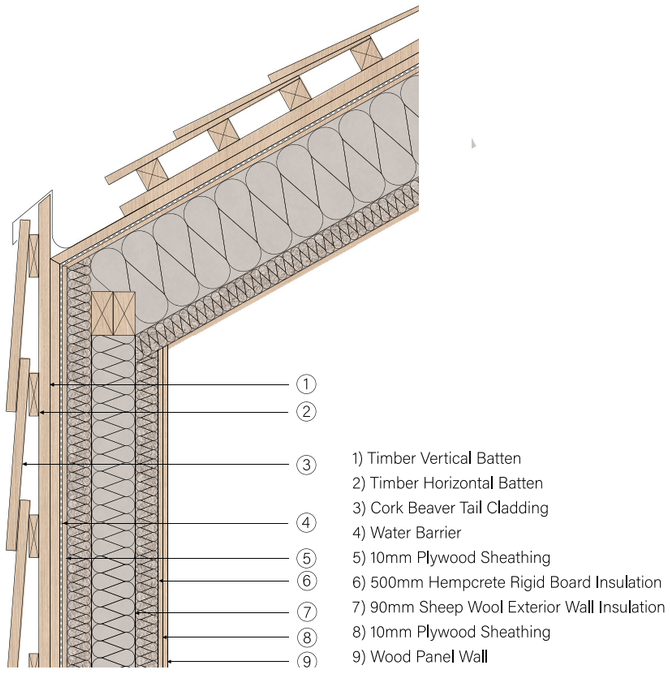


Figure 51. Cork Roof Detail Drawing (Scale 1:200)

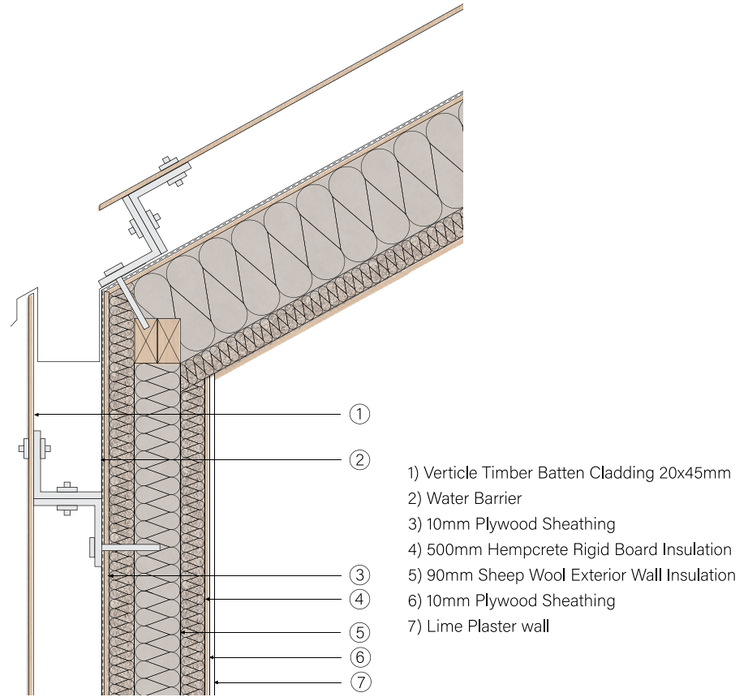


Figure 52. Timber Roof Detail Drawing Version Two (Scale 1:200)

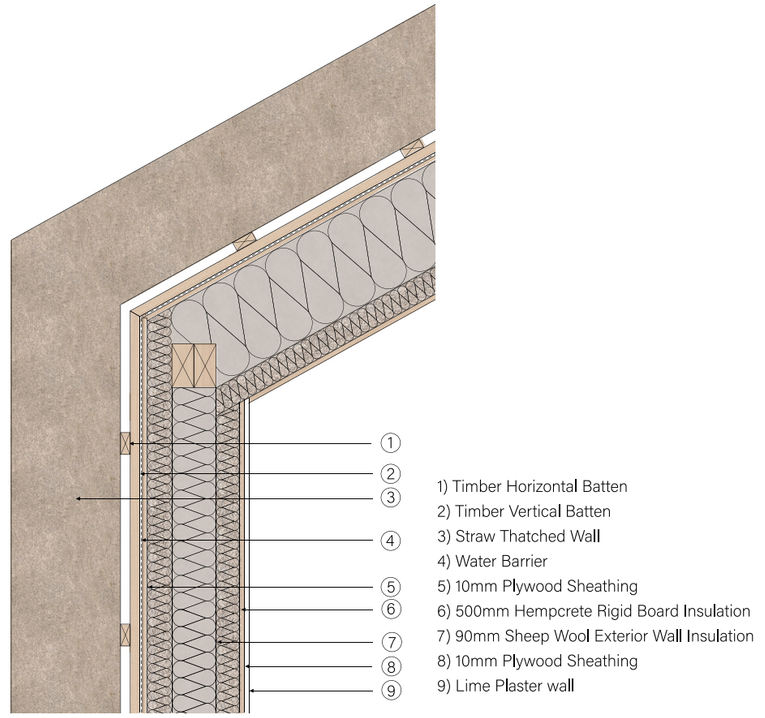
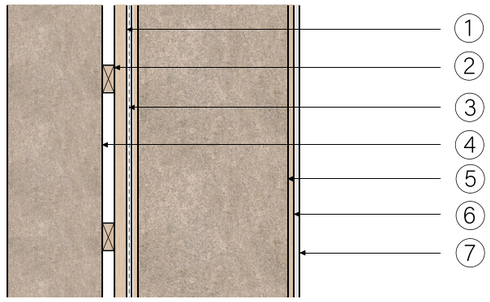


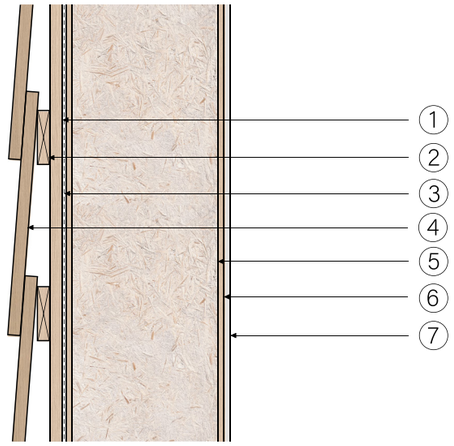
Figure 53. Straw Roof Detail Drawing (Scale 1:200)

Wall Details



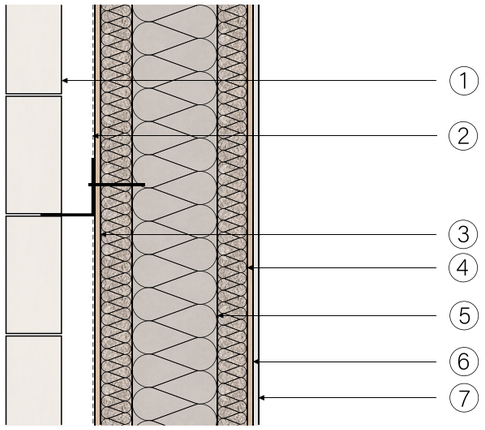
1) Timber Vertical Batten
2) Timber Horizontal Batten
3) Water Barrier
4) Straw Thatched Wall
5) Straw Insulation
6) 10mm Plywood Sheathing
7) Lime Plaster Wall

Figure 54. Straw Wall Detail Drawing (Scale 1:200)



