# REGENERATIVE Building

Examples, processes, and stories
from an ongoing paradigm shift

Aarhus Center for Regenerativt Byggeri

Realdania

# REGENERATIVE Building

## Aarhus Center for Regenerative Building

CEBRA

Søren Jensen

AARHUS UNIVERSITY
DEPARTMENT OF CIVIL AND ARCHITECTURAL ENGINEERING

AARHUS KOMMUNE

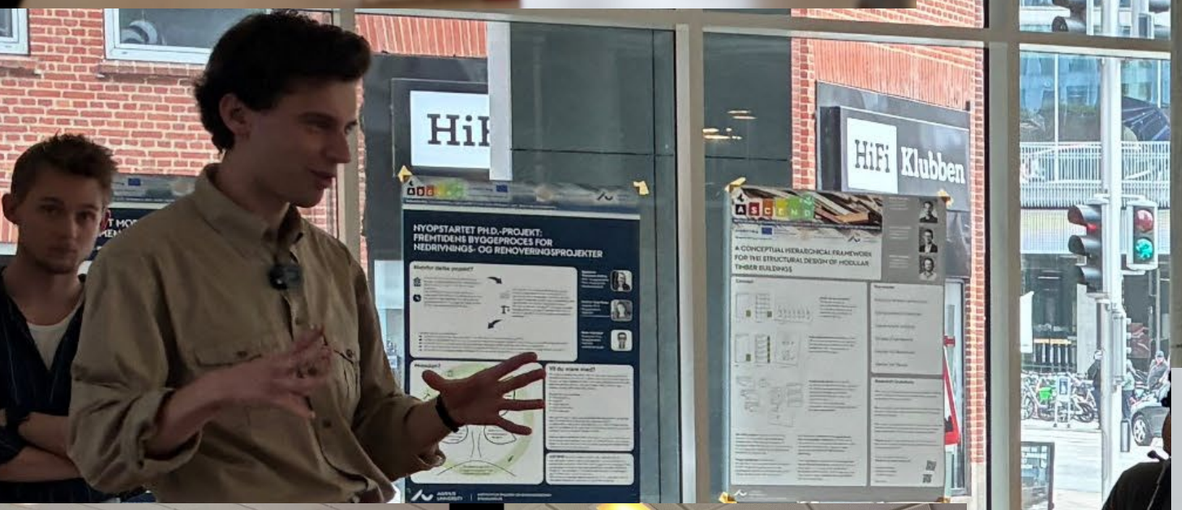
TEKNOLOGISK INSTITUT

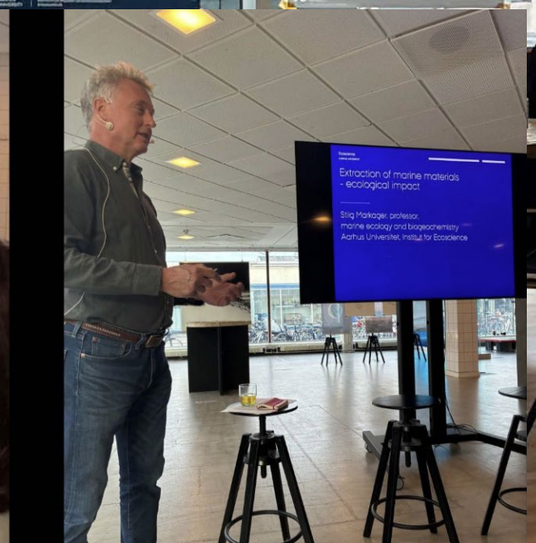
BLOXHUB

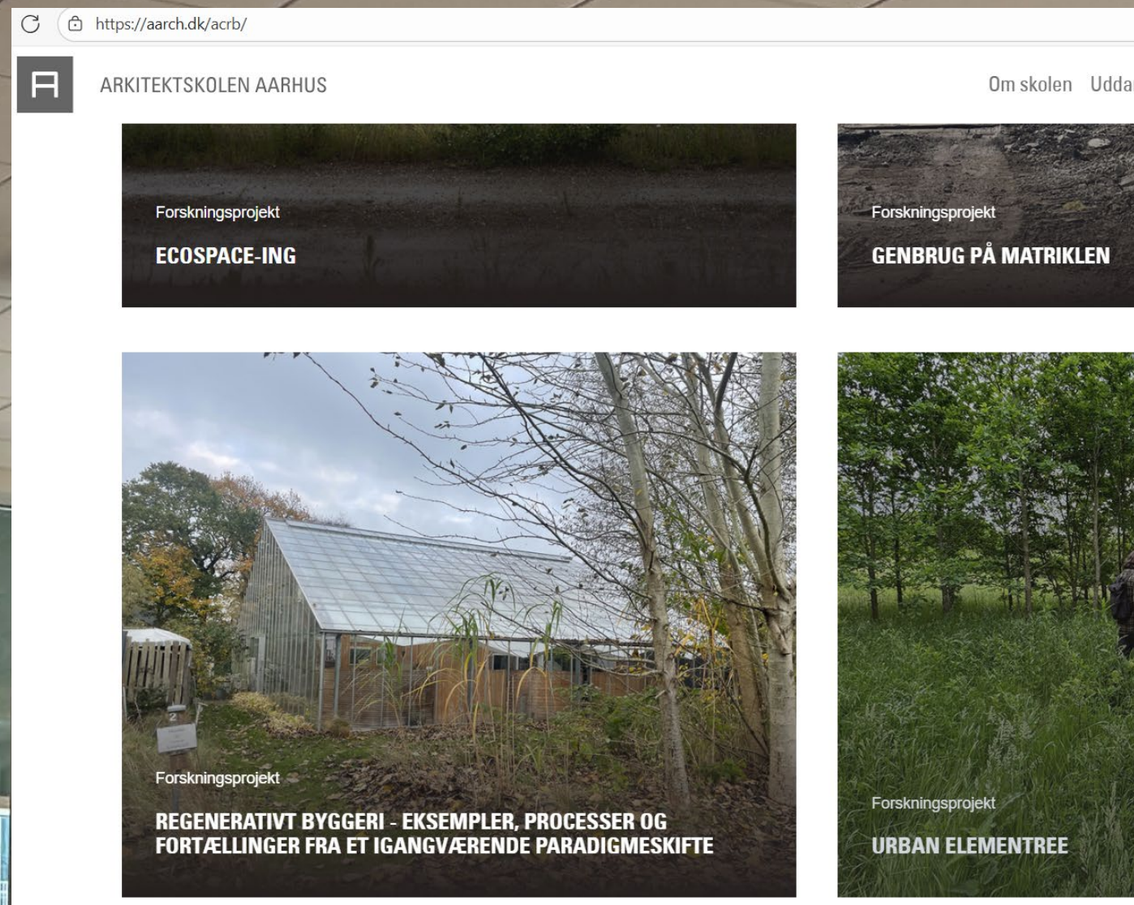
ARKITEKTSKOLEN AARHUS

INCUBA

ALEXANDRA INSTITUTTET


HiFi Klubben
NYOPSTARTET PH.D.-PROJEKT:
FREMTIDENS BYGGEPROCES FOR
NEDRIVNINGS- OG RENOVERINGSPROJEKTER
A CONCEPTUAL HIERARCHICAL FRAMEWORK
FOR THE STRUCTURAL DESIGN OF MODULAR
TIMBER BUILDINGS


Extraction of marine materials
- ecological impact
Stig Markager, professor,
marine ecology and biogeochemistry
Aarhus Universitet, Institut for Ecoscience


https://aarch.dk/acrb/
ARKITEKTSKOLEN AARHUS
Om skolen
Udda
Forskningsprojekt
ECOSPACE-ING
Forskningsprojekt
GENBRUG PÅ MATRIKLEN
Forskningsprojekt
REGENERATIVT BYGGERI - EKSEMPLER, PROCESSER OG
FORTÆLLINGER FRA ET IGANGVÆRENDE PARADIGMESKIFTE
Forskningsprojekt
URBAN ELEMENTREE

Forskningsprojekter

# REGENERATIVT BYGGERI – EKSEMPLER, PROCESSER OG FORTÆLLINGER FRA ET IGANGVÆRENDE PARADIGMESKIFTE

Projektets mål er at styrke og påvirke debatten om en regenerativ omstilling af byggeriet i samfundet ved hjælp af fakta baserede kortlægninger og visuelle fremtidsscenarier på grundlag af disse.

# REGENERATIVE Building

## The project group at Aarhus School of Architecture

Lotte Bjerregaard Jensen
(PI)

August Sørensen
(LCA specialist/external lecturer)

Peer Näthke
(Research assistant)

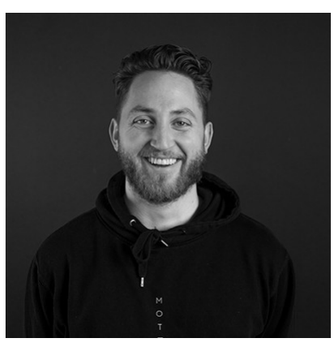
Heidi Merrild
(Postdoctoral researcher)

Antonio Bernacch
Associate professor

Alicia Lazzaron
Associate professor
i

Anna-Lena Müller (Research Assistant)

Elizabeth Donovan
(Co-PI)



Jens Pedersen

Emma Holm Kjær
(Student Assistant)

Johan Hvidtfeldt Rahbek (Student assistant)

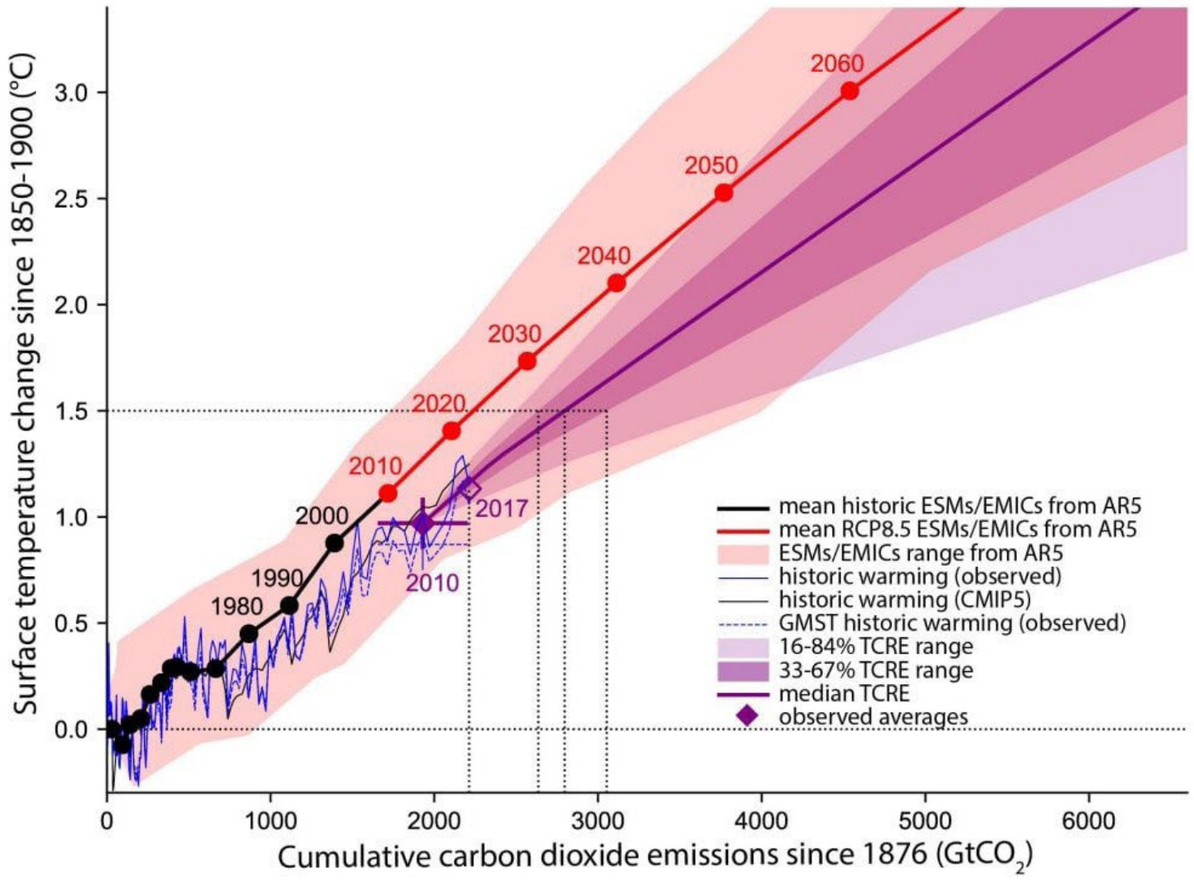
# Why regenerative Building?

# REGENERATIVE Building

## Why Regenerative Building?

Why regenerative Building?

- Climate crisis




Temperature changes from 1850–1900 versus cumulative CO2 emissions since January 1, 1876.

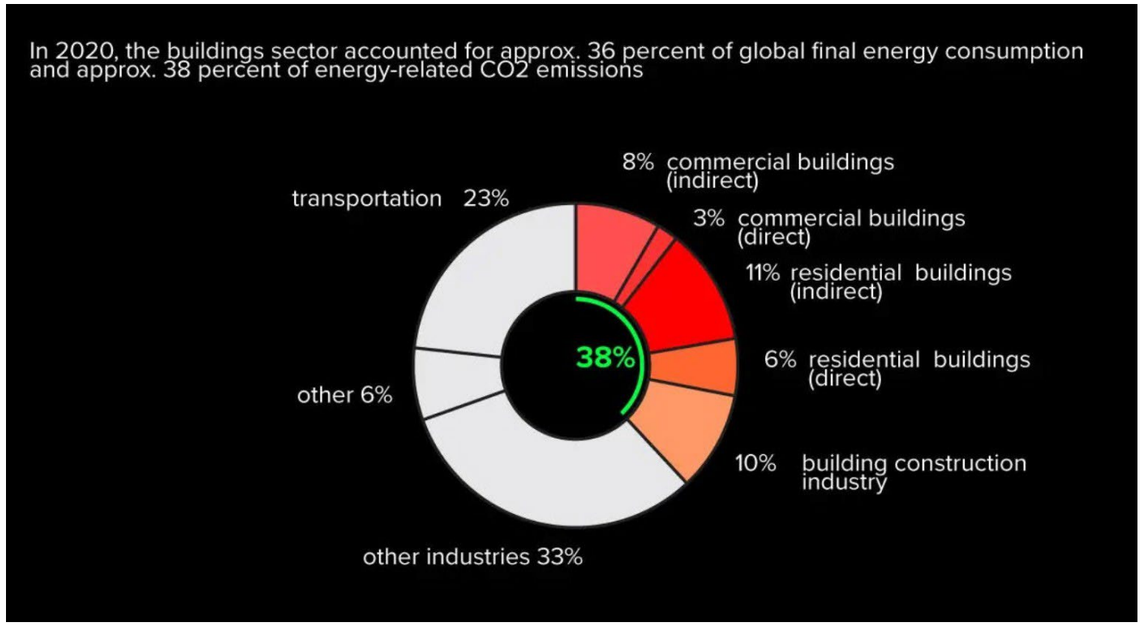
*IPCC Special Report: Global Warming of 1.5 °C*
*https://www.ipcc.ch/sr15/chapter/chapter-2/*

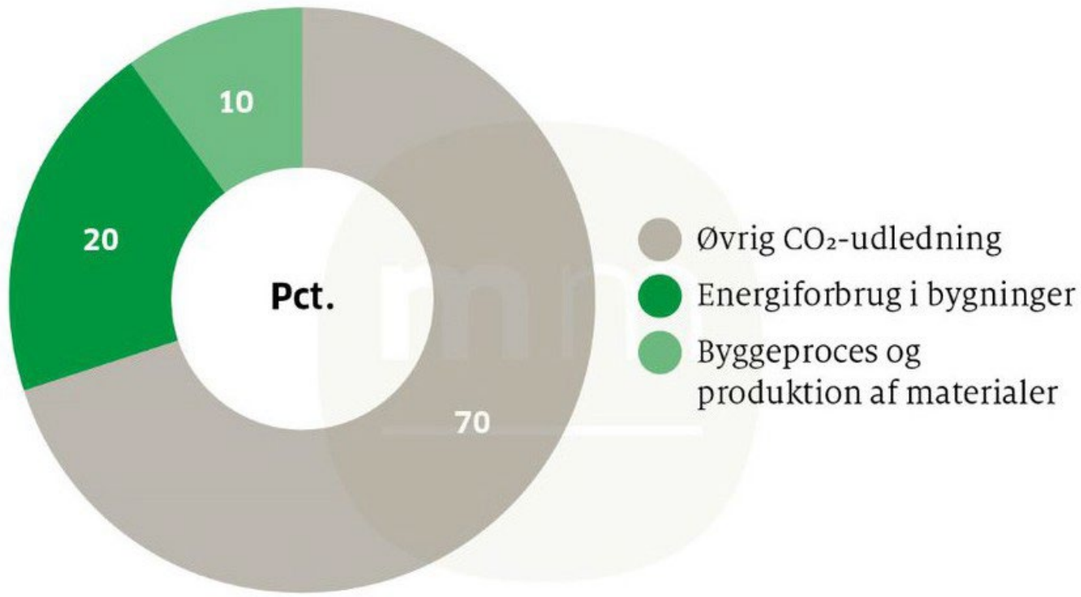
# REGENERATIVE Building

## Why Regenerative Building?

Why regenerative Building?

