SLOW BIODESIGN

A bioreceptive approach for multispecies participatory design practices

Barbara Pollini

Design Department, Aalto University, School of Arts, Design and Architecture, Helsinki, Finland
barbara.pollini@aalto.fi

ABSTRACT

In the emerging practice of biodesign, living organisms are active components of the design process for creating biofabricated materials, living artefacts, or systems. In this context, an interesting and overlooked aspect is the role of design in creating abiotic elements to support living agents. Bioreceptive artefacts, namely life-enabling materials and structures able to host and enhance biological colonisation, can be addressed in multispecies design approaches, considering human and non-human needs.

This contribution explores the potential of low-tech bioreceptive design practices for multispecies design. Drawing on a project by the author, *Designed Wilderness: Minimum Viable Ecosystems*, the study reflects how craft can contribute to biodiversity and multispecies encounters. The project foresees the creation of clay-sculpted artefacts as a platform for multiple species to co-author a collaborative and open-ended design path. Moreover, bioreceptive artefacts can support relational approaches in biodesign, cultivating an aesthetic of wonder that follows the evolution of the adaptive surfaces, intended here as multispecies participatory design practices.

As human activities increasingly reshape our built environments into low-biodiversity landscapes, the urgency of creative and effective strategies for species integration and conservation has never been more pressing. Bioreceptive artefacts, co-evolving with nature's rhythms, can act as catalysts for new life forms, becoming habitable spaces and living laboratories that foster design practices that contribute to multispecies coexistence.

BIORECEPTIVE DESIGN, AN EMERGING APPROACH IN BIODESIGN

Biodesign is a nascent discipline that entangles design and creative practices with sciences such as biology, bioengineering, chemistry, and materials science (Ihls & Pollini, 2025). Material experimentation is widely explored in the field, spanning from biomass-based sources to biofabrication to inert materials' bioreceptive properties. Focusing on the latter, bioreceptivity has been addressed as "the totality of material properties that contribute to the establishment, anchorage and development of fauna and/or flora" (Guillitte, 1995, p.216), Materials' bioreceptivity has historically been referred to as "biodegradation" and "biodeterioration" of the built environment until the late-60s and has most often been associated with negative connotations (Sanmartín et al., 2021). Still, in Biodesign, this material feature can be particularly interesting, as the livingness of materials and artefacts is emerging as a design option (Karana et al., 2020). In this perspective, the design of the inert counterpart supporting life is gaining momentum, defining the design of abiotic elements to support living agents as Bioreceptive Design (Cruz & Beckett, 2016; Pollini & Rognoli, 2021). Life-enabling materials, namely bioreceptive materials and structures able to host and enhance biological colonisation, can be addressed in multispecies design for different purposes, such as increasing the biodiversity of a site or restoring a depleted area (Pollini & Rognoli, 2021).

During my doctoral studies, I explored bioreceptive design from a theoretical perspective, analysing some of the early case studies related to the concept of *intentionally designed materials/artefacts to be colonised by life forms,* and outlining a procedural thinking to support designers in the development of new bioreceptive materials and artefacts. Design for bioreceptivity focus on dynamically matching three main variables mediated by design: the organism requirements, the environmental conditions, and the intrinsic material properties; the design of the material accommodates the organisms needs according to environmental conditions, working on different parameters, such as material composition, shapes and textures and adjusting nutrients, porosity, colors and specie-related affordances (Pollini & Rognoli, 2021).

To test this approach and the potential of Bioreceptive Design, I initiated an interdisciplinary research-through-design project to develop materials and surfaces receptive to mosses and lichens for use as biosensors in biomonitoring activities in urban environments (Pollini et al., 2023). Thanks to this project, I was able to fully grasp the potential applications of this design approach, which might easily translate into architectural, remedial, biophilic, and regenerative applications (Pollini et al., 2023). In this project, the design objectives were achieved by adopting a computational design approach and using additive manufacturing as a core activity; however, I also began to consider a more craft-based approach to test alternatives to reduce the time required to make prototypes. In fact, clay 3D printing can be time-consuming compared, for example, to 3D printing plastic stamps to be subsequently used as stamps in a

ceramic studio. I approached this second technique to be able to create multiple material samples to test different bioreceptive variables and materials compositions in a reasonable amount of time (as these variables would require further extensive adjustments for a 3D printing process), and this was the start of a personal reflection about the use of craft in biodesign.