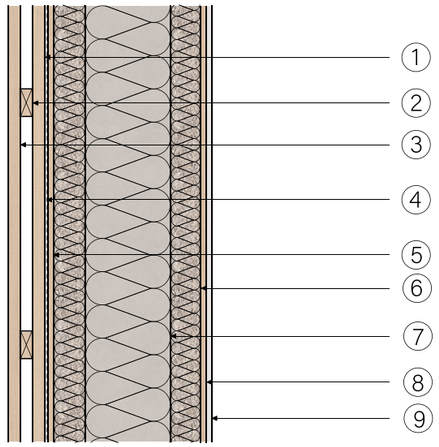
1) Timber Vertical Batten
2) Timber Horizontal Batten
3) Water Barrier
4) Cork Beaver Tail Cladding
5) Straw and Mycelium Insulation
6) 10mm Plywood Sheathing
7) Lime Plaster Wall

Figure 55. Cork Wall Detail Drawing (Scale 1:200)



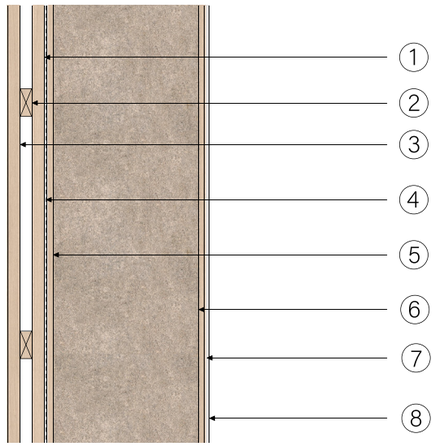
1) Fluted Limestone Brick
2) Water Barrier
3) 10mm Plywood Sheathing
4) 500mm Hempcrete Rigid Board Insulation
5) 90mm Sheep Wool Exterior Wall Insulation
6) 10mm Plywood Sheathing
7) Lime Plaster wall

Figure 56. Limestone Wall Detail Drawing (Scale 1:200)



1) Verticle Timber Batten 25x50mm
2) Horizontal Timber Batten 25x50mm
3) Verticle Timber Batten Cladding 20x45mm
4) Water Barrier
5) 10mm Plywood Sheathing
6) 500mm Hempcrete Rigid Board Insulation
7) 90mm Sheep Wool Exterior Wall Insulation
8) 10mm Plywood Sheathing
9) Lime Plaster wall

Figure 57. Timber Wall Detail Drawing Version One (Scale 1:200)



1) Verticle Timber Batten 25x50mm
2) Horizontal Timber Batten 25x50mm
3) Verticle Timber Batten Cladding 20x45mm
4) Water Barrier
5) 10mm Plywood Sheathing
6) Straw Insulation
7) 10mm Plywood Sheathing
8) Lime Plaster wall

Figure 58. Timber Wall Detail Drawing Version Two (Scale 1:200)

5.7 Presentation Board

The image in Figure 59 shows my final crit presentation pin-up, which visually brought together the conceptual, material, and ecological threads of the thesis. While the layout followed a conventional architectural structure — site analysis, concepts, plans, sections, and visuals — these elements were reinterpreted to reflect the project's speculative and temporal focus.

Rather than emphasising spatial organisation or technical detail, the drawings and plans were illustrated to convey material temporality, decomposition, and ecological growth, prioritising transformation over practical room arrangement.

At the base of the pin-up, long horizontal strips displayed the storyboard frames of the GIF animations, narrating degradation and ecological succession. These sequences complemented the looping videos shown alongside them, allowing viewers to engage with the temporal narrative through both motion and static imagery.

Through this presentation format, the critique became not just a review of a building proposal, but a reflection on how architecture can be represented, understood, and communicated as a living, changing system rather than a fixed object.

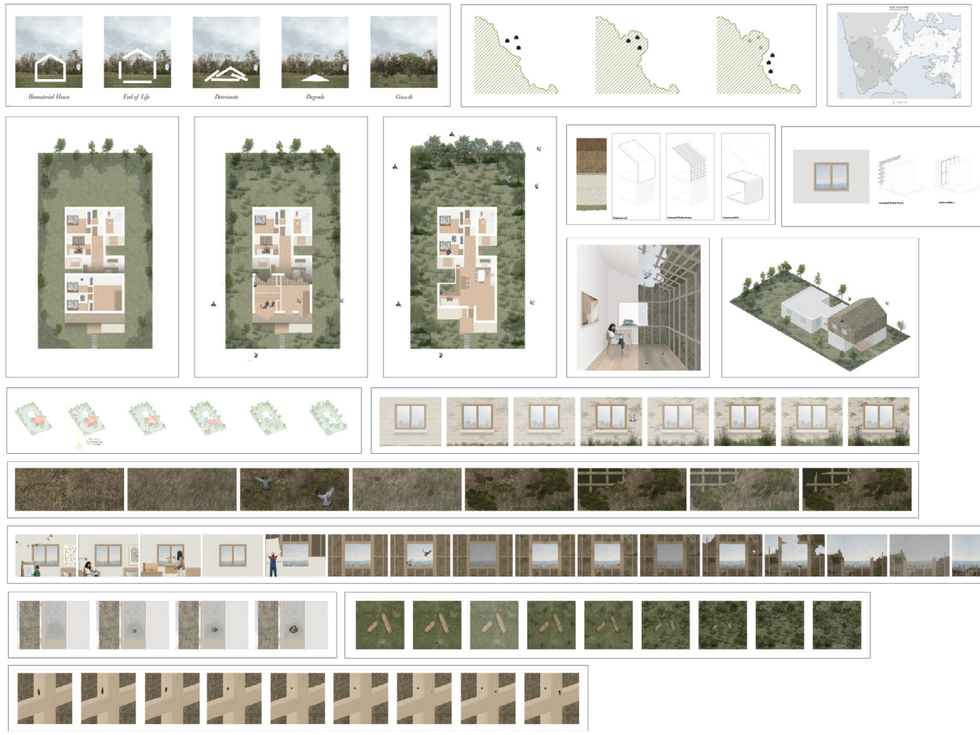


Figure 59. Crit Presentation Board

5.8 (Not) Final Design

Feedback from Final Crit

Figure 60. Limestone and Hemp Building Elevation (Scale 1:100)

The design shown in Figure 60 represented the initial "final" iteration with a thatched straw upper level and a limestone-brick lower level.

However, feedback from the final crit highlighted that limestone did not fully align with the project's aim of a building designed to decompose and return to the earth. Though sustainable and locally appropriate, limestone is highly durable, eroding over centuries rather than biodegrading and breaking down into nutrient-rich organic matter. Its longevity conflicted with the project's focus on architectural impermanence and ecological regeneration. As a result, the design was reconsidered to prioritise materials that more actively participate in natural cycles of decay.

Material Change

Following feedback from the final crit, limestone was removed from the design. While environmentally stable, it erodes rather than biodegrades and therefore does not contribute to soil health like organic materials such as straw or timber. While manually breaking down limestone into fine particles could be an option, it contradicts the project's natural degradation process. Organic particles offer far greater ecological value, enhancing soil fertility, water retention, and microbial activity whereas erosion primarily provides nutrients at a much slower rate (Bortoluzzi et al., 2022).

Returning to earlier material research, factors such as climate suitability, ecological contribution, and decomposition behaviour were reviewed. Timber was selected as the replacement cladding material, specifically Douglas Fir. Untreated Douglas Fir has a lifespan of 5–15 years, is locally available, and performs well in New Zealand's environment (Page & Singh, 2014). Its biodegradability supports the project's temporal intentions: it can safely decompose on site, enrich soil, and either be replaced during occupation or left to break down alongside the structure at the end of its life.