- Climate crisis




Buildings' share of total greenhouse gas emissions - Internationally and in Denmark

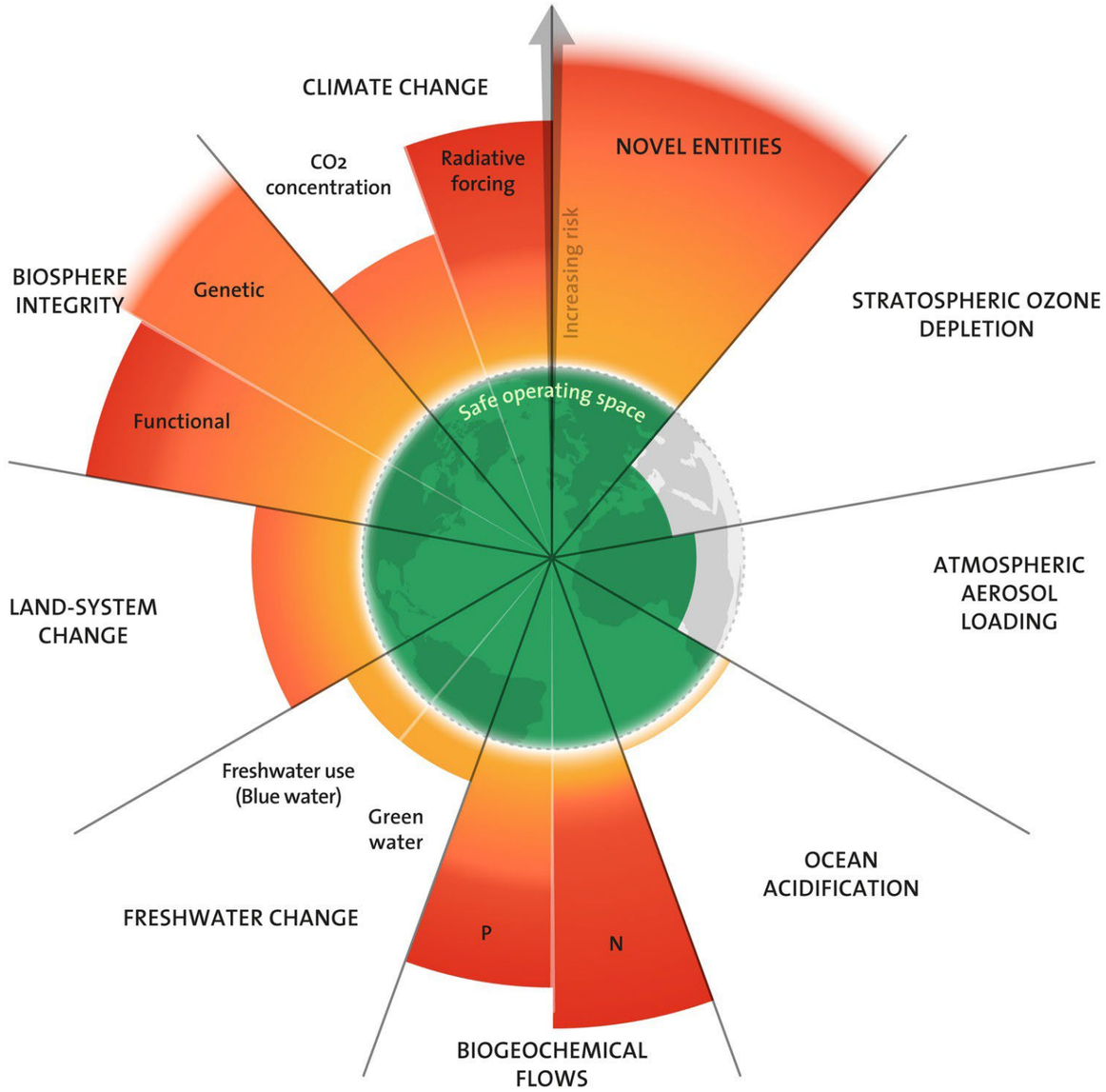
*Spaceforfuture.org / DI Building / Social and Housing Authority*

# REGENERATIVE Building

## Why Regenerative Building?

### Why regenerative Building?

- Climate crisis
- Biodiversity crisis
- Overconsumption of resources
- Air pollution
- Nutrient leaching
- Overconsumption of fresh water
- …



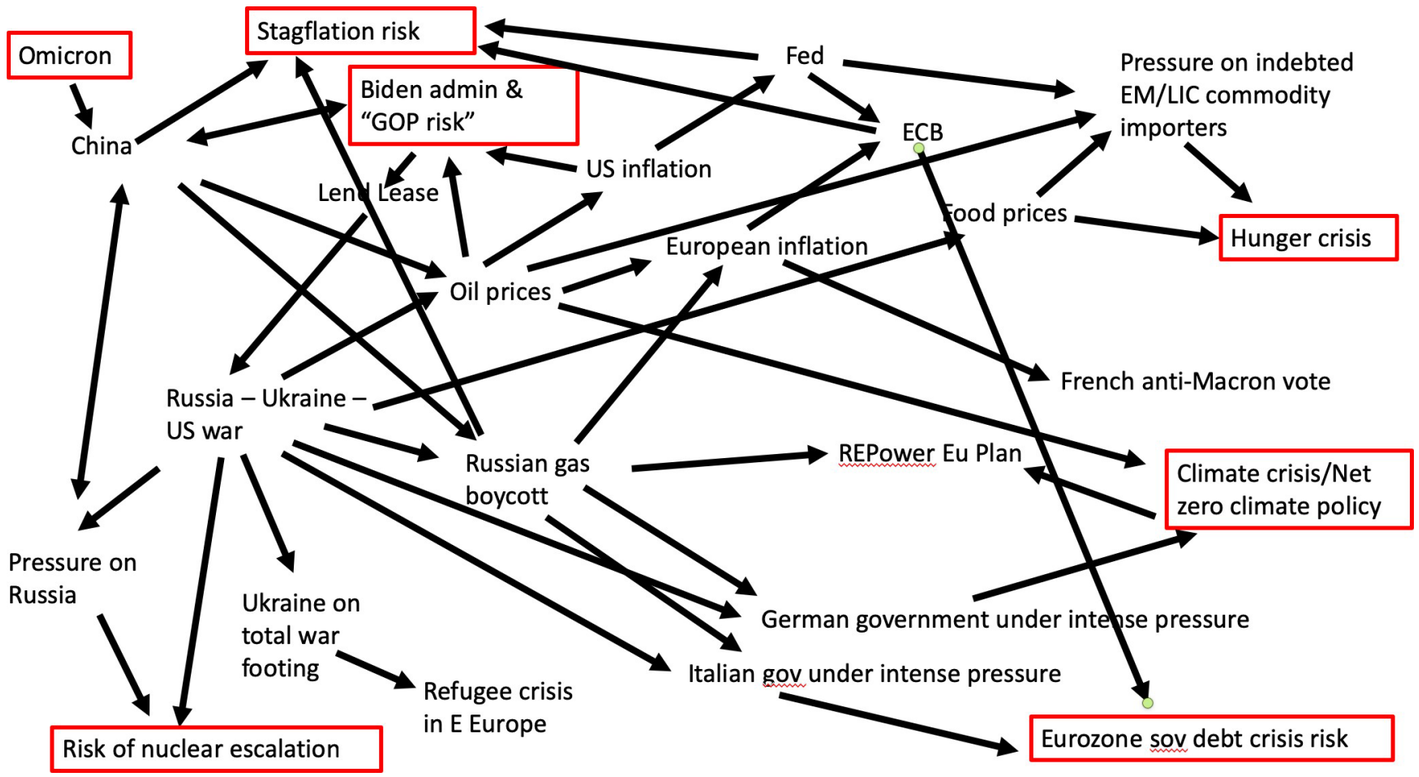

The 2025 update to the Planetary boundaries

*Azote for Stockholm Resilience Centre, based on analysis in Sakschewski and Caesar et al. 2025*

# REGENERATIVE Building

## Why Regenerative Building?

Polycrisis




| How do risks interact? | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | COVID | Inflation | Recession | GOP risk | Hunger crisis | Climate crisis | EZ sov debt | Nuclear escalation |
| | COVID | | Deescalate | **Escalate** | ? | **Escalate** | Deescalate | **Escalate** | ? |
| | Inflation | NA | | **Escalate** | **Escalate** | **Escalate** | ? | **Escalate** | NA |
| | Recession | NA | Deescalate | | **Escalate** | **Escalate** | **Escalate** | **Escalate** | NA |
| | GOP risk | **Escalate** | Deescalate | **Escalate** | | **Escalate** | **Escalate** | ? | ? |
| | Hunger crisis | **Escalate** | ? | ? | NA | | NA | NA | NA |
| | Climate crisis | NA | **Escalate** | Deescalate | **Escalate** | **Escalate** | | NA | NA |
| | EZ sov debt | NA | Deescalate | **Escalate** | NA | NA | **Escalate** | | NA |
| | Nuclear escalation | NA | Deescalate | **Escalate** | ? | **Escalate** | **Escalate** | **Escalate** | |
| | | | | | | | | | |
| | Cells show impact of risk in row on risk in column | | | | | | | | |
| | e.g. a new COVID outbreak will deescalate the risk of inflation but escalate the riks of recession | | | | | | | | |

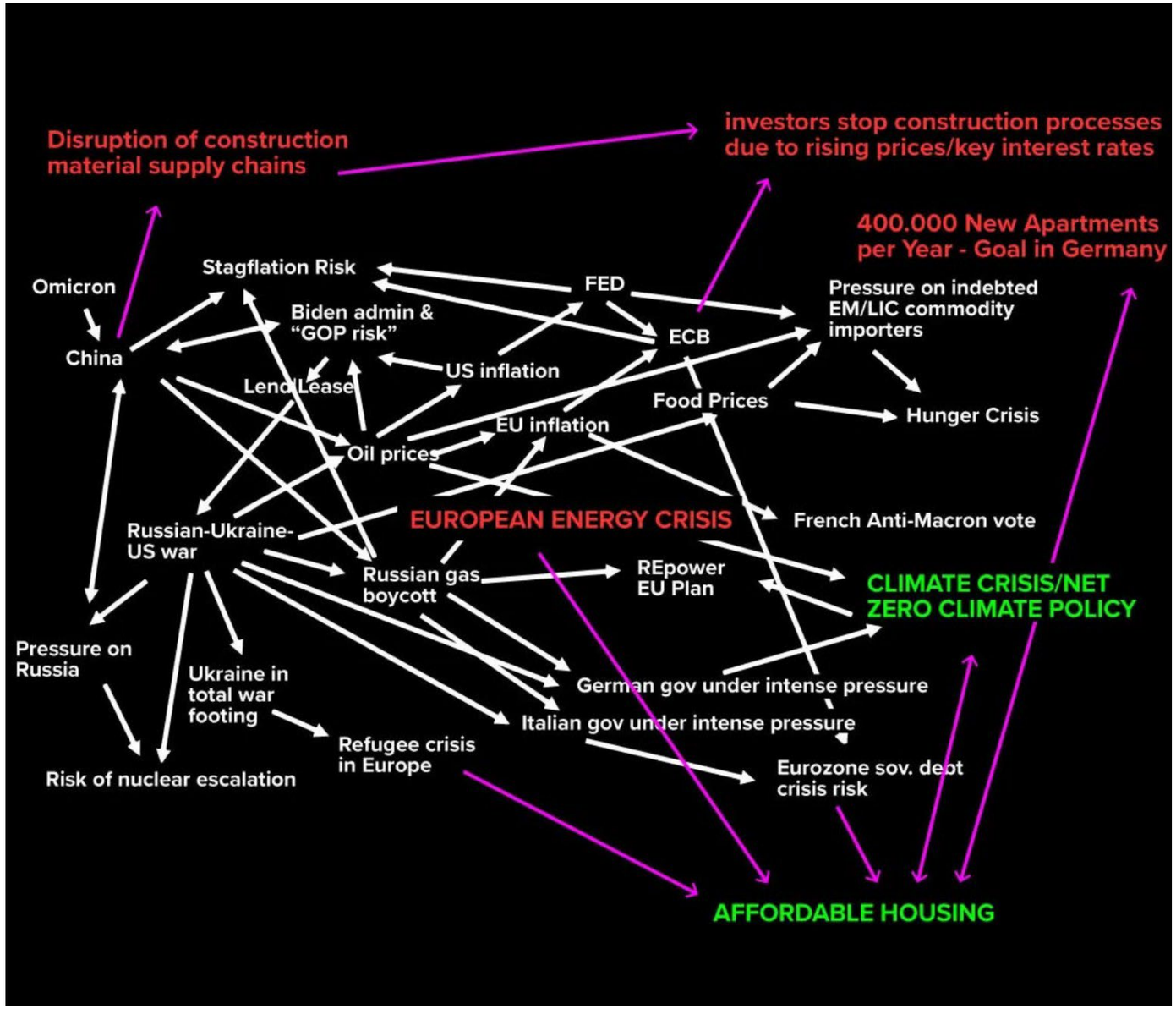
Crisis Pictures: Defining polycrisis - from crisis pictures to the crisis matrix.