Biodesign is often associated with lab settings, given the need for safety and hygiene protocols when working with living organisms; however, for bioreceptive design, this is not always the preferred work setting, as it entails living interfaces, whose applications often involve urbanised or wild environments. In this context, a craft approach seems appropriate and feasible, at times a deliberated design choice. Another pivotal moment for this reflection has been an interview with Nigel George, co-founder of Artecology (Pollini, 2023), a not-for-profit organisation specialising in *nature inclusive designs and eco-engineering.* Artecology uses an eco-engineering approach to improve wildlife habitats by creating designed elements, including hand-sculpted elements. Nigel described his work as *artworks with an ecological function*; the accessibility of some of the techniques used in their creation allows him to involve local communities in the creation of bioreceptive artefacts easily. Discovering his approach to bioreceptive design was another invitation to consider the many advantages a craftier approach might offer in the field.

Observing some of the prototypes I created for the project on biomonitoring over time has also helped me understand that Bioreceptive design often adopts simple, basic rules (such as material porosity and water channelling) that can attract different life forms, creating an ecological service that goes beyond the targeted species, and that can easily transform into an autonomous and regenerative system. Only a niche of Biodesign projects tend towards such regenerative processes; this possibility coincides with the artefact's ability to create a system that can regenerate, namely *one that can evolve, self-organise, and propagate* without any further human maintenance (Pollini & Rognoli, 2024). The prototypes developed to test bioreceptive materials targeting lichen and mosses showed this possibility, acting as a support for the moss's autonomous life, and serving little insects and snails that were observed over time taking advantage of the protective environment resulting from the colonised prototypes over time, not to mention the microbial life inhabiting the same space undisturbed and invisible to the human eye. In fact, in a first study on bioreceptive materials for biomonitoring, we were able to observe the pioneer species coconneis placentula using Scanning Electron Microscopy, otherwise visible to the naked eye only as a green patina (Pollini et al., 2023).

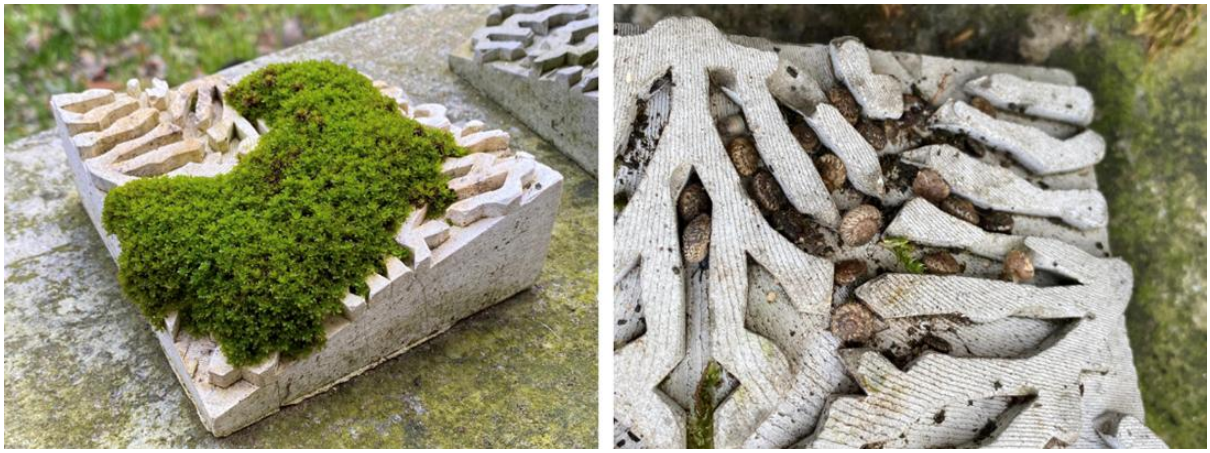

Figure 1

Prototypes developed to test moss transplant viability for biomonitoring (Pollini et al., 2023), which accidentally became shelter for little snails