5.9 Critical Reflection

The design development process served as a bridge between conceptual research and speculative design, transforming theoretical ideas of biodegradability and regeneration into architectural form. Each stage, from typology exploration to material selection and degradation concepts, tested how architecture might participate in ecological cycles rather than resist them. Through iteration, reflection and critique, the project shifted from a conventional-looking housing proposal to a speculative framework for living architecture.

A key learning outcome was recognising that material behaviour must align with the project's conceptual intent. Earlier reflection made clear that not all “sustainable” materials support ecological regeneration in the way this design requires; the use of limestone revealed a contradiction between erosion and biodegradation. Limestone erodes but doesn’t break down into organic matter, prompting a shift to shorter-lived materials like timber that biodegrade into particles returning nutrients to the soil. While manually breaking down limestone into fine particles could be an option, it contradicts the project's natural degradation process. Organic particles offer far greater ecological value, enhancing soil fertility, water retention, and microbial activity whereas erosion primarily provides nutrients at a much slower rate (Bortoluzzi et al., 2022). Although limestone is sustainable, timber better aligns with the project’s aims, strengthening the design's conceptual intentions and emphasizing the role of materials in ecological systems.

The design development phase reaffirmed the speculative nature of the thesis. Rather than seeking to resolve technical or structural details, it explored how architecture might one day decompose, nourish ecosystems, and coexist with nonhuman life. Each revision contributed to a broader inquiry into designing with time, decay, and regeneration, repositioning architecture as a temporary participant in the landscape’s ongoing cycle of renewal.

Chapter Six - Final Design

Figure 61. Building Axonometric

Figure 62. Project Concept Diagram

Figure 63. Floor Plan Stage One

Figure 64. Floor Plan Stage Two

Figure 65. Floor Plan Stage Three

Figure 66. Floor Plan Stage Four

Figure 67. Floor Plan Stage Five

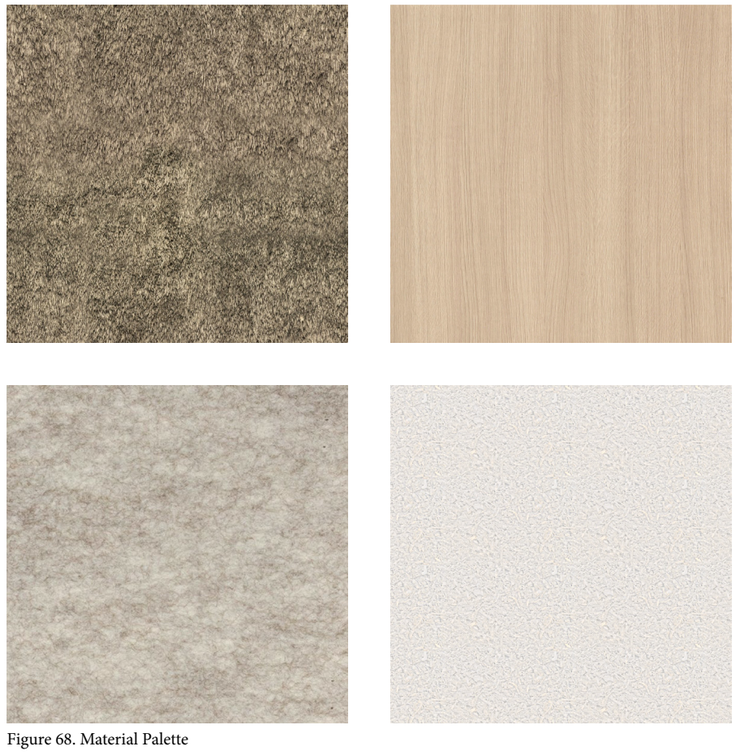
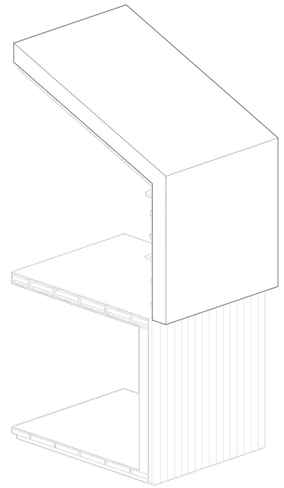
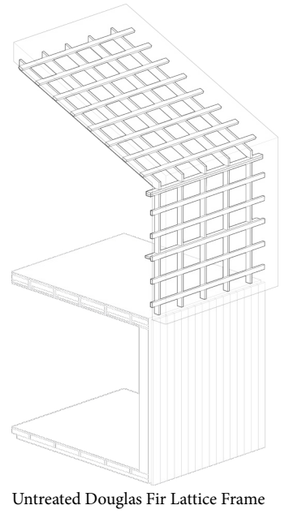