*AdamTooze*
*https://adamtooze.substack.com/p/chartbook-130-defining-polycrisis*

# REGENERATIVE Building

## Why Regenerative Building?

Polycrisis




The complexity of polycrisis. Extended illustration based on the thinking of Adam Tooze

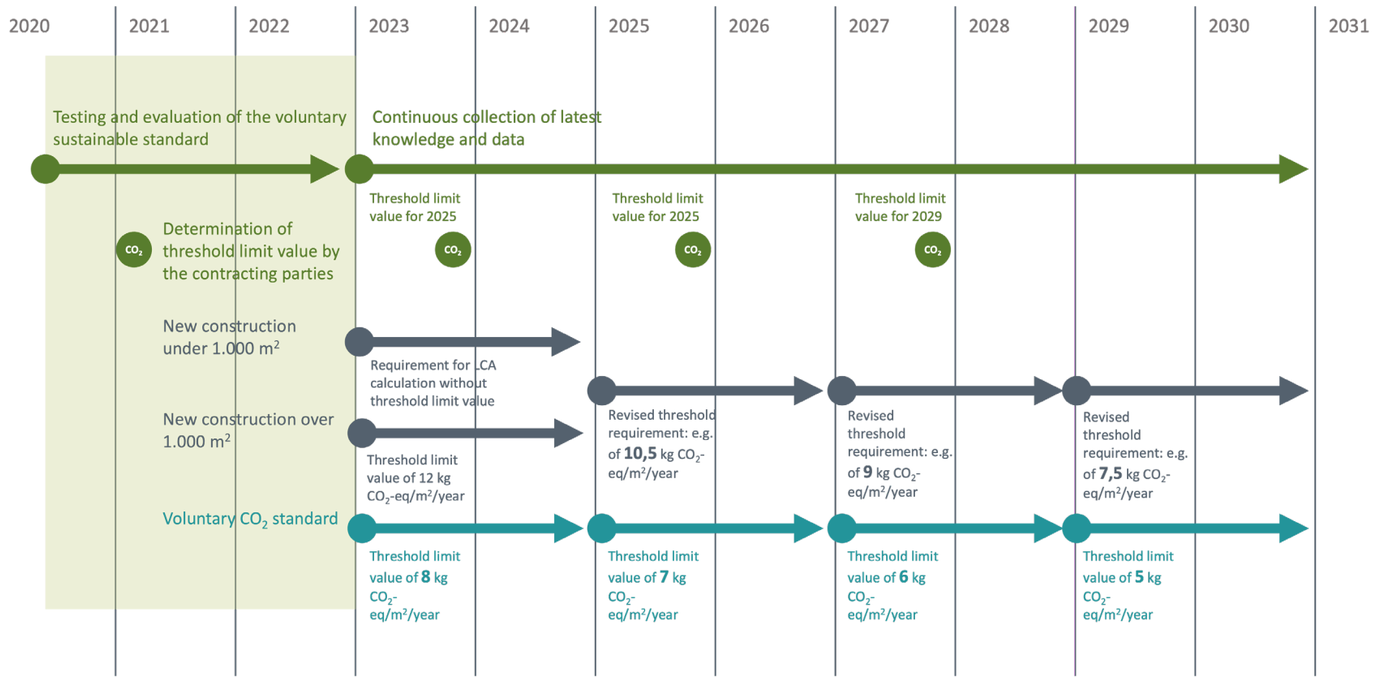
*spaceforfuture_org*

# REGENERATIVE Building

## Why Regenerative Building?

### Initiatives

- Doughnut Biotool
- 41Planet
- (beyond)Reduction Roadmap
- Building freeze
- Danish Climate Requirements (LCA) in building regulations

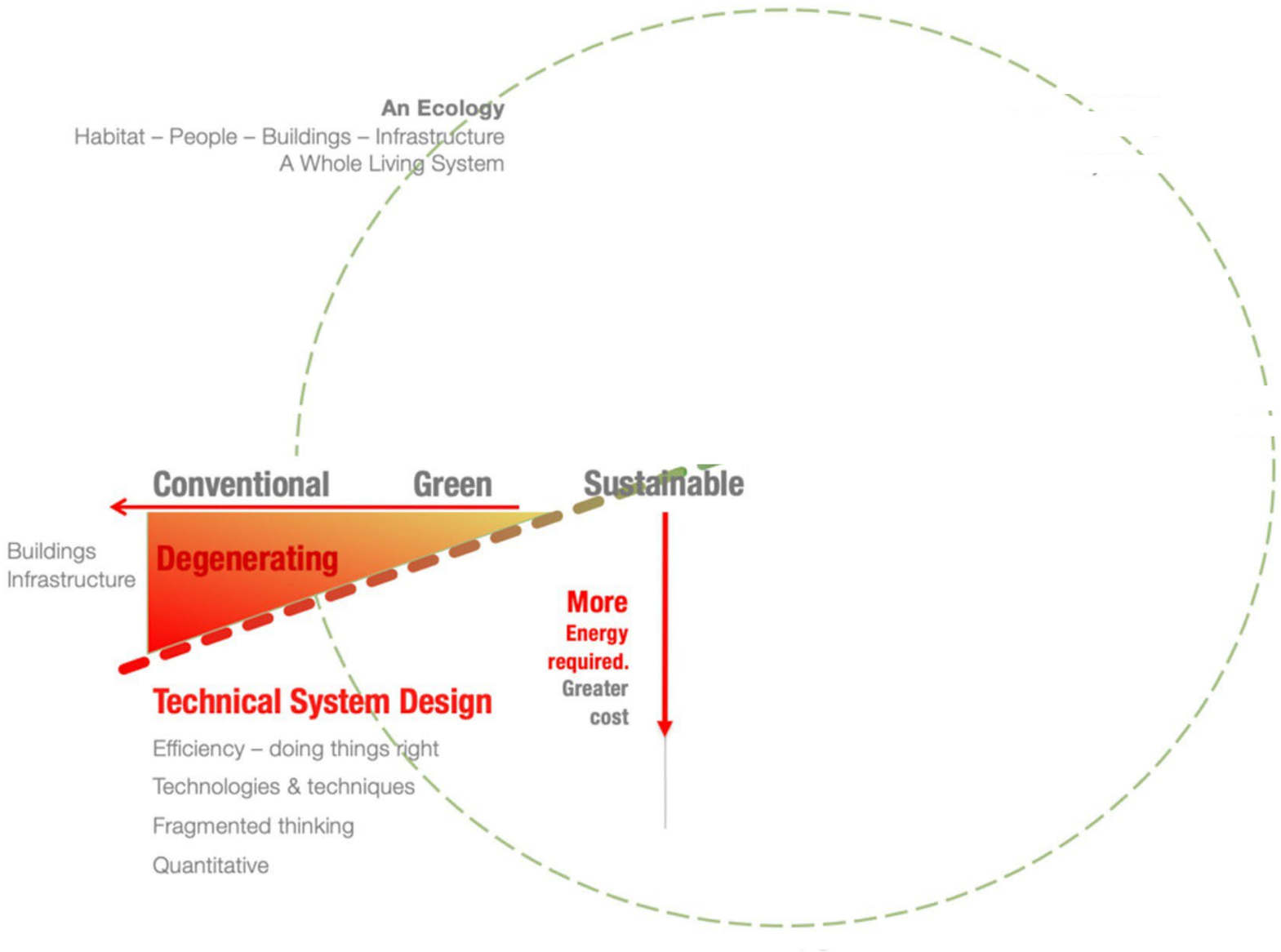



CO2 requirements in new buildings from 2023

*LCAByg*

# REGENERATIVE Building

## Why Regenerative Building?

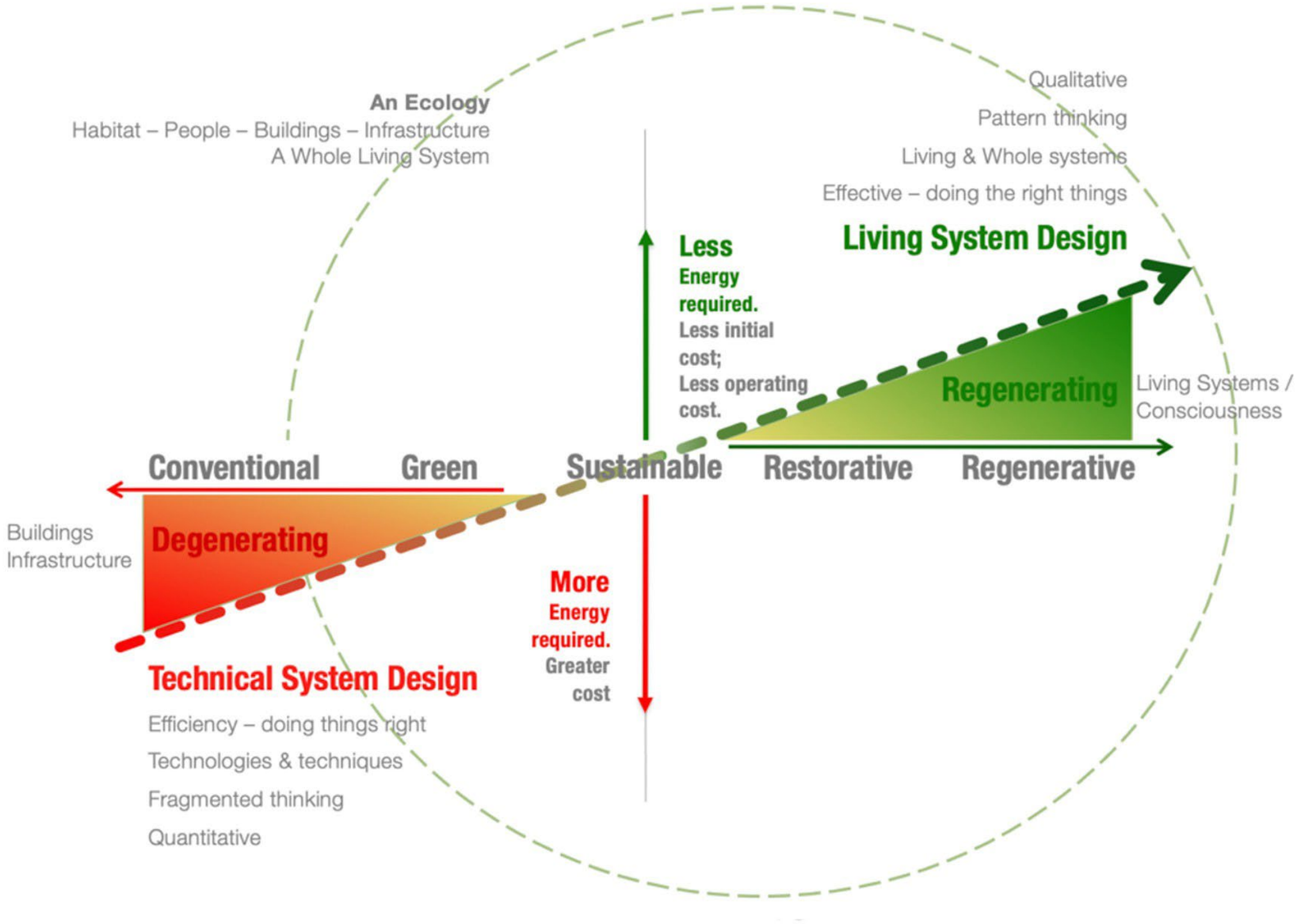



Trajectory of ecological design

*Bill Reed, Regenesis Group*

# REGENERATIVE Building

## Why Regenerative Building?




Trajectory of ecological design

*Bill Reed, Regenesis Group*

# REGENERATIVE Building

## About the Project

Can Building be regenerative?

- What is regenerative Building?
- Are there examples of regenerative Building?
- Is regenerative Building feasible today?
- How do you measure regeneration?
- What obstacles/barriers stand in the way of more regenerative Building?
- What is needed to make Building more regenerative?

...

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# REGENERATIVE Building

## About the Project

**WORK PACKAGE ONE**



MAPPING

**WORK PACKAGE TWO**

INTERVIEWS

**WORK PACKAGE THREE**

SCENARIOS

## Three Work Packages

# REGENERATIVE Building

## About the Project

### WORK PACKAGE ONE



MAPPING

- Literature review and definitions
- Quantification of regeneration?
- Long List
- Short List

### WORK PACKAGE TWO

INTERVIEWS

- Opportunities and obstacles – findings from interviews
- Why did the selected cases not reach a regenerative level?
- What would it take?

### WORK PACKAGE THREE

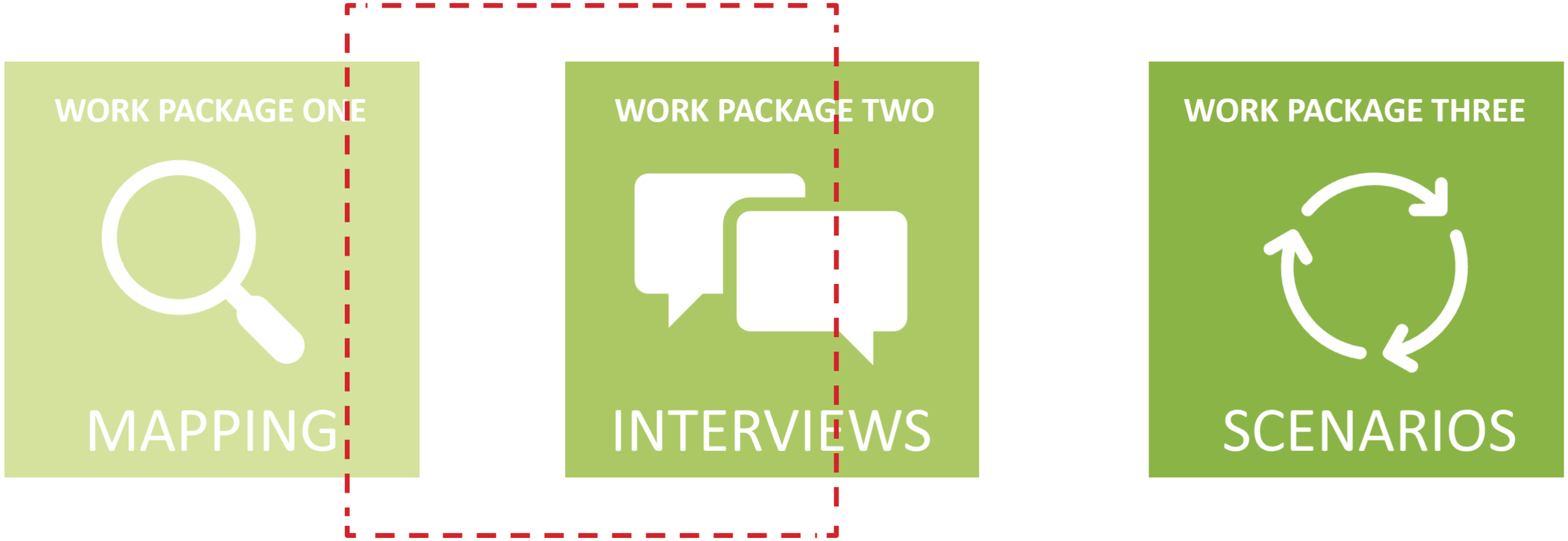
SCENARIOS

- Regenerative Speculations
- Baseline for a regenerative design process?
- A regenerative student house?
- Robotic Regeneration?

Three Work Packages

# REGENERATIVE Building

## About the Project




- Literature review and definitions
- Quantification of regeneration?
- Long List
- Short List

- Opportunities and obstacles – findings from interviews
- Why did the selected cases not reach a regenerative level?
- What would it take?

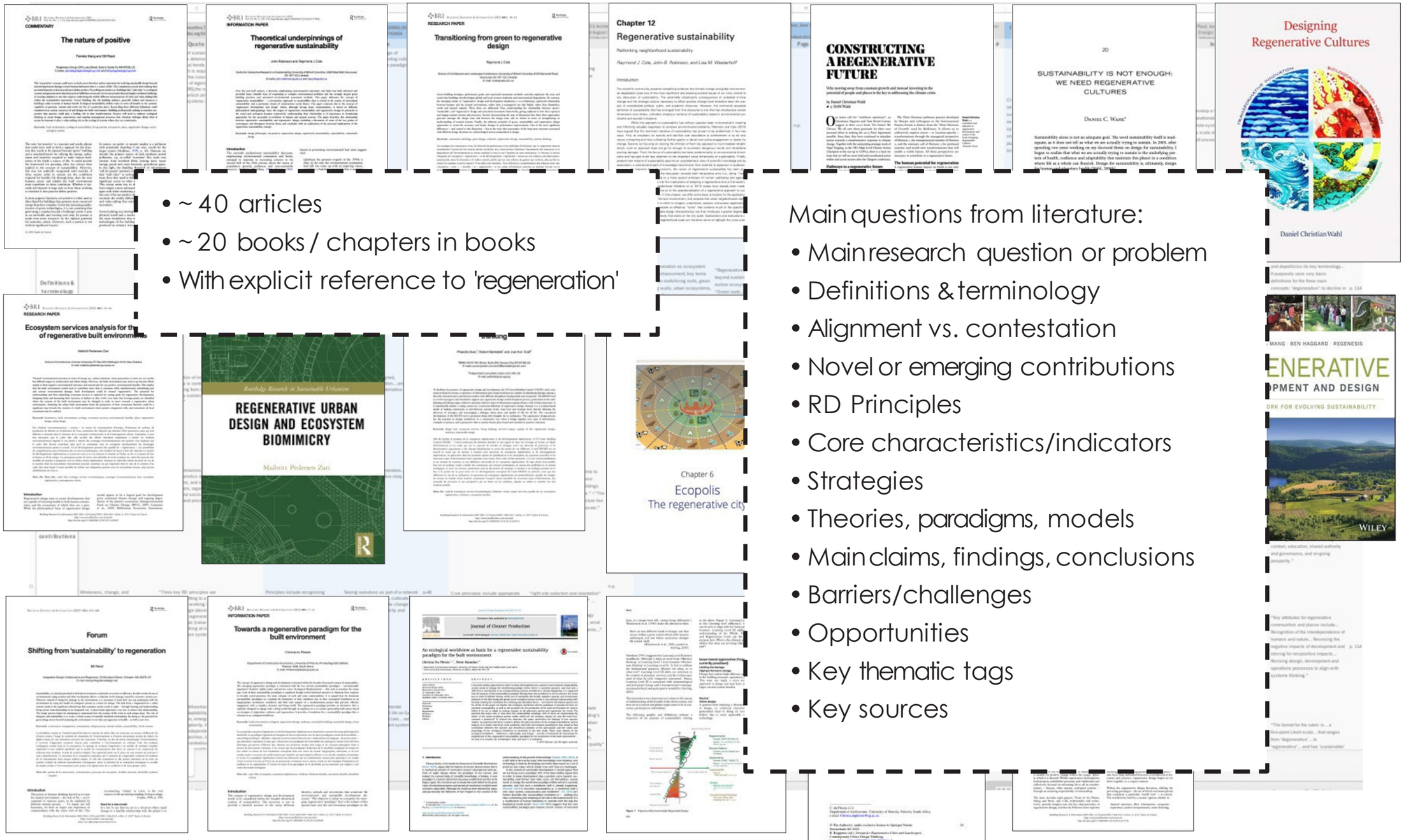
- Regenerative Speculations
- Baseline for a regenerative design process
- A regenerative student house
- Robotic Regeneration