SLOW BIODESIGN: DESIGNED WILDERNESS, MINIMUM VIABLE ECOSYSTEMS

Reflections made retrospectively on the first project and matured over time - a time that follows the rhythm of the spontaneous colonisation of lichens and mosses that requires long-term observation – facilitated ideas for a new exploration of bioreceptivity in Biodesign. After my PhD, in the summer of 2024, I decided to explore bioreceptive design under the light of craftsmanship, slow colonisations, and the art of noticing. I called this approach ***slow biodesign***, meaning *an approach that foresees and embraces the slowness, variability and unpredictability of both material making and spontaneous colonisation*. The project, titled *Designed Wilderness, Minimum Viable Ecosystems,* consists of bioreceptive sculptures made in ceramics as a means to encourage spontaneous colonisation by living organisms, transforming the artefacts over time into habitable spaces for a multitude of situated species, might them be microalgae, mosses, or insects, transforming a designed object into a small ecosystem. Unlike the previous project, which targeted specific species, I wanted to maintain a more artistic, less scientific approach, letting chance and time decide who would benefit most from the presence of these bioreceptive artefacts in a given environment.

In spring 2024, a set of five small sculptures (average size: 12 x 6 x 6 cm) was created in unglazed fired red clay. Red clay was selected as previous prototypes showed better results than white clay in microalgae colonisation. Red granite has also been observed to stimulate algal colonisation, suggesting that this colour might be more attractive to pioneer species than other colours (Sanmartín et al., 2020). The artefacts are unglazed, with only minor coloured details in ceramic slip (Figure 2). In this project, bioreceptivity is ensured through the material's porosity, which naturally occurs in unglazed ceramics (Portillo et al., 2011), and roughness is increased through pattern design that creates small cavities and microgrooves (Mustafa et al., 2021). Moreover, organic shapes create larger niches, where dust, ground,

spores, and seeds can sediment, serving as secondary bioreceptivity, as exogenous deposits that modify the initial material bioreceptivity (Guillitte, 1995). Material composition was not addressed in this project because the primary goal was to focus on relationality and observation in multispecies design.

A relational approach to the material started with the sculpting process. In the computational approach, the form is defined digitally beforehand and then printed, incapable of undergoing further changes without repeating the digital production process. This separation between thought forms and material making prevents a design that evolves in the process. In contrast, during manual sculpting, designers can think while making, following the material's rhythm and cues, with the freedom to modify their design in the making. For this project, I didn't begin by sculpting artifacts that I'd previously studied in detail on purpose, but I did have formal objectives, such as organic shapes, niches for insect nesting and for the sedimentation of dust, soil, or organic material, and bioreceptive textures such as holes or lines that would create a surface accessibility to biofilm and other organisms. In line with Malafouris' Material Engagement Theory (Malafouris, 2013, 2019) and the material agency described in New Materialism (Bennett, 2010), this indeterminacy in the initial design allowed me to make design decisions as I modelled, based on the opportunities suggested by the material in the making, and by the envisioned bioreceptive scenarios. Specifically, the idea that clay's affordances actively shape the design process described by Malafouris (2019) closely matches the possibility of a relational, slow design, which requires time to listen to the matter and to envision multiple options emerging during the making.