Figure 68. Material Palette

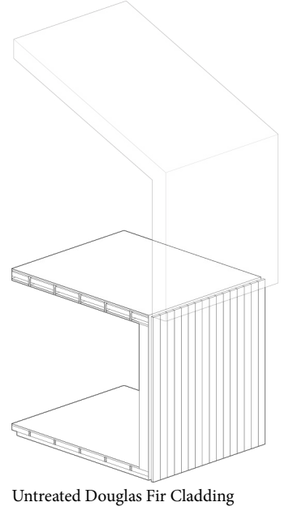
Figure 69. Exterior Materials



Thatched Long Straw Roof

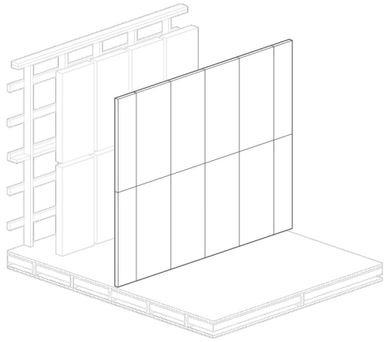


Untreated Douglas Fir Lattice Frame

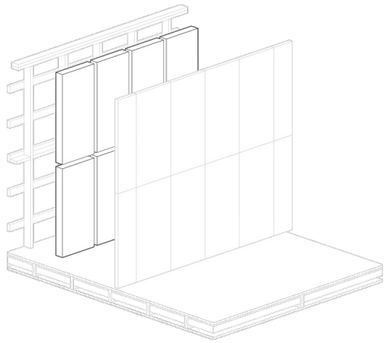


Untreated Douglas Fir Cladding

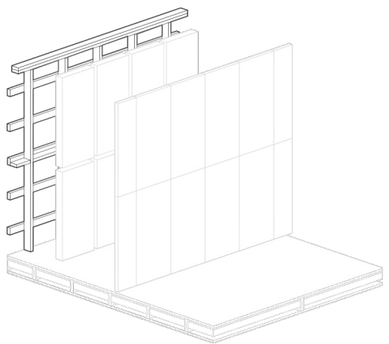
Figure 70. Internal Materials



Hempcrete wall panels



Sheep Wool Insulation



Untreated Douglas Fir Lattice Frame

Figure 71. Building Before & After

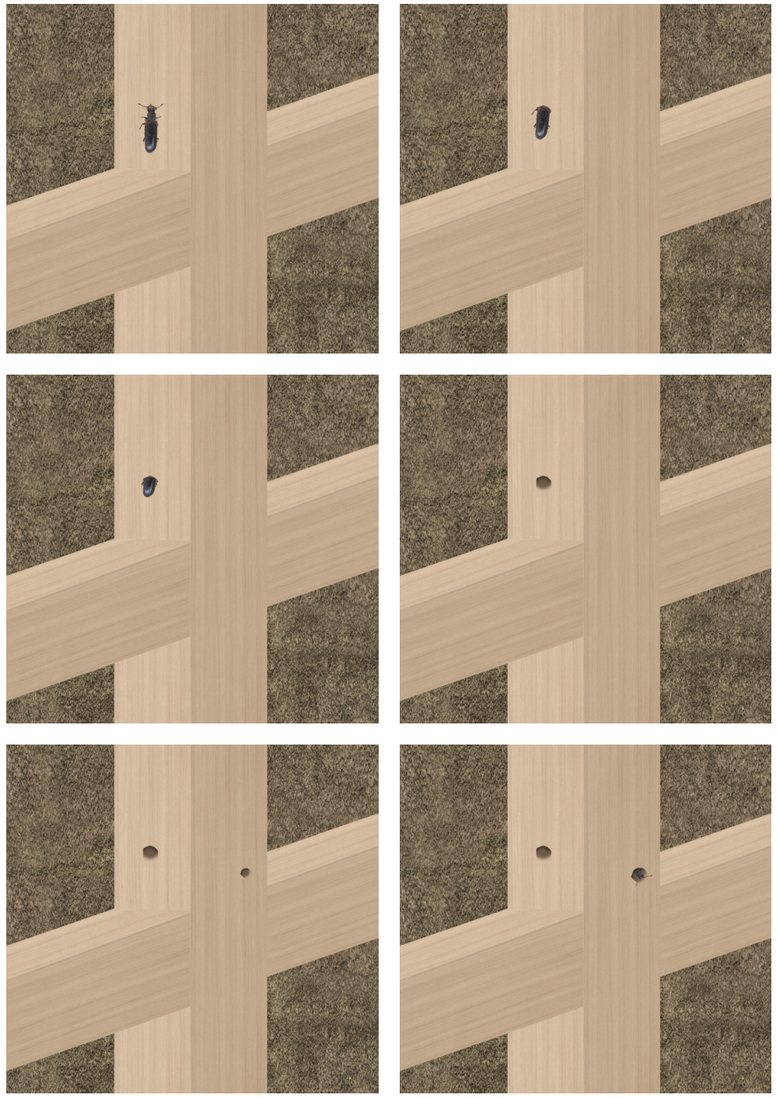


Figure 72. Insect GIF Storyboard

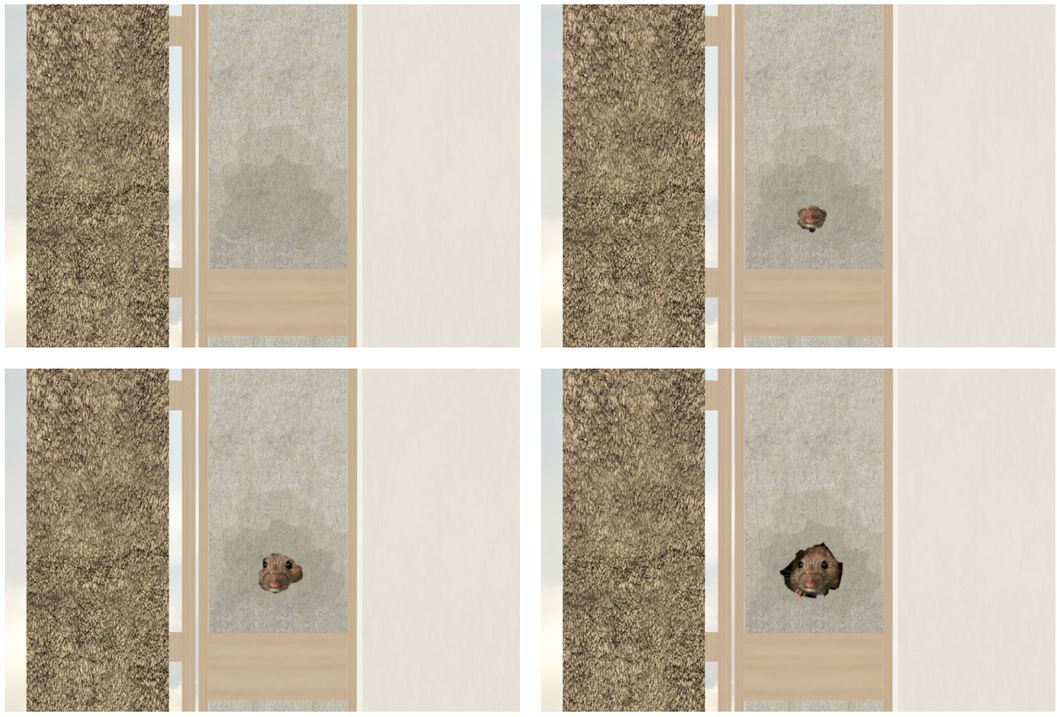


Figure 73. Mouse GIF Storyboard

Figure 74. Straw Roof GIF Storyboard

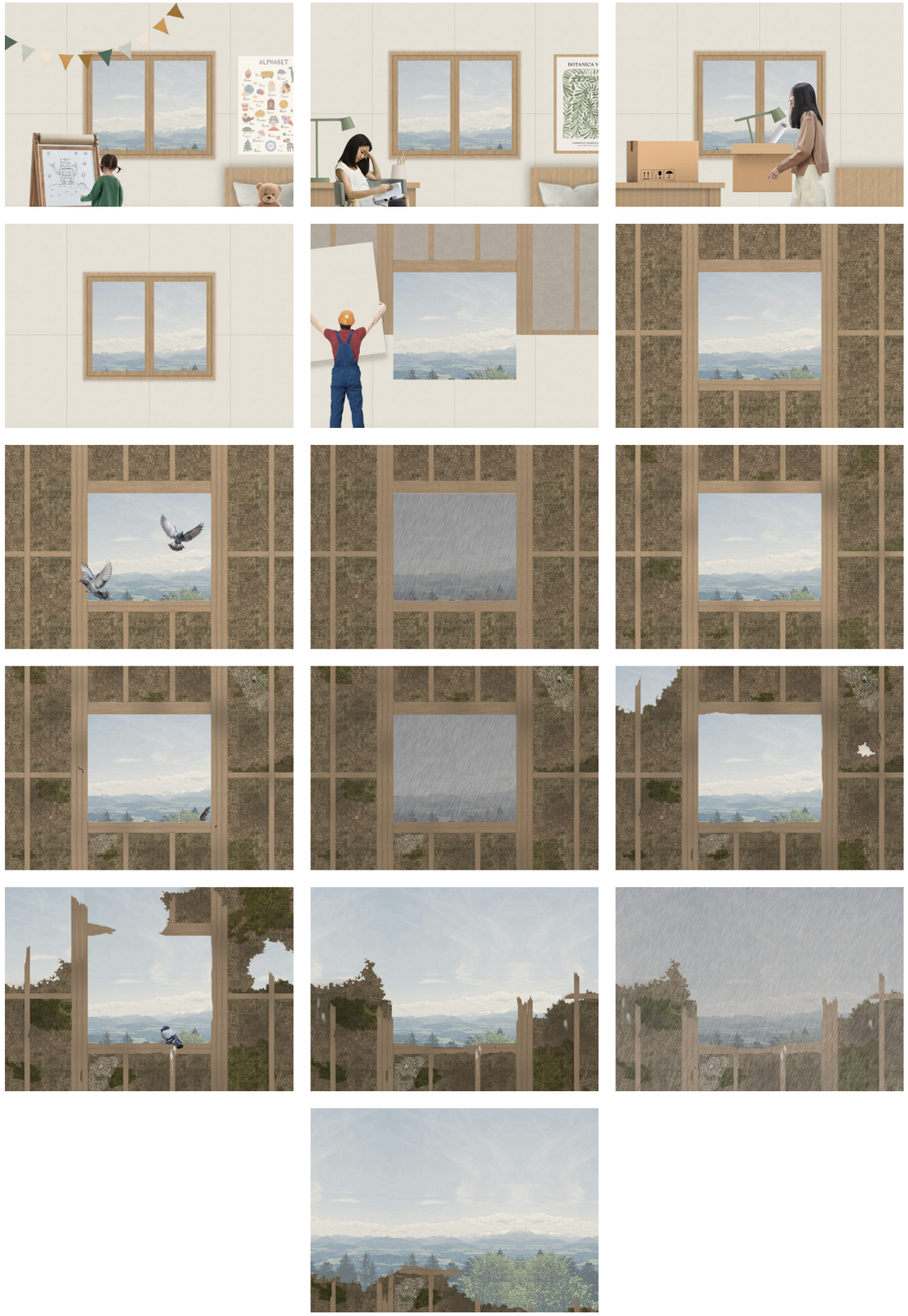


Figure 75. Top Storey GIF Storyboard

Figure 76. Bottom Storey GIF Storyboard

Figure 77. Wood Rotting GIF Storyboard

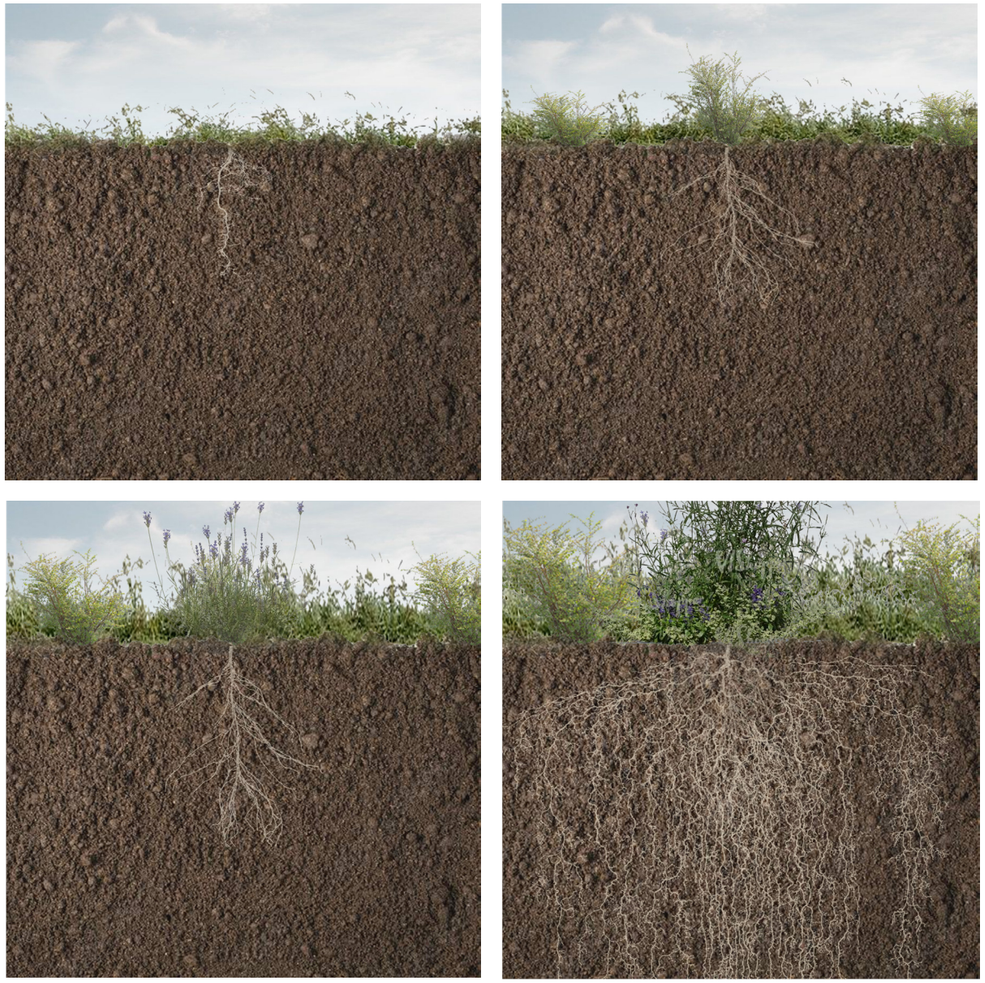


Figure 78. Plant Growing GIF Storyboard

Chapter Seven – Discussion

This chapter reflects on the key findings and insights and theoretical ideas that have emerged through the research. It revisits the research question and aims, considering how the design process has addressed issues of material temporality, ecological succession, and architecture's role within living systems. The discussion synthesises insights from material research, design exploration, and theoretical inquiry to assess the project's broader implications, particularly in rethinking architecture's relationship with time, decay, and ecology. It also acknowledges the project's limitations, while identifying opportunities for future research and wider application. This chapter positions the project not as a resolution, but as a contribution to an ongoing dialogue about how architecture might re-consider and engage in cycles of growth, decay, and renewal.

7.1 Project Summary

This chapter revisits the research question: In what ways can architectural design embrace material temporality with biomaterials and decomposition to create a continuous cycle of life between built environments and supporting ecological regeneration?

The research challenged the conventional notion of architectural permanence, the ideal yet unrealistic expectation that buildings should last forever, and instead explored how architecture might return to the earth at end-of-life. It was motivated by the recognition that one of New Zealand's pressing environmental issues is the impact of urbanisation and construction waste. The intention was to reposition decay not as failure but as transformation, where discarded materials can nurture new ecological life.