Three Work Packages

# WHAT IS REGENERATIVE Building?

# WHAT IS REGENERATIVE Building?

## Literature review




- ~ 40 articles
- ~ 20 books / chapters in books
- With explicit reference to 'regeneration'

Main questions from literature:

- Main research question or problem
- Definitions & terminology
- Alignment vs. contestation
- Novel or emerging contributions
- RD Principles
- Core characteristics/indicators
- Strategies
- Theories, paradigms, models
- Main claims, findings, conclusions
- Barriers/challenges
- Opportunities
- Key thematic tags
- Key sources

Literature

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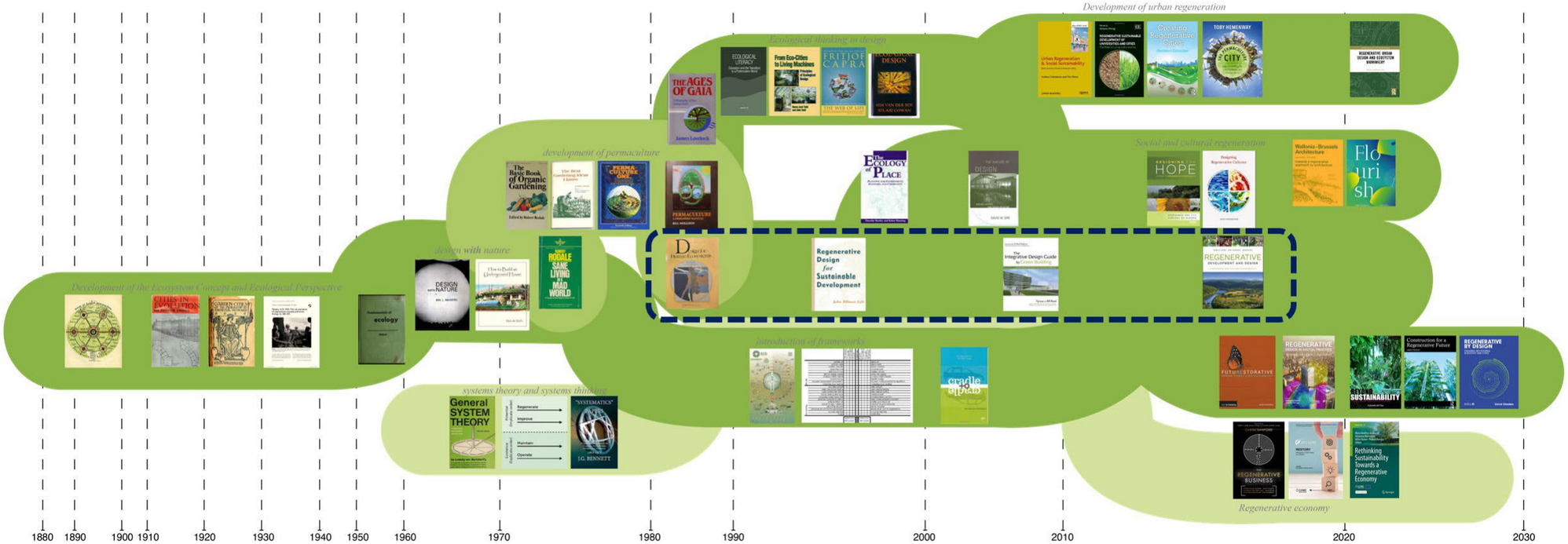
# WHAT IS REGENERATIVE Building?

## Background




## Timeline

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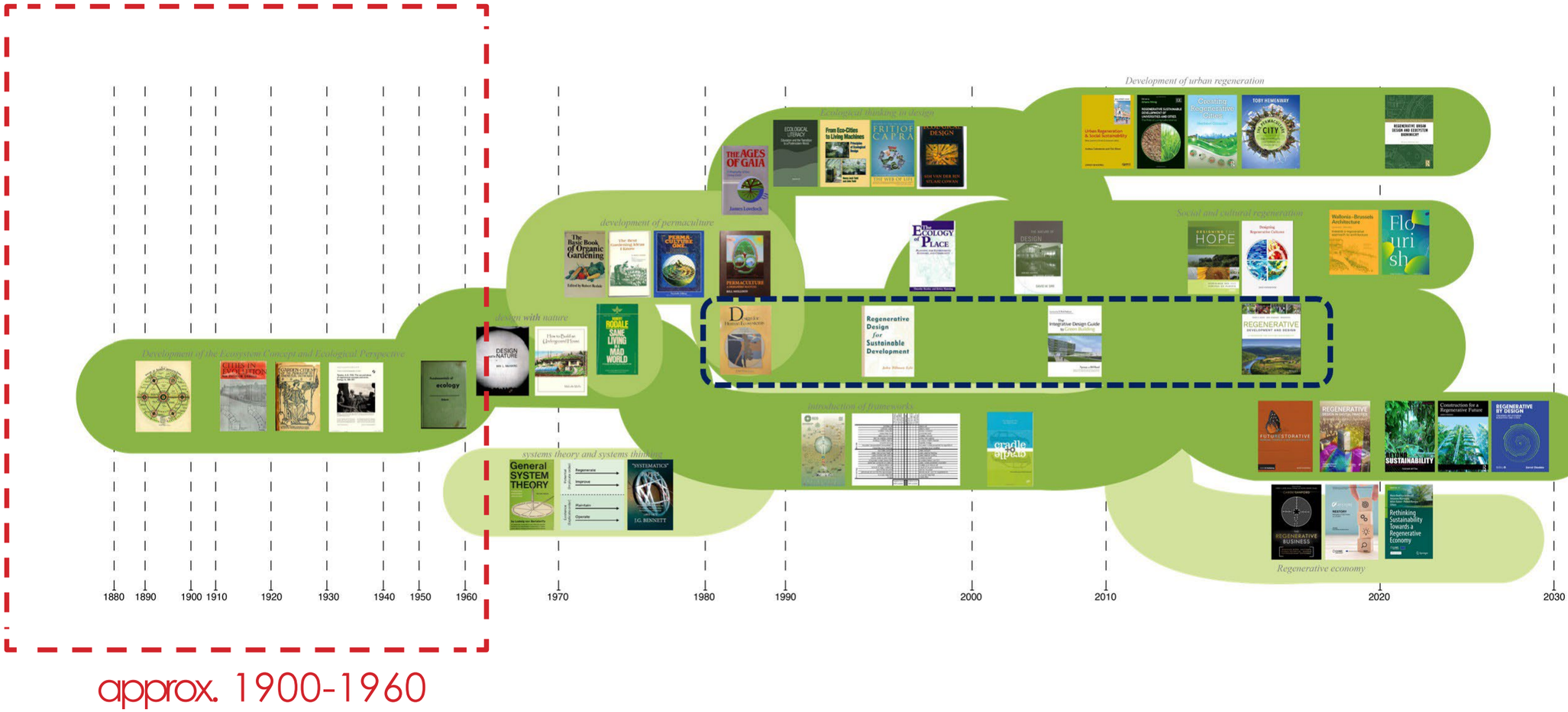
# WHAT IS REGENERATIVE Building?

## Background

Early background for regenerative thinking




approx. 1900-1960

## Timeline

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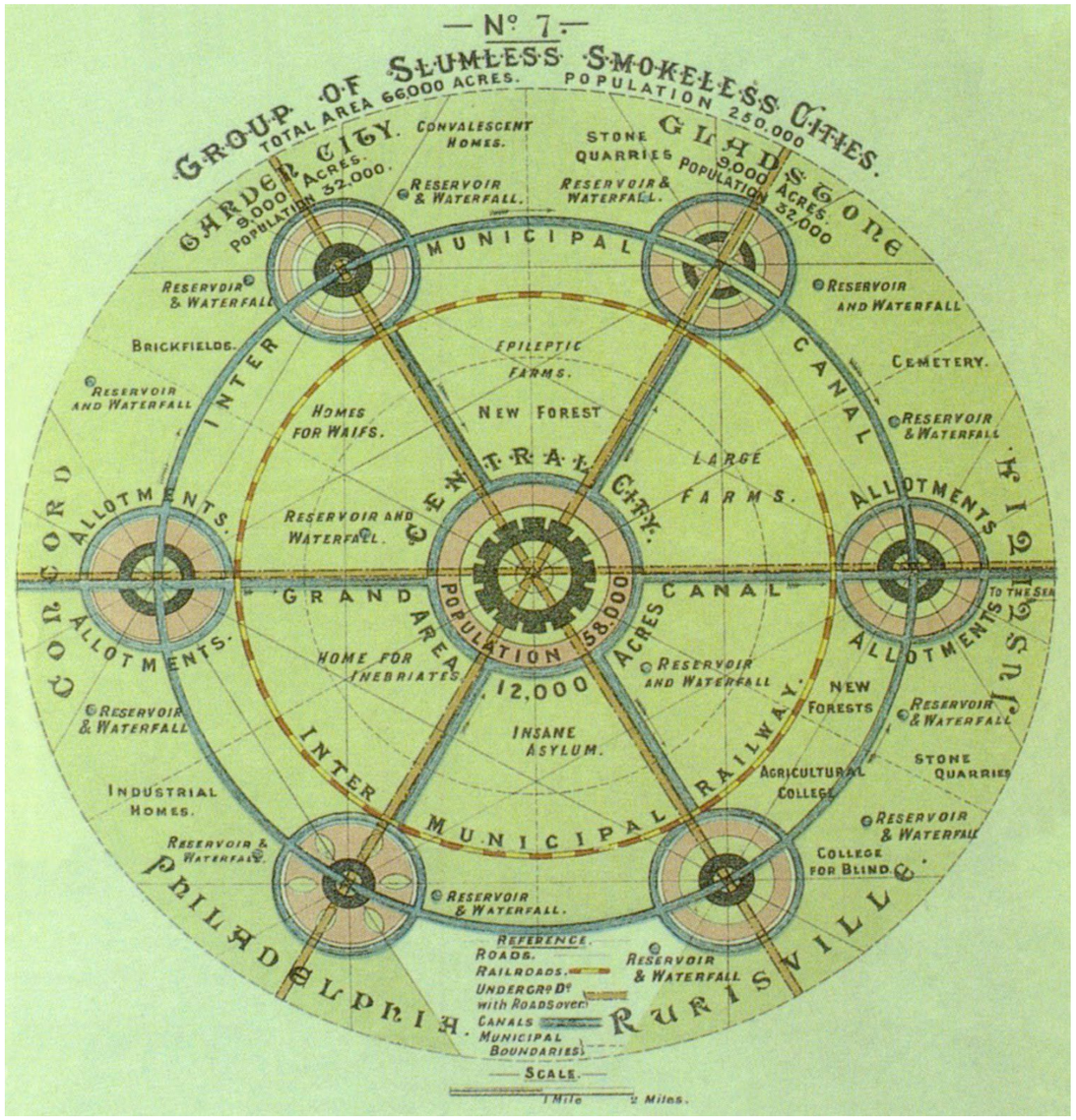
# WHAT IS REGENERATIVE Building?

## Background – Early regenerative thinking

Ebenezer Howard:
Garden Cities (1902)

*"utopian city in which man lives harmoniously with the rest of nature".*




Ebenezer Howard: Garden Cities of Tomorrow

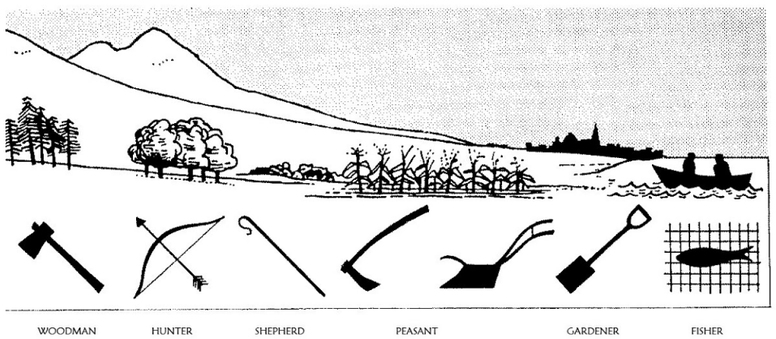
*https://commons.wikimedia.org/wiki/File:Garden_City_Concept_by_Howard.jpg*

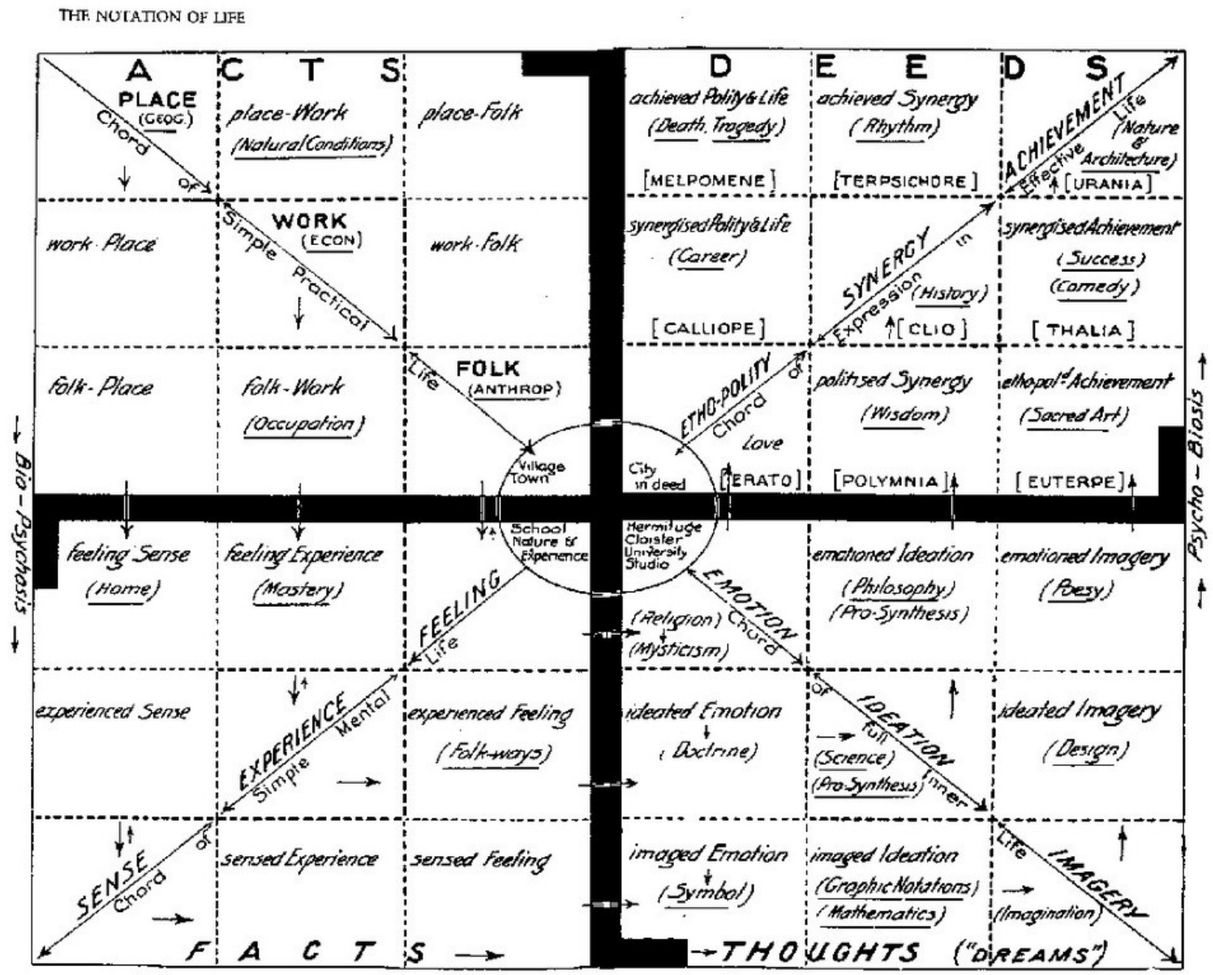
# WHAT IS REGENERATIVE Building?