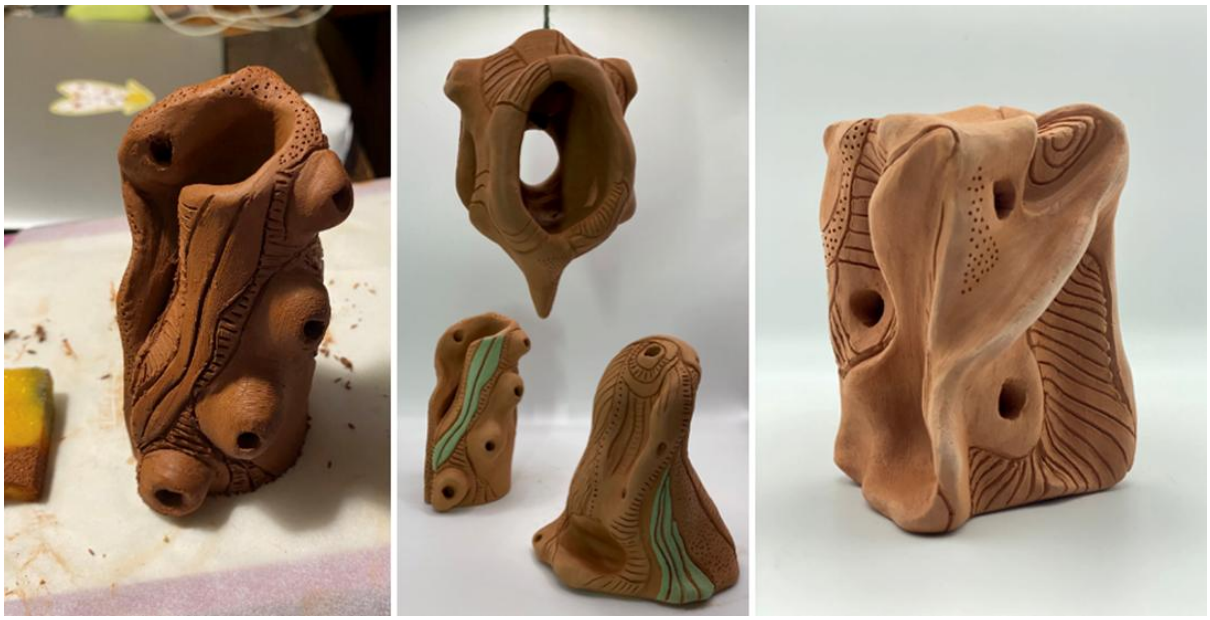

Figure 2

Part of the bioreceptive sculptures in the making (image on the left), and right after firing (center and right)

In bioreceptive design, however, material agency reaches another level of complexity when material features translate into affordances for a multitude of species that will continue to co-design on a surface level. After the firing, the bioreceptive sculptures would be ready for display in natural, rural, or urban environments, including gardens and balconies, as potential habitats. However, I decided to transplant some mosses and lichens to potentially make the artefacts look less sterile and boost the colonisation process.