Although sustainability is increasingly acknowledged within the architectural industry, the focus remains on longevity, efficiency, and technological solutions rather than on natural processes of change. Degradation is still treated as damage, and nature as something separate from architecture. This project does not propose that all architecture should decompose; instead, it speculates on how certain forms could be designed to exist temporarily, participating in ecological cycles and supporting regeneration at the end of their lifespan.

Using speculative design as its method in this practice-led thesis, the research examined how a building might physically and conceptually decompose over time. Through material research, ecological analysis and iterative design, the project explored how biodegradable biomaterials could perform within New Zealand's climate, how wildlife might interact with decaying structures, and how built form could transition from dwelling to habitat. By imagining buildings as temporary participants in wider living systems, the project sought to broaden architecture's role in supporting ecological continuity rather than environmental extraction.

7.2 Theoretical Ideas

The theoretical grounding of this project lies within post humanist and posthuman feminist thinking, which challenge the anthropocentric ideology embedded in conventional contemporary architecture. These frameworks suggest that humans are not separate from material or ecological systems but are participants within a wider network of agencies, in which materials, organisms, and environments shape one another. In this context, biomaterials were not treated as passive resources but as active agents with their own lifecycles, capacities, and ecological effects alongside inhabitants.

The concept of synanthropy, meaning species that thrive in human environments, also played a key role in shaping the project's perspective on cohabitation. Rather than viewing nonhuman inhabitants such as birds, fungi, or insects as nuisances or pests, the project reframed them as important participants in architectural transformation and ecological succession as active agents. This approach allowed the design to speculate on buildings as living systems that evolve, host, and decay in dialogue with surrounding ecologies.