## Background – Early regenerative thinking

Patrick Geddes (1854-1932)

Cities as "*living organisms*"




Patrick Geddes

# WHAT IS REGENERATIVE Building?

## Background - Early regenerative thinking

Arthur Tansley

Introduces the concept of "ecosystem" in 1935

Humans and ecosystems as interconnected

'*We cannot separate them [organisms] from their special environment, with which they form one physical system.*"

*Influenced by Danish botanist Eugenius Warming*

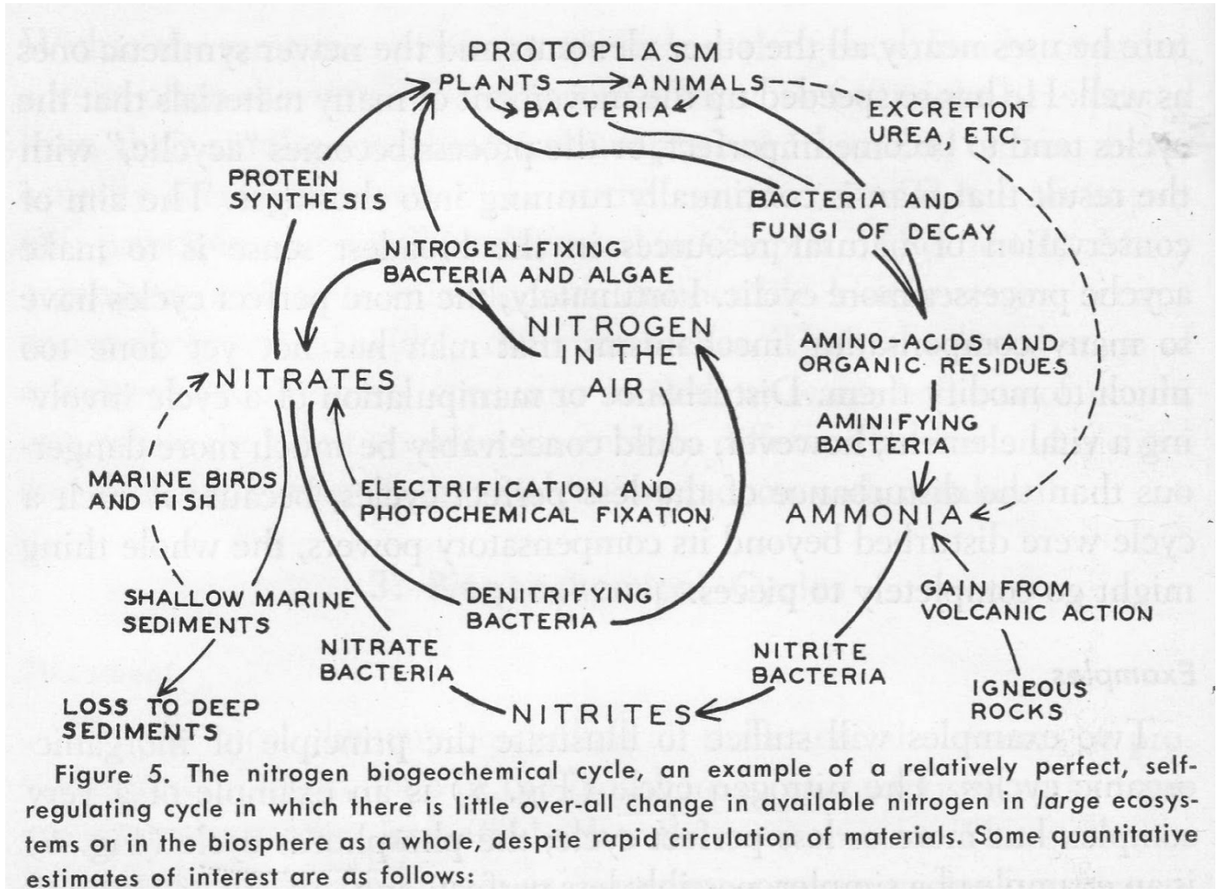



Figure 5. The nitrogen biogeochemical cycle, an example of a relatively perfect, self-regulating cycle in which there is little over-all change in available nitrogen in *large* ecosystems or in the biosphere as a whole, despite rapid circulation of materials. Some quantitative estimates of interest are as follows:

The nitrogen biochemical cycle

...

# WHAT IS REGENERATIVE Building?

## Background - Early regenerative thinking

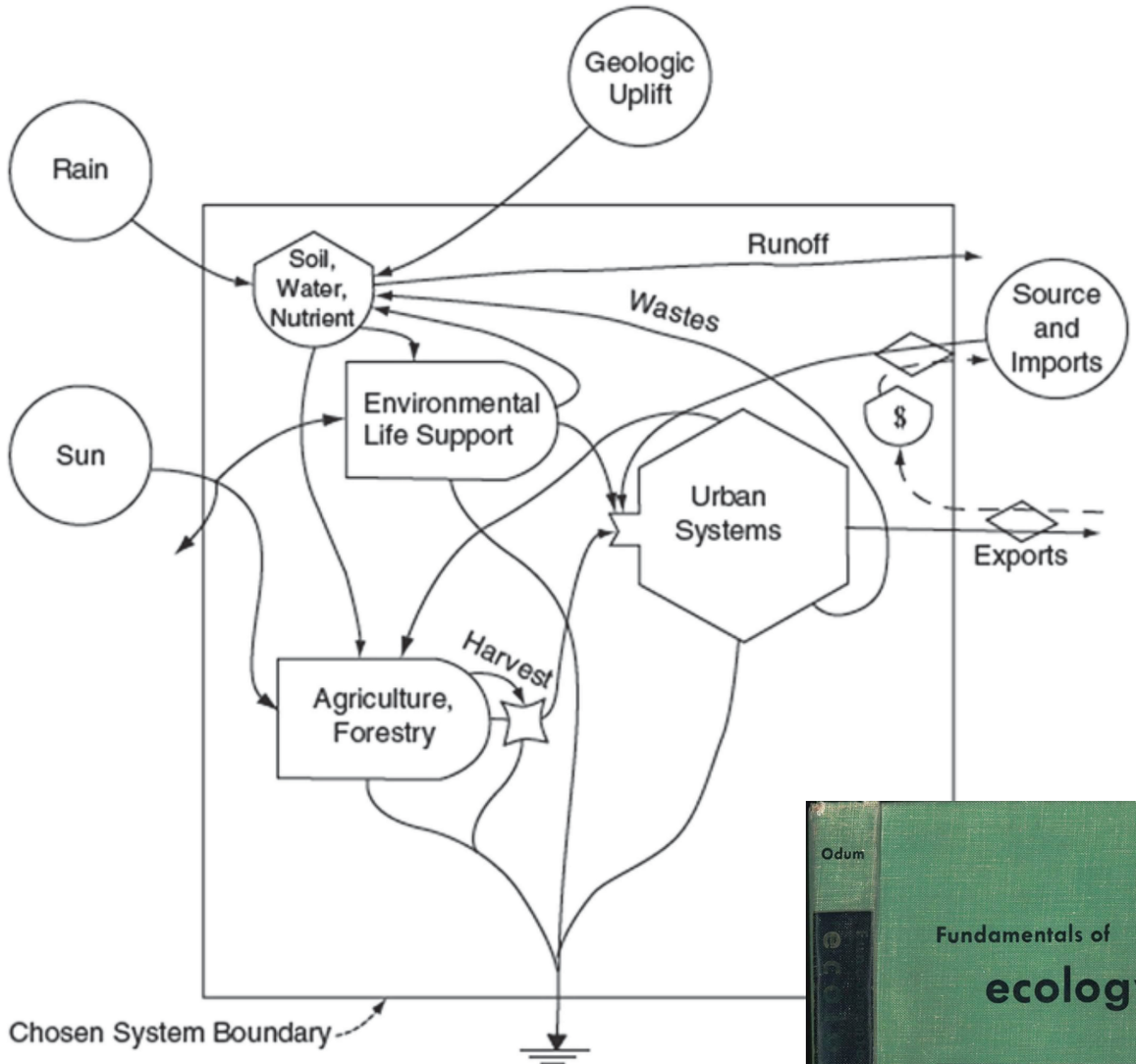
Augene and Howard Odum

The Fundamentals of Ecology (1953)

Establishes ecology as a modern science

Ecology as the central organizational structure in nature

"*Energy Systems Language*"




Fundamentals of ecology

...

# WHAT IS REGENERATIVE Building?

## Background – Early regenerative thinking

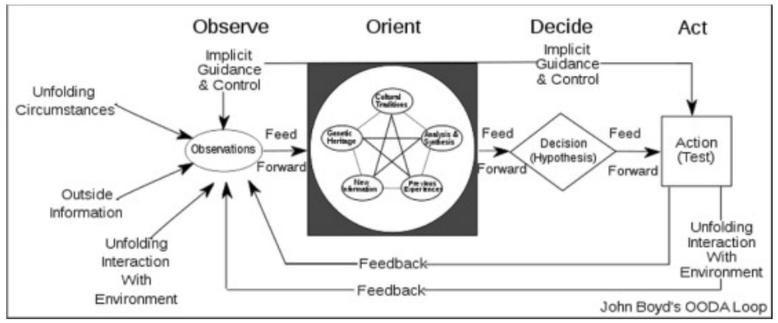
Ludwig von Bertalanffy

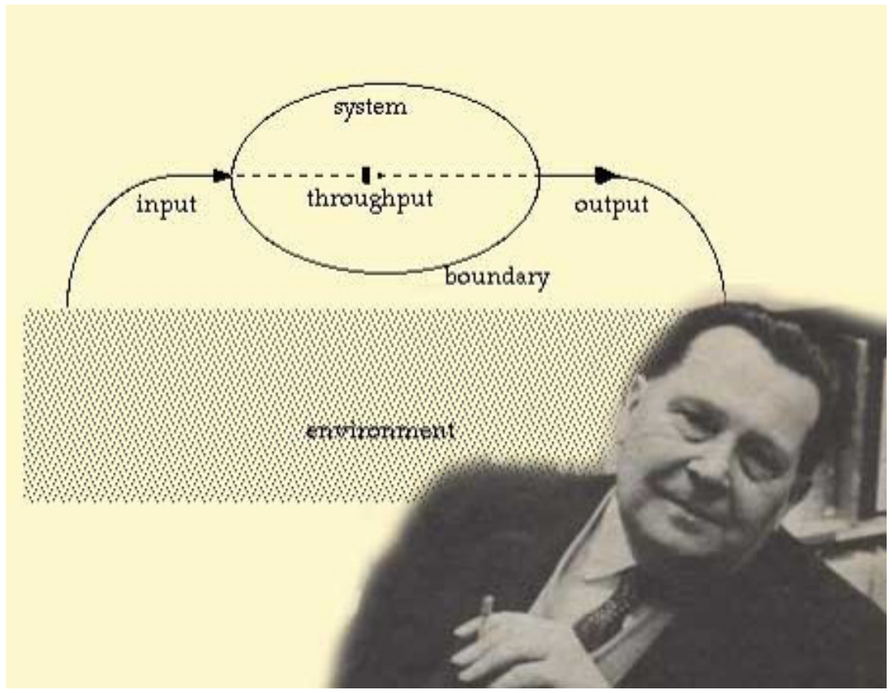
*"General Systems Thinking"* (GST) - 1968

Systems theory

Open systems, evolutionary thinking, and separation between physical (thermodynamics) and biological systems

Holistic analysis of complex systems (rather than reductionist)




General Systems Thinking

*https://www.sesge.org/en/87-uncategorized/296-what-is-the-general-systems-theory.html*

# WHAT IS REGENERATIVE Building?

## Background – Early regenerative thinking

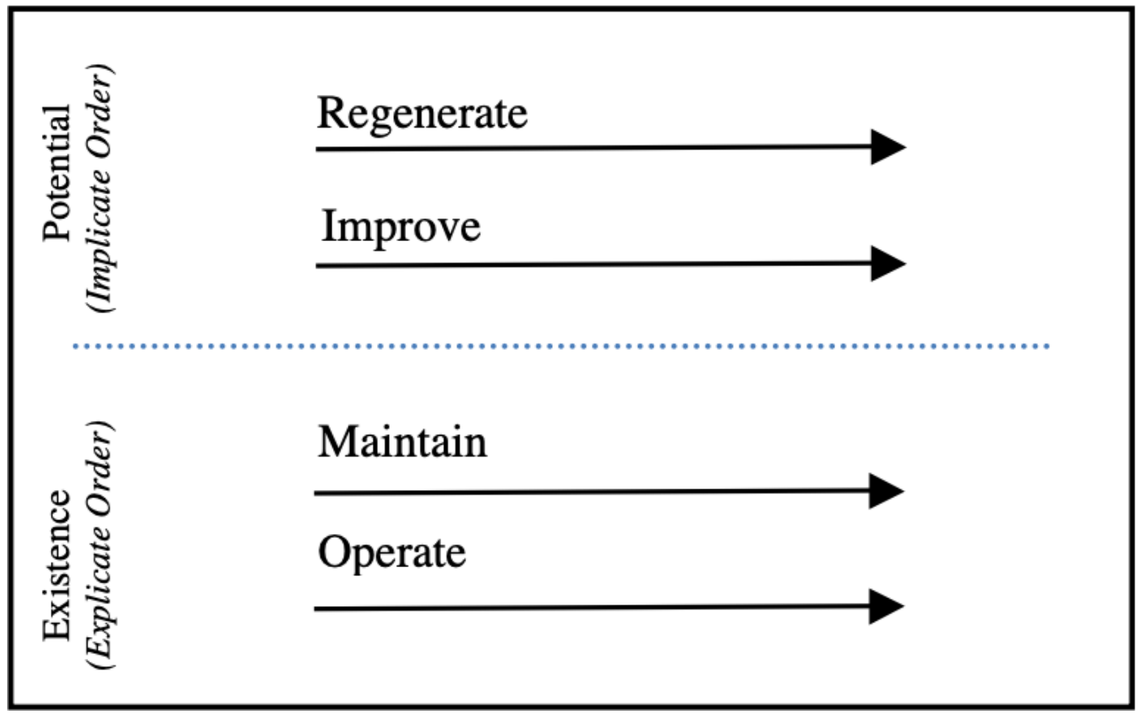
Charles Krone

*"Living Systems Thinking"* (LST)