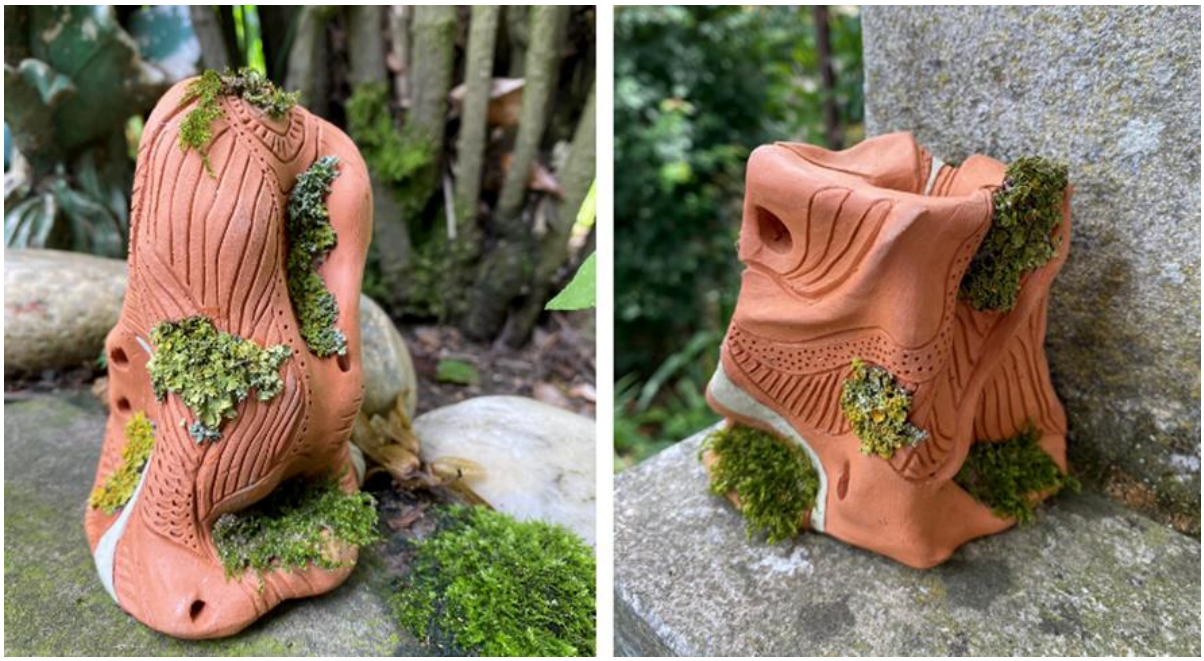

Figure 3

Bioreceptive sculptures with transplanted mosses and lichens

Mosses' transplant was possible thanks to the niches created during the modelling phase, which allowed the deposition of a few millimetres of soil useful for a lasting, regenerative transplant. Lichen transplant was possible using a starch-based bioplastic as a glue. These transplants on the fired pieces were also intended to increase the artefact's biophilic potential. Bioreceptive materials can provide a *visual connection to natural systems*, a biophilic pattern linked to improved health behaviours, environmental awareness, and psychological restoration (Sahu, 2021). Bioreceptive artefacts can definitely enable biophilic experiences through dynamic, textured, and organic shapes, but they reach their biophilic potential when serving as living interfaces that enhance greenery and multispecies habitats.

As the bioreceptive sculptures are exposed to the natural environment, their appearance changes quickly: they accumulate dirt and dust, various animals take advantage of the green enrichment transplanted (sometimes eating it away), and, slowly, the artefacts start to be covered in a biofilm. This allows pioneer species to prepare the ground for the slower-growing species that will follow in the spontaneous colonisation of the piece. A complete colonisation process will take years, but from the first days of exposure, different species will interact and leave their mark, participating in the ongoing transformation of the piece.

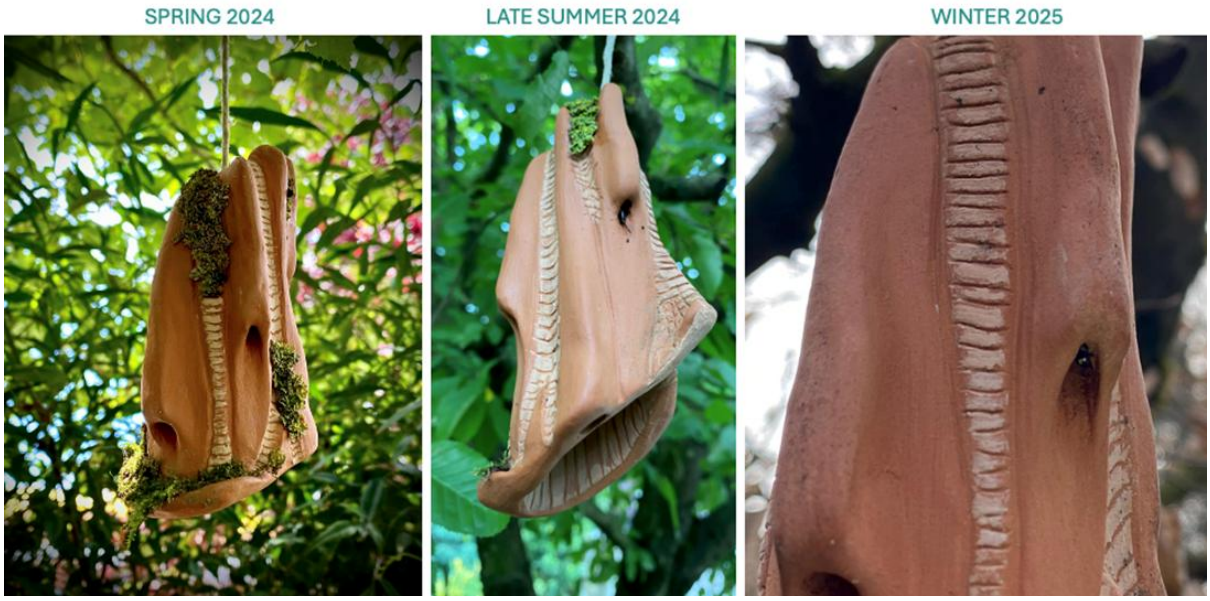

Figure 4

Changes over time of a bioreceptive bell. In the center and on the right, images show how the bell loses some of its green decoration but is inhabited and visited by insects over the seasons

MULTISPECIES PARTICIPATORY DESIGN PROCESSES

In this project, bioreceptive artefacts act as a platform for multiple species to co-author a collaborative and open-ended design path, becoming a pretext for reflection and connection based on human observation of the pieces' evolution over time.