Through these theoretical lenses, the project reimagines architecture as a mediator of relationships between humans and nonhumans — one that embraces decay, temporality, and regeneration as part of design intention. While speculative, this reframing encourages a more-than-human understanding of architecture: one where the building's end of life is not a moment of failure, but a continuation of its ecological agency.

7.3 Aims, Objectives & Outcomes

At the beginning of this research, the project aimed to explore how the agential capacity of materials participates in cycles of transformation, decomposition, and ecological renewal. It explored how architecture might embrace material temporality through biomaterials and decomposition to create a continuous cycle between built environments and ecological regeneration. The goal was to shift away from viewing buildings as permanent and static and instead imagine them as living systems capable of change, decay, and renewal.

Initially, the objectives were to:

- Analyse architectural case studies and theoretical frameworks that inform alternative approaches to temporality, decay, and ecological regeneration.
- Identify a range of sustainable and biodegradable biomaterials suitable for architectural applications in New Zealand.
- Analyse in depth the life cycles of these materials, focusing on how they break down at end-of-life and their potential ecological contributions towards nature and wildlife.
- To develop speculative design strategies, such as diagrams, timelines, and representational experiments, that explore how biomaterials might transition from construction to decomposition.
- Apply the findings in a speculative architectural design for a small home that tests how buildings can be designed to return to the earth and extend native ecologies into suburban contexts
- Reflect on how such practice-led design approaches can support broader goals of climate adaptation, carbon storage, and urban ecosystem revitalisation.

While these objectives remained consistent, their emphasis shifted as the research progressed. Early work was strongly material-driven, identifying and analysing biomaterials for their environmental performance and decomposition potential. However, as the project developed, the focus expanded beyond material behaviour to include ecological and temporal relationships; how architecture might not only degrade but actively support the emergence of new life.

The project then moved towards design speculation, using architectural design to visualise and test how decomposition could be integrated into a building's lifecycle.

The outcome, a speculative design for a two-storey biodegradable house, reflects this transition. It demonstrates how architectural form, materiality, and ecological processes can be designed together to enable controlled decomposition and regeneration. The research therefore met its aim of reframing architecture as a temporal and ecological system rather than a static object.

Critically reflecting on the aims, the project achieved its goal of reimagining architecture as a temporal, ecological process. However, it also revealed limitations: while decomposition can be imagined and represented, it is far more complex to control or predict in real conditions. The research therefore succeeds conceptually, proposing a framework for regenerative, time-based design, but remains speculative in application, inviting future exploration into the material, scientific, and cultural dimensions of architectural decay.

7.4 Key Findings & Insights

Through the course of this research, several key insights emerged about how architecture can engage with material temporality, biodegradation, and ecological regeneration.

One of the most significant insights was a shift in understanding material lifespan. Traditionally, architecture measures success through durability and resistance to decay, but this project showed that decomposition can also hold architectural value when intentionally designed. Biodegradable materials such as straw, timber, and hempcrete can act as active participants in ecological cycles — not simply deteriorating, but transforming, enriching soil, and supporting new life. This challenges the assumption that permanence defines success, proposing that planned impermanence can be equally valuable when aligned with regenerative goals.

As material exploration progressed, it became clear that biomaterials decompose in different ways and at different rates. Limestone, initially considered for its durability and soil benefits, does not biologically decompose like timber or straw. It erodes slowly rather than breaking into organic fragments, and therefore does not return nutrients to the soil in the same way. While limestone can improve soil pH, its centuries-long lifespan meant it offered little ecological contribution within a timescale relevant to the project. This limitation prompted a significant material shift during design development.

The research also highlighted the importance of understanding material chemistry. Discovering that Terra Lana sheep wool insulation contains polyester, required for structure and standards compliance, showed that even products that are labelled sustainable may include synthetic additives that limit their ability to safely return to the earth. This reinforced the need for critical, detailed analysis of any material's true sustainability.

Learning about timber species and durability classes (softwoods, hardwoods, and classes 1–4) deepened understanding of how species choice affects lifespan and decay. This knowledge informed which untreated timbers could provide sufficient structural strength while remaining biodegradable after use.

The project also demonstrated that speculative design is a valuable tool for exploring regenerative futures. By stepping beyond technical or regulatory constraints, the design phase enabled conceptual experimentation, testing how architecture might decompose, host nonhuman life, and participate in ecological succession. The speculative approach enabled architecture to be imagined not as a static object, but as an evolving organism designed to live, die, and return to the earth.

Collectively, these findings refined the project's understanding of biomaterial architecture, shifting from idealised notions of "natural" decay to a more nuanced view that balances performance, chemistry, and temporality while embracing decay as an intentional ecological process.

7.5 Limitations & Recommendation for Future Research

The lifespan of biomaterials in buildings, their performance in New Zealand's climate, and the complexity of their decomposition processes could not be fully assessed within the timeframe of a one-year thesis. The method of construction itself also plays a significant role in determining material longevity (Jones & Brischke, 2017). As a result, much of the analysis relied on secondary research, precedent studies, and speculative exploration rather than long-term testing or empirical data. Future studies could expand upon this through laboratory testing, extended field trials, or interdisciplinary collaborations with material scientists to better understand how biomaterials perform over decades and how their end-of-life transitions unfold in real-world conditions.

The project investigated a broad range of materials, including timber, straw, cork, bamboo, mycelium, hempcrete, rammed earth, limestone, adobe, rice husk, and sheep wool. While these various materials offered valuable comparative insight, it also limited the depth of testing and making possible within the project's scope. Time constraints required prioritising material research and speculative design over physical prototyping. Future research could therefore focus more deeply on a smaller selection of materials to produce measurable data on their mechanical, chemical, and ecological performance.

A further limitation lies in the availability and consistency of literature on biomaterials. Information regarding their rate of decay, environmental impact, and long-term behaviour is often sparse, based on international data rather than local conditions or is varying in results. This gap highlights the need for more comprehensive, region-specific datasets and life-cycle analyses of biomaterials within New Zealand's climate. Establishing such data would be valuable for future researchers and practitioners working toward sustainable, biomaterial use in New Zealand.

The speculative nature of the project also introduced limitations. As a conceptual design, practical aspects such as pest management, regulatory compliance, and construction feasibility were addressed only at a theoretical level. Future research could expand these areas to examine how biodegradable architecture might coexist with pest control strategies or align with initiatives such as Auckland's Predator Free 2050 plan. Collaborations with councils, environmental agencies, and manufacturers could support the development of new regulatory pathways for biodegradable materials that ensure both safety and ecological benefit.

Material availability presents another significant challenge. Some materials identified as suitable for New Zealand's environment — such as cork and rice husk — are not currently produced locally due to climatic or economic constraints. Further research could explore the feasibility of cultivating these materials domestically or substituting them with regionally available bio-wastes to support circular economies and material self-sufficiency.

While these limitations restricted the empirical reach of the research, they also point toward rich opportunities for future interdisciplinary collaboration. Integrating design experimentation with scientific testing, ecological monitoring, and material innovation could help advance biodegradable architecture from speculative concept to viable, regenerative practice in New Zealand.

7.6 Wider Application

This research was developed with insights from practice-driven design, ecological theory, extensive material research and speculative architecture design. Gaining a clearer understanding of how biomaterials can participate in cycles of decay and renewal has provided a framework for rethinking how architecture might coexist with natural processes rather than resist them.

The speculative design outcomes proposed are not intended as practical, buildable solutions but as conceptual provocations. They test how biodegradable materials and ecological succession could reshape architectural lifespans and challenge current perceptions of permanence. While these interventions cannot be realistically applied without further testing and refinement, they serve as models for how design might operate within living, changing environments.