The 1960s and 1970s

Creating mutual connections between organizations, society, and nature

Figure 3: Levels of Work Framework

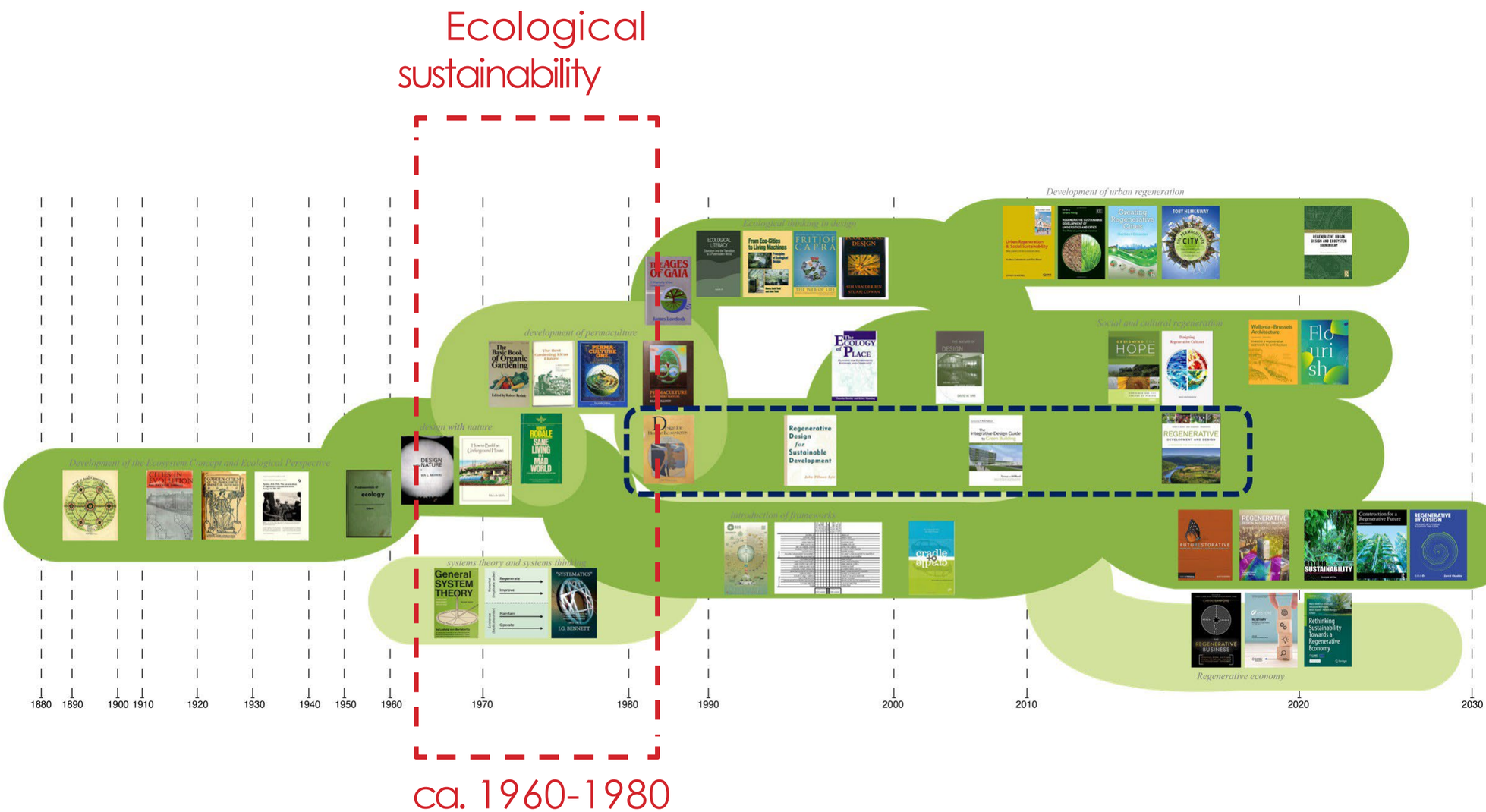



Charles Krone: Levels of work framework

*https://thesustainableagency.com/blog/the-history-of-regeneration-and-regenerative-sustainability/*

# WHAT IS REGENERATIVE Building?

## Background




## Timeline

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# WHAT IS REGENERATIVE Building?

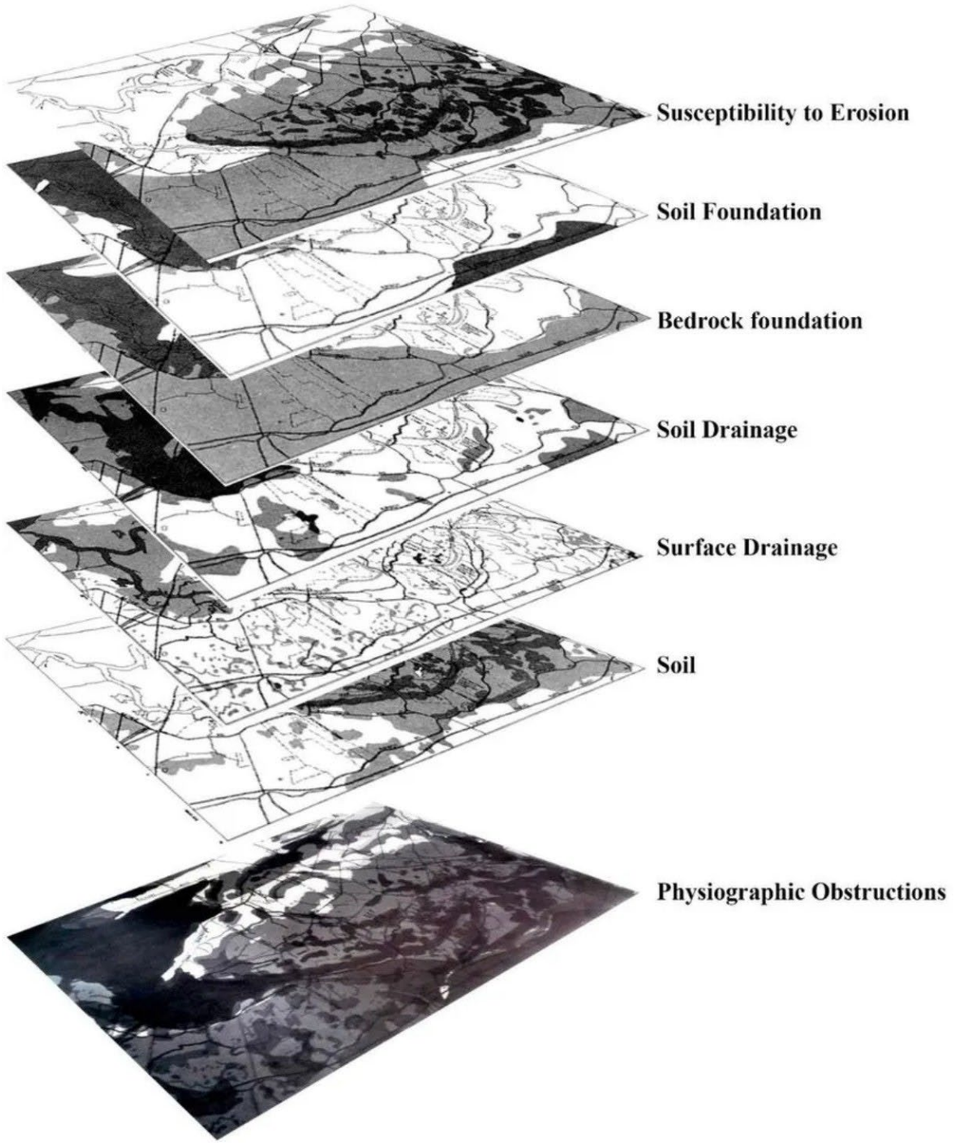
## Background - Ecological sustainability

Ian McHarg

*Design with Nature* (1969)

Ecological landscape planning

Inspired the development of GIS





Ian McHarg's Physiographic Obstructions

*Design with nature*

# WHAT IS REGENERATIVE Building?

## Background - Ecological sustainability

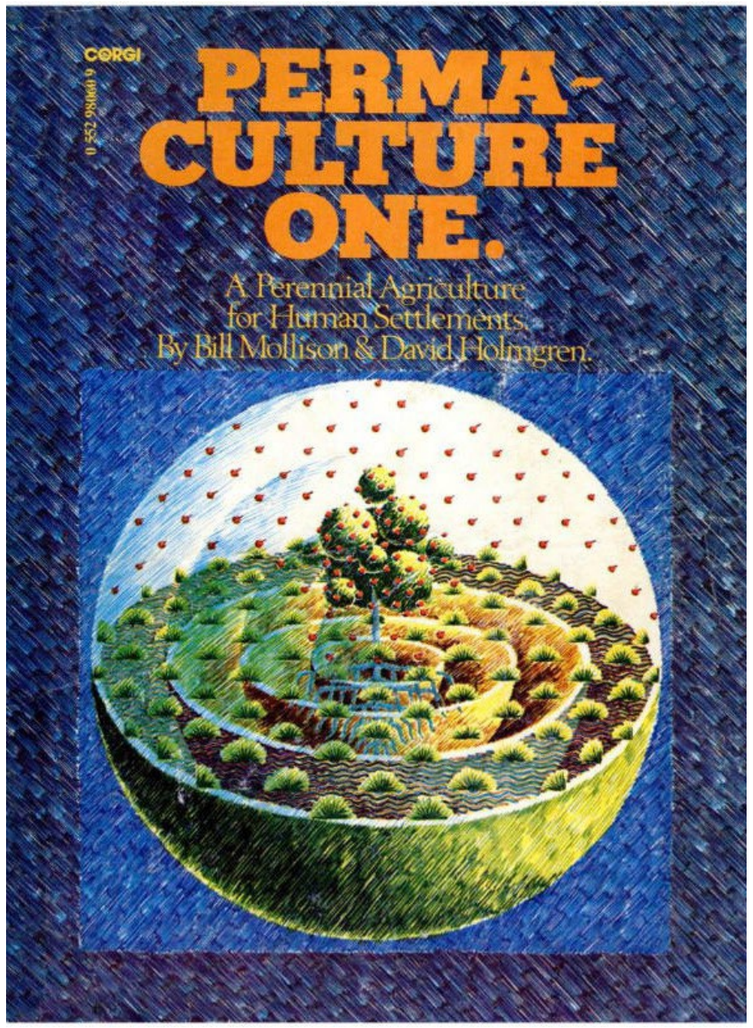
Bill Mollison and David Holmgren

*Permaculture One:*
*A Perennial Agriculture for Human Settlements* (1978)

Invention of the permaculture concept

"*Regenerative* effect" as "*generating a surplus of energy and resources that can be* reinvested" in ecosystems

Self-sustaining, closed systems




Permaculture One: A Perennial Agriculture for Human Settlements

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# WHAT IS REGENERATIVE Building?

## Background - Ecological sustainability

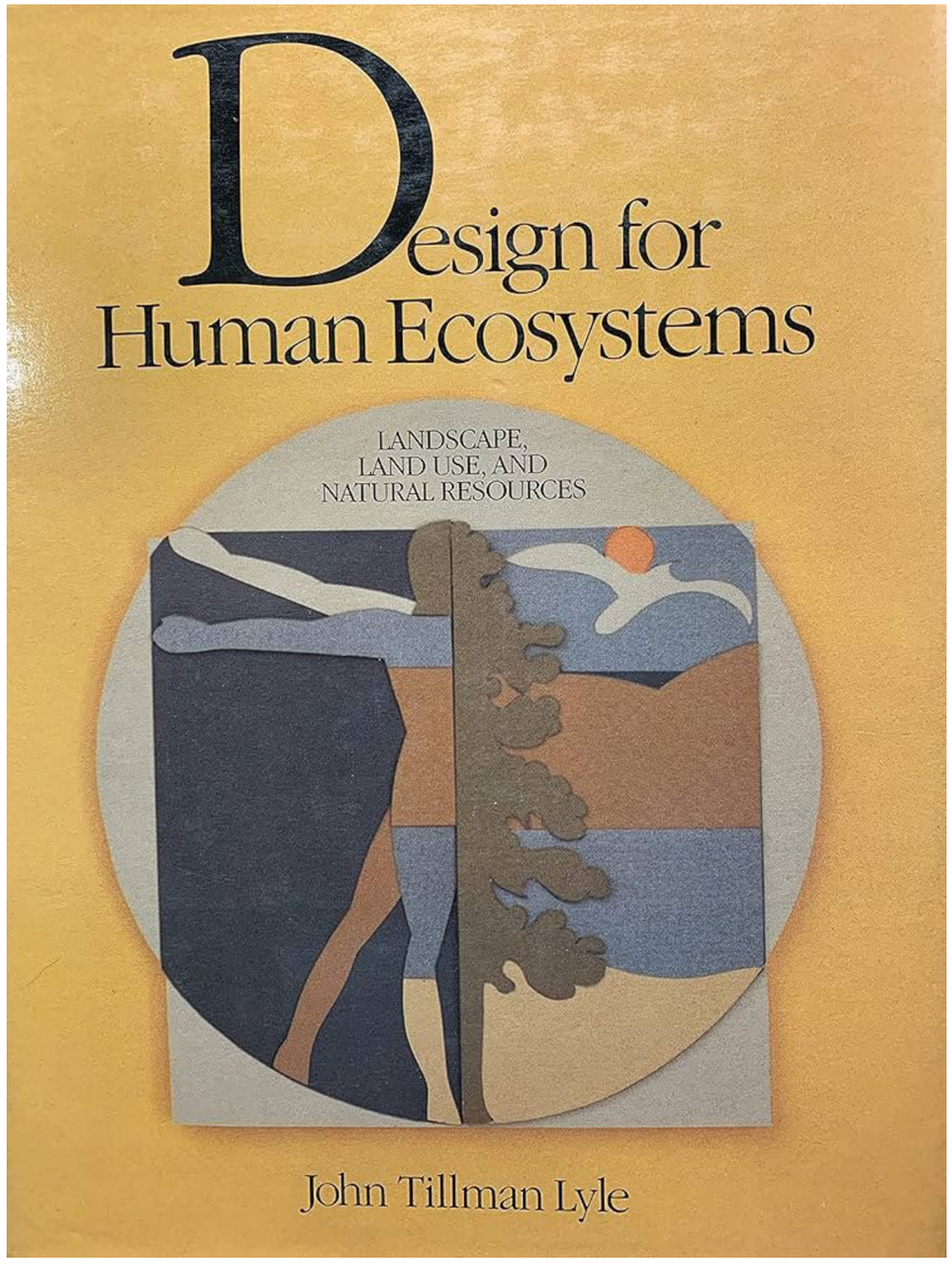
John Tillman Lyle

Design of Human Ecosystems (1985)

Ecosystem thinking in design

Introduces design principles for human ecosystems where people and nature can coexist

Forms the basis for regenerative design methods




Design of Human Ecosystems

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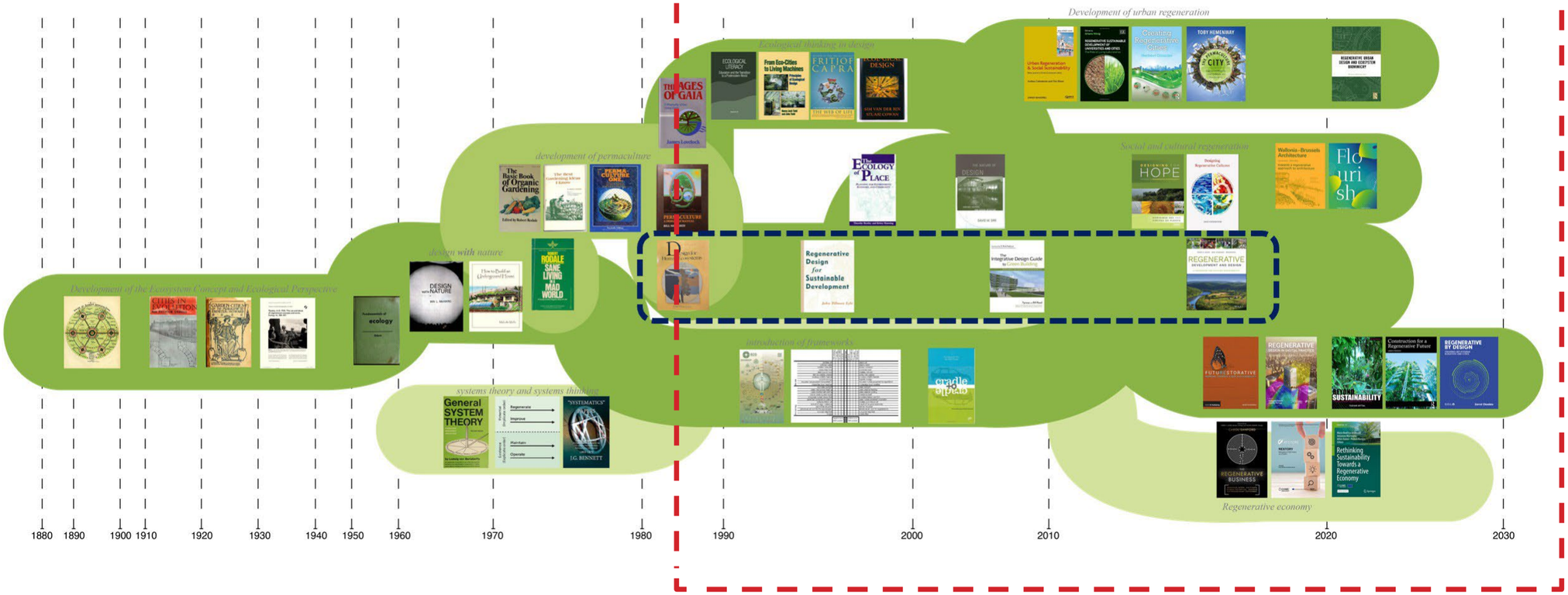
# WHAT IS REGENERATIVE Building?