The *art of noticing* has been defined as a process of understanding non-humans and natural systems based on multi-sensorial observation (Liu et al., 2018; Rosén et al., 2024; Tsing, 2021). In my exploration of Bioreceptive Design, the art of noticing (here intended as a slow, recursive, and attentive observation of natural dynamics in urbanised environments) has been fundamental to grasp a relational understanding of the organisms I was addressing alongside scientific knowledge. My interest in lichens began with regular observations during dog walks in a city park in a small town in the Po Valley, one of the most air-polluted regions in Italy and Europe (Marinoni et al., 2025). My attention was caught by a lichen about 5 centimeters in diameter sitting on a streetlamp's plastic pole, whose scientific name I didn't even know at the time. I later discovered that the lichen was a Xanthoria parietina, a cosmopolitan specie that tolerates polluted human environment, which became the target species for the biomonitoring research project (Pollini et al., 2023). The frequency with which I observed it taught me how it behaved, changed with the seasons, and grew over time. What was dry, fragmented at the center, and seemingly fragile in summer, transformed with the cold and rains of autumn into a regular, lush bouquet of bright colours. This fascination led me to investigate more lichens in the context of my discipline, Biodesign, and to rely again on the art

of noticing to detect patterns of growth in lichens and mosses across surfaces, weather conditions, and orientations, among other parameters. The art of noting, and the possibility that this act of attention could lead to a better relational understanding of non-humans and natural systems, also became the final goal of the project, *Designed Wilderness, Minimum Viable Ecosystems.*

In Bioreceptive Design, the time frame of observation can be extensive. Designing with living organisms, the time scale can highly influence the user experience, and this project has also been fundamental to my research path in understanding different temporalities in Biodesign. If commonly used organisms in the field, such as mycelium, bacteria, or algae, can grow in weeks and are considered fast renewable; this cannot be said of mosses and lichens, which grow only a few centimetres per year. In line with indigenous knowledge principle that *design is how all living beings co-operate to co-create* (Moran et al., 2018), the waiting for organisms changes, growth and colonisation brings human observers closer to the temporalities of others-than-human, stimulating temporal ecologies and relational approaches in tune with the biological rhythms of the organisms observed (Pollini & Kääriäinen, 2025; Williams, 2022). Moreover, when other species start to be considered as co-creators, as often claimed in biodesign (Collet, 2020; Davidova, 2017) and definitely evident in bioreceptive design, multispecies collaboration in design practice can be seen as participatory processes. In an attempt to reimagine multispecies commons, co-design and open-ended design can be seen as a pathway to frame participatory design beyond human exceptionalism (Haldrup et al., 2022). In fact, the field of participatory design, rooted in human rights and well-being, is increasingly questioning the need to embrace entanglement theories, reframing the discipline's focus on relations that include non-human living and non-living entities (Heitlinger et al., 2025).

CONCLUSIONS

The project presented here, *Designed Wilderness, Minimum Viable Ecosystems,* explores the potential of craft in bioreceptive design practices, potentially contributing to urban biodiversity, biophilia, and ultimately to multispecies participatory design. The project aims to exemplify a paradigm shift in design practice, in which temporal and ecological processes become central to aesthetic and functional outcomes. By embracing slow transformation through colonisation by diverse organisms, these artefacts function as living laboratories, material substrates that actively facilitate multispecies coexistence while simultaneously serving as experimental sites for understanding design's role in supporting biological diversity. In the context of contemporary biodiversity loss, bioreceptive design offers a methodologically grounded approach to integrating ecological regeneration with human experience. Beyond their symbolic or contemplative dimensions, these bioreceptive sculptures carry a pedagogical potential as educational instruments that engage both children and adults in direct

observation and interaction with local biodiversity, thereby fostering ecological literacy and environmental awareness. The scalability of this approach further underscores its relevance; applications ranging from bioreceptive building facades and architectural surfaces to everyday objects designed for urban settings suggest the possibility of transforming the built environment into functional ecological infrastructure. Concurrently, the relational and contemplative qualities inherent to bioreceptive practice invite users to decelerate and re-engage with natural processes, supporting human connection with nature, fostering observational relationships with natural systems, and cultivating an aesthetic of wonder regarding the evolution of the adaptive surfaces, intended as multispecies participatory design processes.

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