The geographical location where the project was situated on a single site in Glen Eden, a threshold between suburban Auckland and the Waitākere Ranges, its geographic specificity highlights both the ecological potential of the area and the threat posed by suburban intensification. Extending this approach across multiple suburban sites across the suburb, and possibly in the future, among other Auckland suburbs, could form an interconnected system of regenerative dwellings, gradually expand native habitats and re-establish ecological continuity between the city and the forest.

7.7 Unanswered Questions & Emerging Tensions

While this research expanded understanding of material temporality and regenerative design, several questions remain difficult to resolve and point toward areas requiring further investigation, particularly if such concepts were to be applied to future practice or pursued in continued research. Designing for coexistence with species typically deemed pests, for instance, raises tensions between ecological generosity and human health or maintenance concerns. Similarly, although the project imagines built environments that support nonhuman habitation, it is unclear how such spaces can remain safe, comfortable, or socially acceptable for human occupants.

Allowing architecture to decompose also challenges conventional measures of performance. If a building's purpose includes decay, there is no established metric for evaluating its success: should performance be assessed through ecological contribution, duration, stability, or rate of disintegration? This leads to broader questions about authorship and control. How much of the decomposition process should architects intentionally design, and at what point should natural processes take precedence?

These uncertainties reveal an ethical dimension as well. There is an unresolved boundary between "designing for decay" and relinquishing control altogether, raising questions about responsibility, intention, and the extent to which architects can shape processes that unfold long after human involvement ends, and whether they should intervene at all. Rather than providing definitive answers, these tensions highlight the complexity of designing within ecological timescales and point toward future research in both material science and environmental ethics.

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Figures

All figures not included on this list are the authors own images

Appendix

Material Glossary

Timber

Description: A solid, fibrous material with a warm, natural grain pattern. Comes in various tones (light blondes to deep browns) and textures, from rough-sawn to polished smooth, different species (oak, spruce, cedar and pine).

Biomaterial Identity: Renewable, organic, carbon-sequestering plant material from trees.

Climate Contribution: Stores carbon during tree growth; low embodied energy if locally sourced.

Source: Harvested from trees; sustainably sourced timber is usually certified and comes from managed forests.

Architectural Use: Structural framing, cladding, flooring, decking, windows, joinery.

End of Life: Can be reused, upcycled, or shredded into mulch. Untreated timber biodegrades fully and enriches soil.

Plant Growth Support: Can be shredded into mulch, improving soil structure and moisture for seedlings.

Wildlife & Insects: Fallen timber habitats support fungi, beetles, birds, and small mammals.

Note: Timber sequesters carbon during its lifespan, making it valuable for sustainable design.

Straw

Description: Lightweight stalks, golden-yellow in colour with a coarse texture.

Biomaterial Identity: Agricultural residue from grain harvests; reused waste.

Climate Contribution: During the growth of the straw, the plants absorb carbon dioxide through photosynthesis.

Source: A byproduct of harvesting grains (wheat, barley, rice), specifically the dried stalks left behind after the grain heads are removed.

Architectural Use: Wall insulation (straw bale construction), thatching for roofs, straw-clay infill, acoustic panels.

End of Life: Fully biodegradable; can be composted or integrated into soil.

Plant Growth Support: Composts into carbon-rich soil additives that improves fertility and aeration.

Wildlife & Insects: Straw stacks and decomposing material provide shelter for insects, birds, and soil organisms.

Note: Good for thermal and sound insulation, straw bales can be used to build load-bearing walls in construction, compressed straw can be surprisingly fire-resistant

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Cork

Description: Soft, spongy texture with a mottled, cellular appearance. Natural tan-brown colour with variation.

Biomaterial Identity: Bark harvested from cork oak trees without cutting them down and regenerates naturally.
Climate Contribution: Trees absorb CO_2, production is low-waste.

Source: Harvested from the bark of cork oak trees (every 9–12 years) without harming the tree.

Architectural Use: Flooring, wall cladding, acoustic panels, insulation.

End of Life: Recyclable or compostable if untreated. Granules can be reused in panels or soils.

Plant Growth Support: Ground cork slowly decomposes, improving soil aeration and retaining water.

Wildlife & Insects: Its porous, insulating texture mimics natural bark environments for insects. As cork slowly biodegrades, especially when untreated, it can host fungi, mosses, and beneficial microbes. These microbes and fungi, in turn, attract insects like springtails, isopods, and mites—important parts of soil food webs.

Note: Naturally water-resistant but not waterproof, antimicrobial, and fire-retardant.

Bamboo

Description: Hollow, jointed stalks with a smooth outer surface; light yellow to greenish-brown in colour.

Source: Rapidly renewable grass species, harvested in 3–5 years.

Biomaterial Identity: Fast-growing grass with woody stalks, harvested within 3–5 years.

Climate Contribution: Sequesters carbon rapidly; regrows without replanting; minimal processing.

Architectural Use: Framing (especially in lightweight structures), flooring, wall cladding, ceiling panels, furniture.

End of Life: Biodegradable or compostable if untreated. Can also be chipped and reused as mulch.

Note: Stronger than many hardwoods by weight, and fast-growing.

Mycelium

Description: Fungal root system with a fibrous, lightweight, sponge-like texture. Cream to light brown in colour.

Source: Grown in molds by feeding fungi agricultural waste (like corn husks or sawdust).

Biomaterial Identity: Living fungal tissue grown into form using agricultural waste.

Climate Contribution: Low-energy, biodegradable material that consumes organic waste during growth.

Architectural Use: Insulation panels, acoustic tiles, interior cladding.

End of Life: 100% compostable; returns nutrients to soil and supports plant growth.

Plant Growth Support: Decomposes into mycelial networks that form symbiotic (mycorrhizal) relationships with plant roots.

Wildlife & Insects: Supports soil fungi, beneficial bacteria, and microfauna; promotes a healthy underground biome.

Note: Naturally fire-resistant, water resistant to a certain point – but best to keep away from water or wet weather conditions (not using it on building exteriors).

Hempcrete

Description: Lightweight concrete-like composite with a coarse, fibrous texture; pale beige or grey in tone.

Source: Made from chopped hemp stalks (shiv) mixed with lime binder and water.

Biomaterial Identity: Composite of hemp hurds (plant-based) and lime, combining organic and mineral elements.

Climate Contribution: Carbon-negative and absorbs more CO2 during hemp growth and curing than it emits

Architectural Use: Wall infill, thermal insulation, non-load-bearing walls.

End of Life: Breaks down slowly; lime component improves soil pH. Can be crushed and used as soil amendment.

Plant Growth Support: Crushed hempcrete can improve soil pH and texture, particularly in acidic soils.

Wildlife & Insects: Decomposed particles offer soil aeration for burrowing insects.

Note: Breathable, mold-resistant, resistant to pests like termites, rodents, and ants and carbon-sequestering during curing.

Rammed Earth

Description: Compressed layers of soil and aggregates with a stratified, earthy appearance. Dense and stone-like texture.

Source: Locally sourced soil mixed with clay and small stones, compacted in formwork. Sometimes mixed with concrete for stabilisation

Biomaterial Identity: Unfired natural soil compacted into solid walls and minimally processed earth.

Climate Contribution: Extremely low embodied carbon; no firing or chemical processing required.

Architectural Use: Walls (load-bearing and decorative), thermal mass elements.

End of Life: Fully returnable to the ground. Can be broken down and re-integrated into landscapes.

Note: Offers excellent thermal mass and a natural aesthetic.