## Background

The beginnings of regenerative thinking in the context of Building




ca. 1980

## Timeline

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# WHAT IS REGENERATIVE Building?

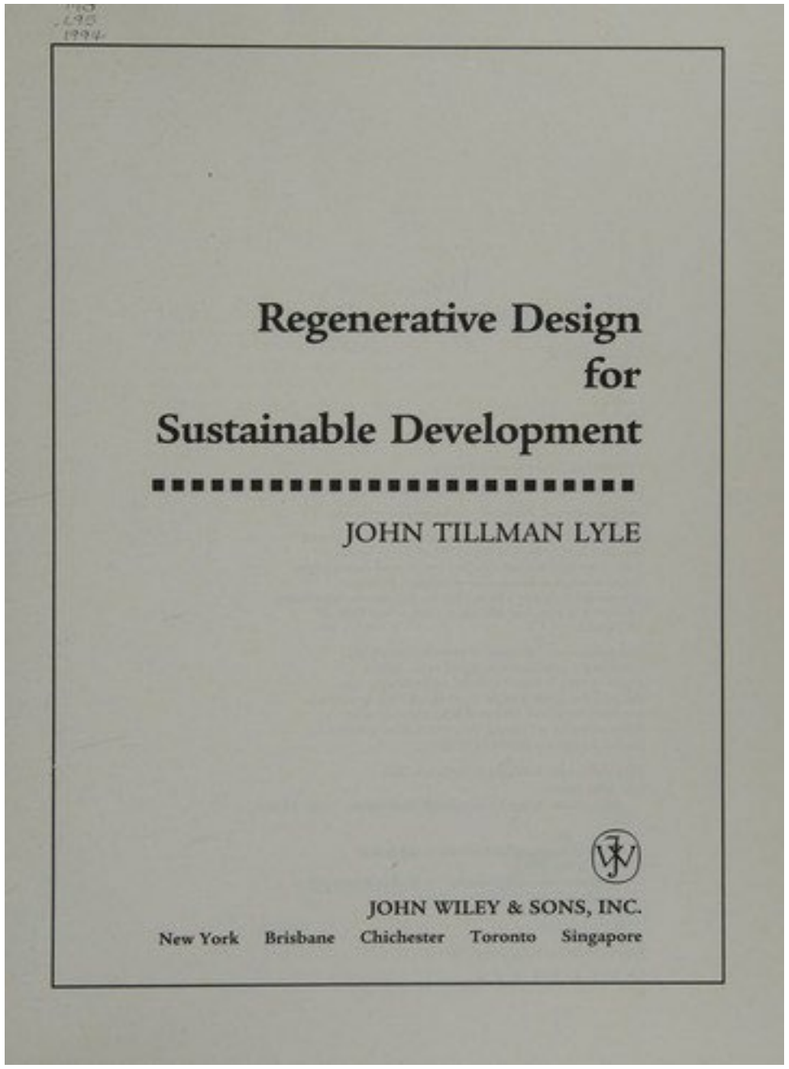
## Background - Regenerative thinking and Building

John Tillman Lyle

*"Regenerative Design for Sustainable Development"* (1985/1994)

From linear, destructive processes to "*cyclical* flows" that enable continuous restoration in accordance with natural ecosystems

'closed loop', Critique: Physical systems that only support themselves?




Regenerative Design for Sustainable Development

*John Tillman Lyle*

# WHAT IS REGENERATIVE Building?

Background - Regenerative thinking and Building

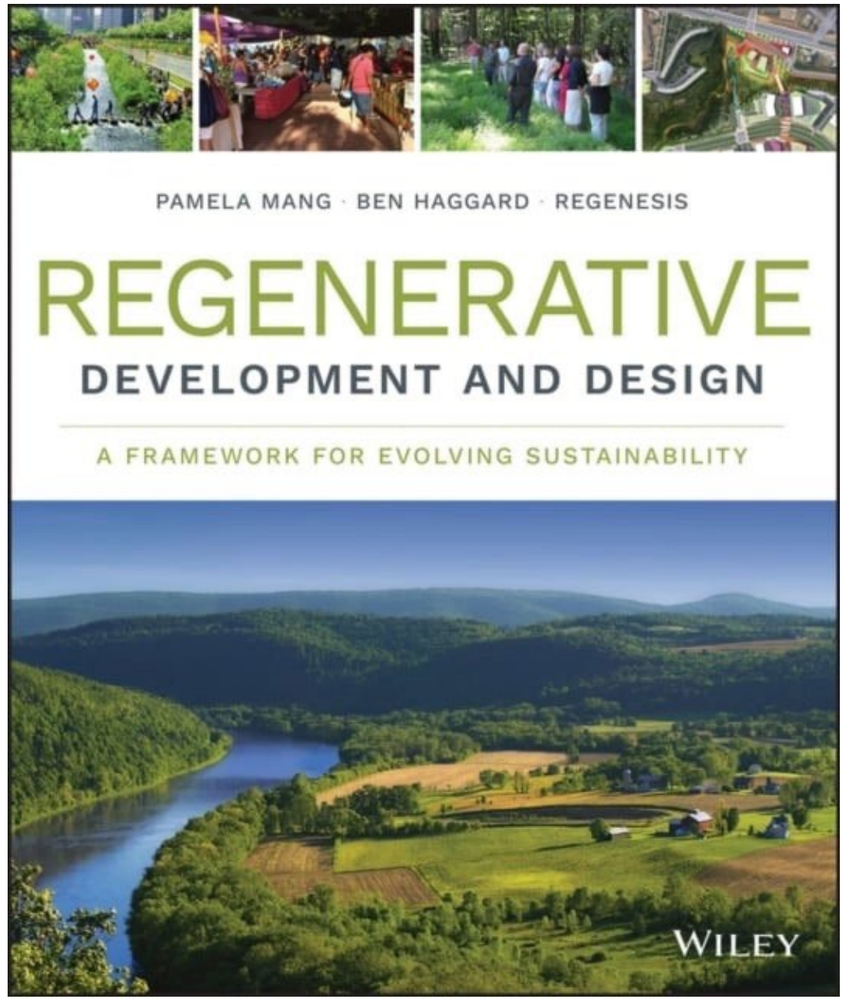
REGENESIS

Regenesis Group (1995-)

Building social, ecological, and cultural foundations for co-evolution with nature

'*Whole systems understanding of place*"

Involving stakeholders and local communities in developing capacity for continuous adaptation and resilience across entire systems




Regenerative Development and Design (2016)

*Regenesis Group: Pamela Mang & Ben Haggard*

# WHAT IS REGENERATIVE Building?

## Definitions

*"Building capacity, not things"*

*"Regenerative design is a system of technologies and strategies, based on an understanding of the inner workings of ecosystems that generates designs that regenerate socio-ecological wholes rather than deplete their underlying life support systems and resources."*

*"Regenerative development provides the framework and builds the local capability required to ensure that regenerative design processes achieve maximum systemic leverage and support over time."*

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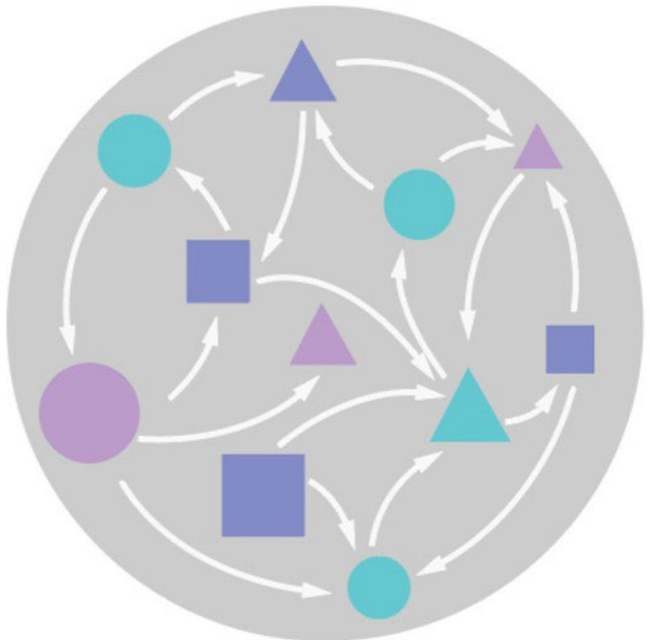
# WHAT IS REGENERATIVE Building?

## Three Concepts

### ECOLOGICAL WORLDVIEW

### CONTEXTUAL KNOWLEDGE

### SYSTEMS THINKING



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# WHAT IS REGENERATIVE Building?

Seven Principles

1. Place
2. Future Action (Future potential)
3. Lifecycle thinking
4. Trans-scalar
5. Wholeness
6. Reciprocity
7. Leverage systems

The Seven First Principles of Regeneration Carol Sanford
+
… Regenesis Group
…

# WHAT IS REGENERATIVE Building?

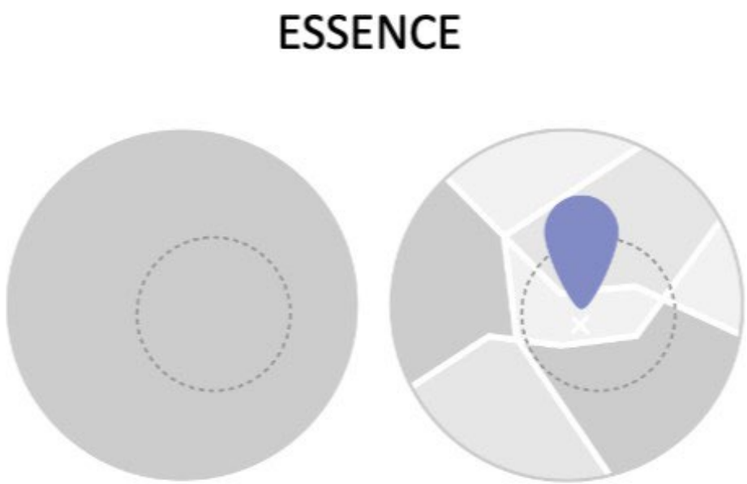
Seven Principles: 1) Location

Understanding place

Site-specific ecological patterns: Soil, water, climate, flora, and fauna. Cultural and historical narratives

"*story of the place*"

Contextual rather than universal checklists




***Place-based adaptability** versus universal standards*

...

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# WHAT IS REGENERATIVE Building?

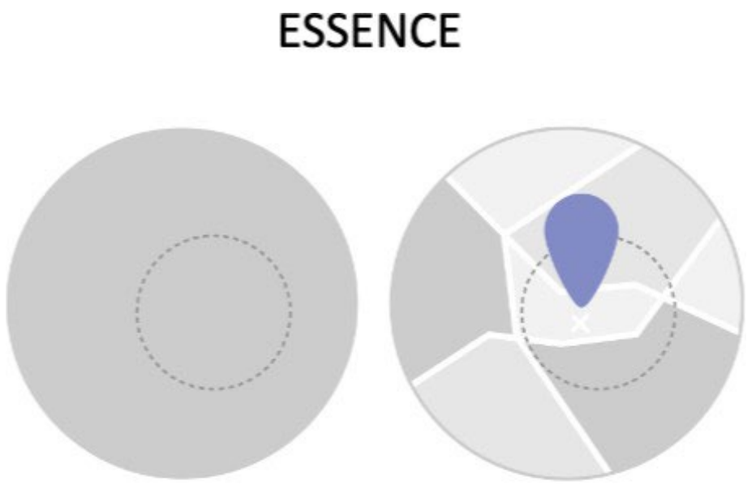
Seven Principles: 2) Future Potential

Future potential

Promote systems' ability to evolve rather than just repair isolated problems

*"What is the greatest potential of this place and how can it be supported?"*

Realizing potential rather than solving problems




***Place-based adaptability** versus universal standards*

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# WHAT IS REGENERATIVE Building?

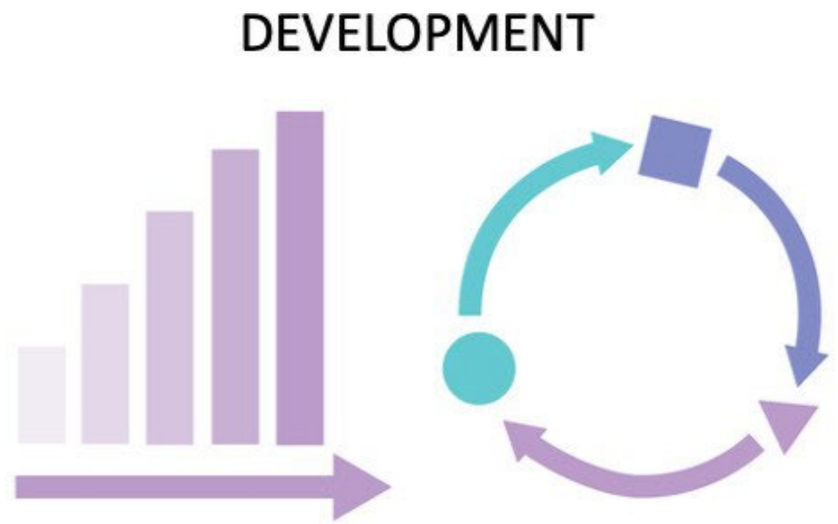
Seven Principles: 3) Life cycle thinking

Life cycle thinking

Possibility of adaptation and change over time

*"Not a final condition but a process of continuous co-evolution between human and natural systems"*

Continuous development rather than static end products




**Long-term adaptability** *versus* immediate efficiency

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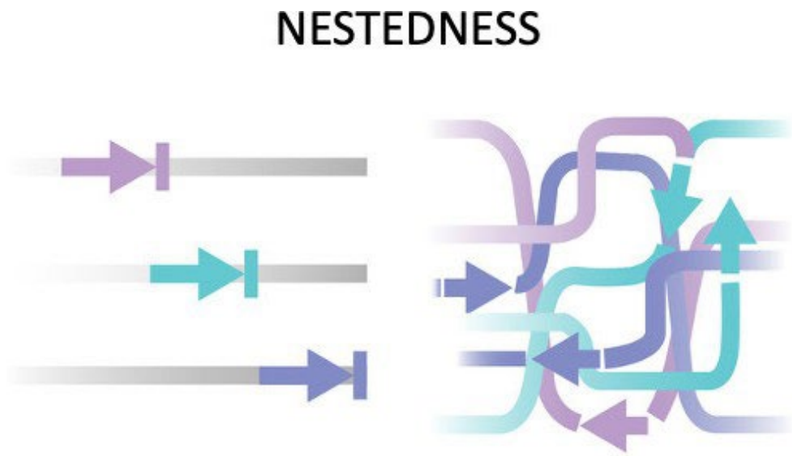
# WHAT IS REGENERATIVE Building?

Seven Principles: 4) Transscalar

Across scales

Everything exists in systems embedded within other systems

*"All designs are embedded within both greater and lesser systems, each playing a core role in the success of the entire whole as well as other necessary wholes."*




***Co-evolution** with nature instead of resource management*

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# WHAT IS REGENERATIVE Building?

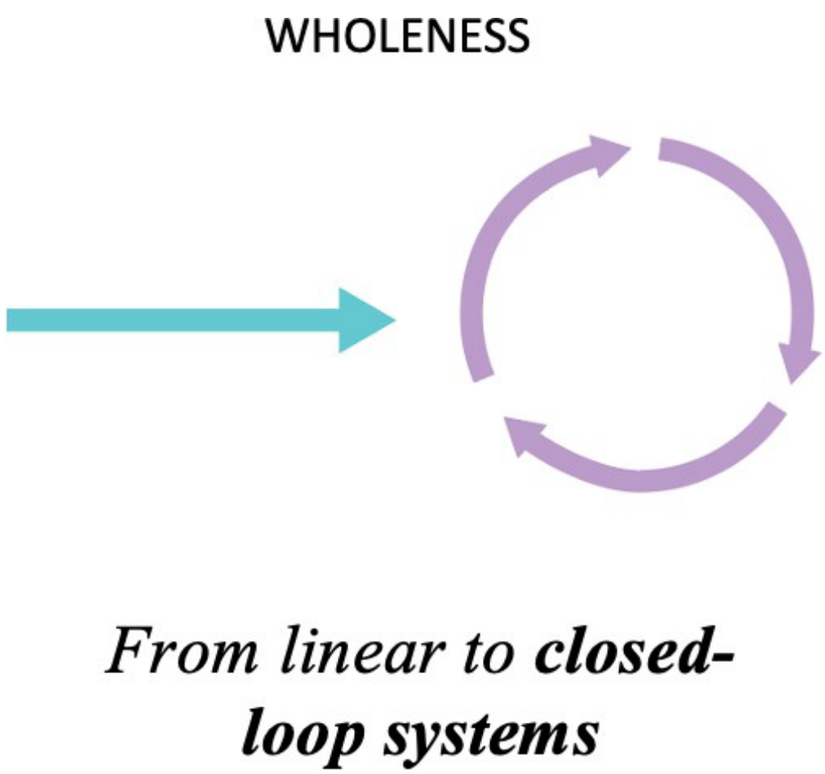
Seven Principles: 5) Wholeness

Wholeness

All elements must be aligned and work together

*"see what they are working on as asystem of energies or life processes, rather than as things"*

Design as a whole rather than as the sum of its individual elements




*From linear to* ***closed-loop systems***

...