Limestone

Description: Pale cream to grey sedimentary rock with a fine grain and subtle veining.

Source: Quarried from natural limestone deposits.

Biomaterial Identity: Naturally occurring sedimentary rock; minimally processed or calcined into lime.

Climate Contribution: High embodied carbon if fired into quicklime; low if used raw. Helps offset acidity in soils post-use.

Architectural Use: Cladding, paving, mortar, limewash, or lime render (when processed), load-bearing walls and foundational elements.

End of Life: Crushed limestone can be reused in aggregates or as a soil amendment to reduce acidity.

Plant Growth Support: Crushed limestone neutralises acidic soils, creating favorable growing conditions.

Wildlife & Insects: Limestone outcrops host lichens, mosses, and small insects; lime applications can enhance microbial diversity in acidic soils.

Note: Lime absorbs excess moisture from the air and releases it when conditions become dry. This ability makes lime a natural humidity regulator, maintaining balanced indoor moisture levels and improving indoor air quality.

Adobe

Description: Sun-dried earthen bricks made from clay, sand, water, and straw. Coarse, crumbly surface in warm, earthen hues.

Source: Locally sourced clay soil mixed with organic fiber.

Biomaterial Identity: Mix of earth, straw, and water, also entirely organic and locally sourced.

Climate Contribution: No firing = low embodied energy; uses local resources and passive solar mass.

Architectural Use: load-bearing walls, foundations, roofs, and even interior finishes.

End of Life: Fully biodegradable; crumbles into the earth and supports plant life.

Plant Growth Support: Fully compostable and soil-like; breaks down into clay and straw to support plant roots.

Wildlife & Insects: Adobe walls are known to shelter birds and insects; their decay provides loose soil habitats.

Note: Great for dry climates.

Rice Husk

Description: Thin, flaky shells from rice grains, light brown with a rough, papery texture.

Source: Agricultural byproduct of rice processing.

Biomaterial Identity: Agricultural waste from rice milling; used as filler or aggregate in construction.

Climate Contribution: Upcycles waste material; sometimes used as fuel in low-emission brick kilns.

Architectural Use: Composite panels, insulation, cement additive, or burned as fuel in brickmaking.

End of Life: Biodegradable when used naturally. Adds silica and porosity to soil when composted.

Plant Growth Support: Adds silica to soil, enhancing strength and pest resistance in certain plants.

Wildlife & Insects: Composting husks feed soil microbes and invertebrates, improving habitat quality.

Note: Increasingly used in circular building materials.

Sheep Wool

Description: Soft, fibrous texture with natural curl and lanolin-rich feel. Off-white to cream color.

Source: Harvested from live sheep through shearing.

Architectural Use: Thermal and acoustic insulation (batts, rolls), natural plasters.

End of Life: Fully compostable; slowly releases nitrogen into the soil.

Note: Excellent at regulating humidity and fully renewable.

Wood Species

Class 1 (very durable) >25 years	Class 2 (durable) 15-25 years	Class 3 (moderately durable) 5–15 years	Class 3 (moderately durable) 5–15 years	Class 4 (non-durable) <5 years
Hardwoods	**Hardwoods**	**Hardwoods**	**Softwoods**	**Hardwoods**
Eucalyptus cladocalyx	*E. amygdalina*	Black beech[2]	Japanese cedar[2]	*Paulownia elongata*
Robinia	*E. botryoides*	Blackwood[2]	Kaikawaka[2]	*Paulownia tomentosa*
	E. cornuta	*E. globulus*[2]	Kauri[2]	Poplar
	E. globoidea	*E. sieberi*[2]	Larch[2]	Tawa
	E. muelleriana	Gleditsia[2]	Lawson cypress[2]	Silver wattle
	E. pilularis	Southern rata[2]	Lusitanica[2]	
Softwoods	*E. radiata (p)*	*E. fastigata*[1]	Macrocarpa[2]	**Softwoods**
Silver pine	*E. saligna*	*E. delegatensis*[1]	Matai[2]	*P. nigra*
Totara	European oak	*E. fraxinoides*[1]	Redwood[2]	
	Hard beech	*E. obliqua*[1]	Rimu[2]	
	Mountain beech	*E. pyrocarpa*[1]	Tanekaha[2]	
	Red beech	*E. viminalis*[1]	Western red cedar[2]	
	Sweet chestnut	*E. regnans*[2]	Douglas fir[1]	
		Hinau[1]	Leyland cypress[1] (p)	
		Mangeao[1]	Miro[1]	
		Pukatea[1]	*Pinus contorta*[1]	
		Silver beech[1]	*P. muricata*[1]	
			P. radiata[1]	
			P. strobus[1]	
			P. ponderosa[1]	

[1] Species with durability towards the lower end of the range.
[2] Species with durability towards the upper end of the range.
(p) Provisional classification, species still in test.

Appendix A - In-ground natural durability classification for the heartwood of NZ-grown species (50 min square stakes

The chart above categorises timber species into four durability classes, ranging from Class 1 (very durable, >25 years) to Class 4 (non-durable, <5 years) (Page & Singh, 2014). These classifications measure how well the heartwood of each species naturally resists decay, fungi, and insect attack — especially when used outdoors or in contact with soil. Understanding these durability levels is crucial in biodegradable architecture, as they determine both the building's functional lifespan and the pace at which it will decompose and return to the earth.

Class 1 timbers, including tōtara, silver pine, and Eucalyptus cladocalyx, are the most durable, capable of lasting for several decades even in exposed conditions. These are well suited for major structural elements such as framing or cladding that need long-term stability. In the context of biodegradable design, their slow decomposition rate means they provide structure for longer before gradually breaking down, offering habitat for fungi, insects, and small organisms during the later stages of decay.

Class 2 timbers, including Eucalyptus amygdalina, E. saligna, and E. pilularis, offer good durability with lifespans of around 15–25 years. These are ideal for external cladding, decking, or framing that benefits from weather resistance without the need for chemical treatment. Their moderate lifespan also makes them appealing within regenerative design frameworks, as they eventually decompose without long-term persistence in the environment.

Class 3 timbers, such as Douglas fir, macrocarpa, and rimu, provide moderate durability (5–15 years). These are commonly used for interior framing, joinery, or sheltered exterior applications where exposure is limited.

In the context of biodegradable architecture, these timbers offer a balance between structural reliability during use and manageable decomposition rates at end-of-life, making them suitable for experimental housing like the two-storey design proposed in this thesis.

Finally, Class 4 timbers, such as poplar, tawa, and silver wattle, are considered non-durable and typically unsuited for structural or exterior applications without treatment. However, their low durability can be beneficial for temporary structures or design components intended to break down quickly — contributing organic matter back into the soil as part of a planned ecological succession process.

For this research, locally available species such as Douglas fir, macrocarpa, and certain Eucalyptus types offer the most appropriate balance of strength, biodegradability, and availability. These timbers allow for architectural experimentation while aligning with the project's goal: to design buildings that age, decompose, and reintegrate into the landscape rather than resist it.

This classification system highlights the delicate relationship between durability and decay central to this thesis. While highly durable timbers ensure longevity, the project instead embraces those that naturally degrade — allowing the building to transition from structure to soil, contributing to new ecological growth.

Material Making

During the early stages of the developed design, small-scale material samples were produced using a range of biomaterials, including gelatine, straw, seaweed, eggshells, and fruit pulp.

These experiments allowed observations of how each material behaved and cured over time at a small scale.

Appendix B - Material Sample Experiments

Appendix C - Series of Biomaterial Models