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# WHAT IS REGENERATIVE Building?

Seven Principles: 6) Mutual interaction

## Interaction

Systems thrive on mutual exchange

*"Diversity adds nothing if there is no beneficial exchange of resources, energy, or materials."*

Co-creation with actors and ecosystems rather than imposed solutions

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# WHAT IS REGENERATIVE Building?

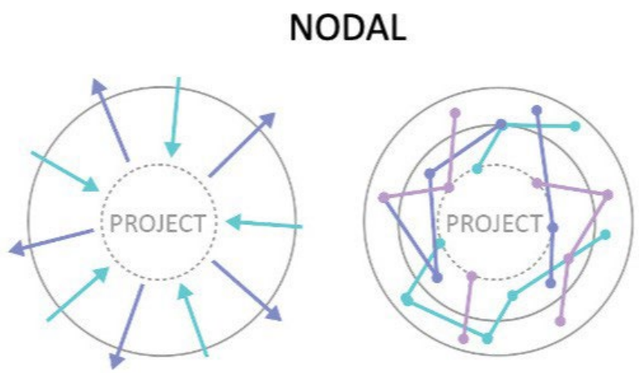
Seven Principles: 7) System leverage points

Leverage points / nodes

At critical intervention points, disproportionate system changes can be achieved with relatively little effort

*"A single point or set of points are recognized as most effective for achieving systemic regeneration."*

System nodes rather than isolated checklists




**Systems thinking** *versus* fragmented metrics

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# WHAT COULD REGENERATIVE Building LOOK LIKE?

# REGENERATIVE Building

The ultimate regenerative case?

- Vernacular Building
- Building components are replaced in line with the growth cycle of the plants from which the materials are harvested

- Center column -80 years
- Other wooden structures -40 years
- Secondary structures -10-15 years
- Underlay (bamboo Building) and roof (deck leaves) - every few years
- Foundation with minimal footprint

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https://the.akdn/en/how-we-work/our-agencies/aga-khan-trust-culture/akaa/preservation-mbaru-niar

## Mbaru Niang

| | |
|---|---|
| Architect... | (Rumah Asuh/Yori Antarestam faut) |
| Site: | Wae Rebo Village, Flores Island (ID) |
| Year: | (2011) |
| Status: | Built/re-built |
| Typology: | Houses |
| Projet Type: | Rebuilding/renovation/conservation |
| Size: | ? (6500 m²) |
| Category: | Vernacular |

**Short description:**

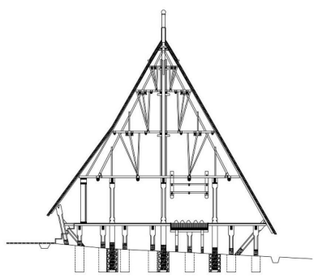
Conical houses of 'worok' wood and bamboo in tied- together rattan construction with thatched roofs are the archetypal buildings of this remote island village but they need to be constantly renovated and, at greater intervals, rebuilt

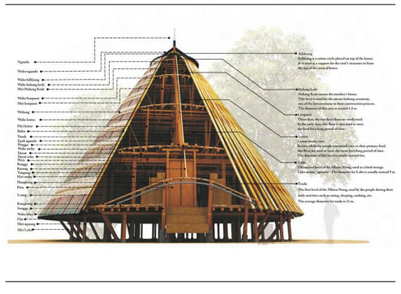
**Regenerative themes:**

- vernacular buildings
- construction components' replacement cycles are in tune with the life-cycle of the plants providing materials
- low impact foundation
- Regenerating and recording local knowledge

**Barriers:**

- different from contemporary living standards
- tropical climate
- fast tropical vegetation





# LONG LIST

## Cases

CARBON

COMMUNITY/

SCARCITY/

REUSE

GROWN

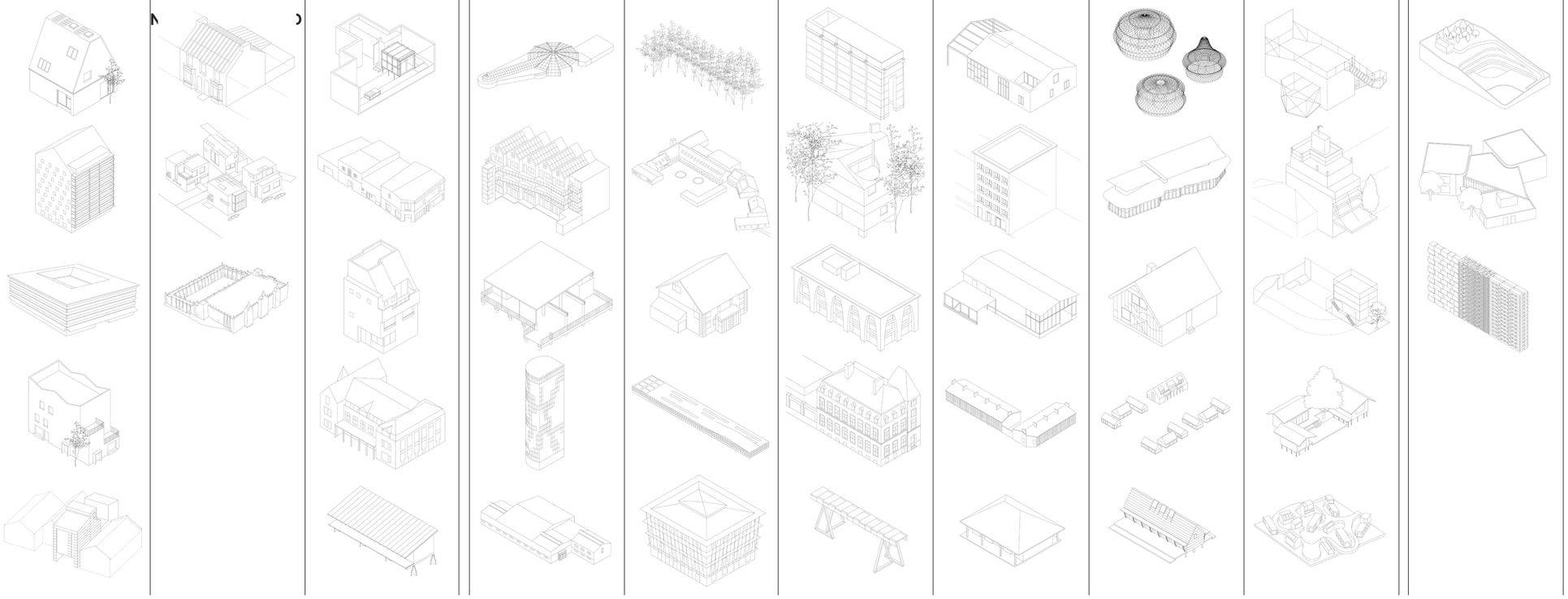
GEOLOGICAL

BIOREGIONAL

VERNACULAR

ECOLOGY/

ADDITIONAL



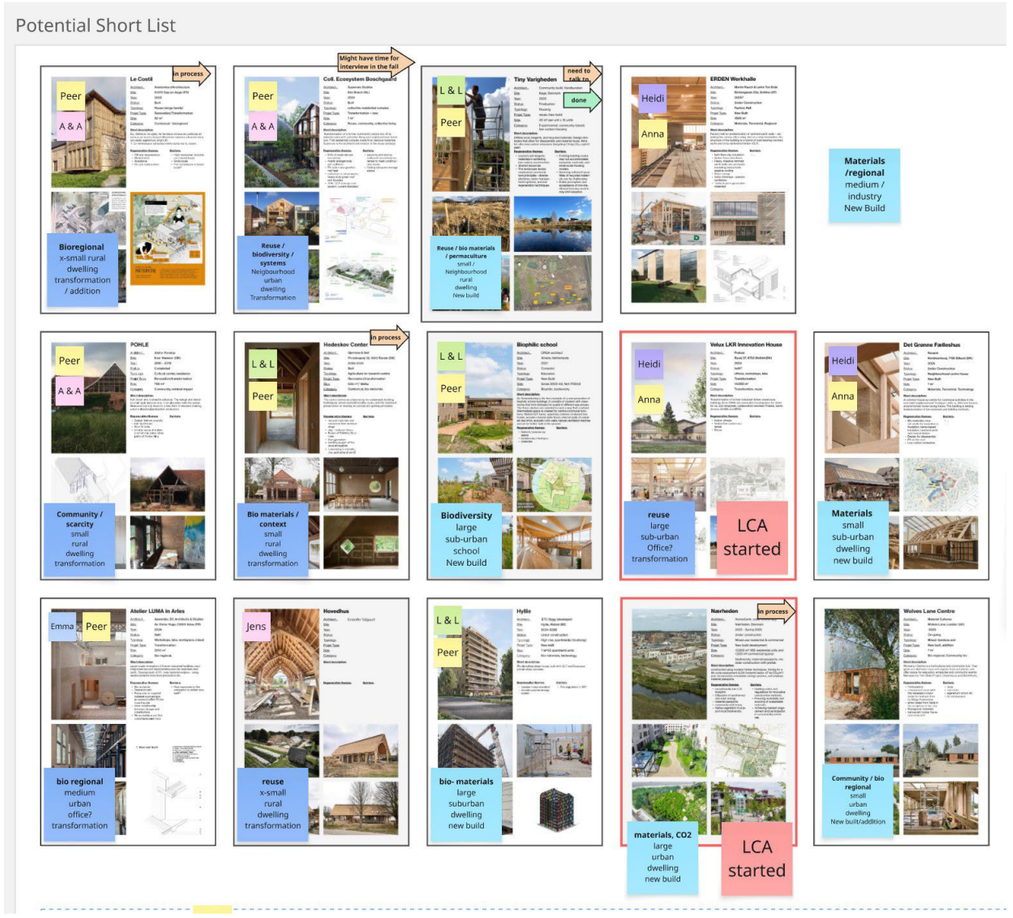
From 100 to approx.
50 cases

...

# SHORT LIST

Selected cases

- Recent Building (projects from the last 10-15 years)
- Cases from climate zones and contexts that can be compared with Denmark (primarily from Northwestern Europe)
- Different typologies, scales, locations
- New Building and transformation
- "Beacons" that have not necessarily achieved a fully regenerative level, but are examples of regenerative ambitions




Workshop with selection of cases

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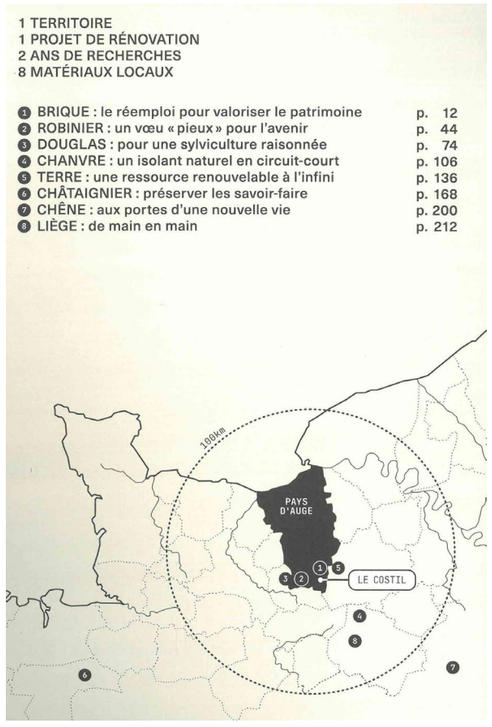
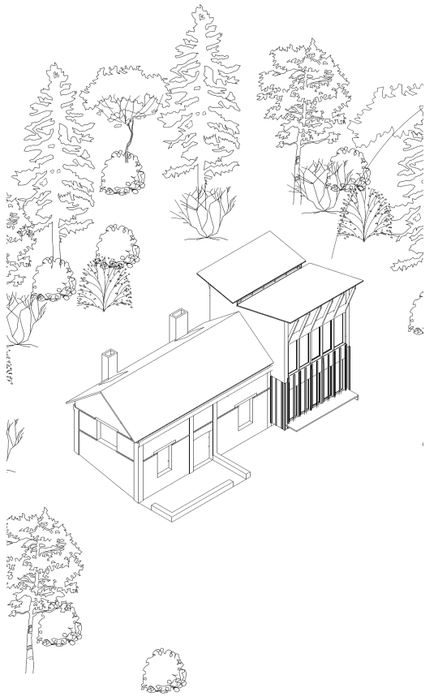
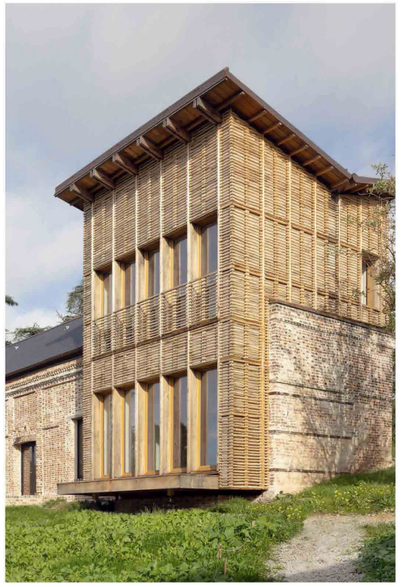
# SHORT LIST

## Le Costil





## Le Costil

| | |
|---|---|
| Architect... | Anatomies d'Architecture |
| Site: | 61470 Sap-en-Auge (FR) |
| Year: | 2022 |
| Status: | Built |
| Typology: | House (singe-family) |
| Projet Type: | Renovation/Transformation |
| Size: | 83 m² |
| Category: | Contextual - bioregional |

**Short description:**

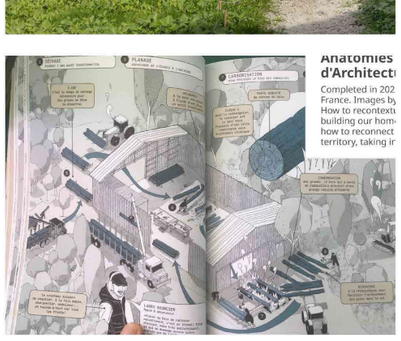
Do, nihilicivis ine egite, nin hendace consus se, publicae ad nonsus ad faucta atussol tilibuntrum tabemur aticaurbi tuius, con sedo, egeremum ortum dit.
Ti. En virmissusce adhuctus vivirte aucta res te, esseri,

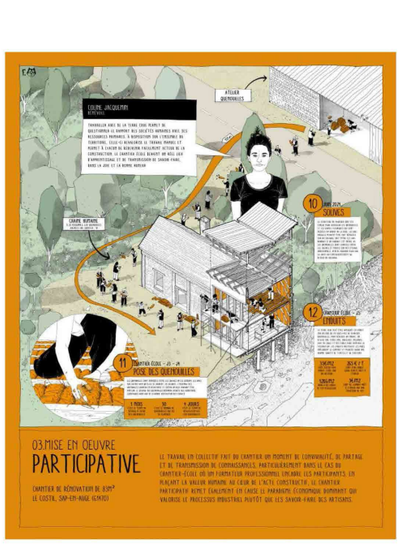
**Regenerative themes:**

- Off-site regeneration
- Minimization
- Avoidance
- On-site restauration

**Barriers:**

- High manpower (volunteers / workshops)
- Small scale
- Fire compliance in larger scale?




Anatomies d'Architecture

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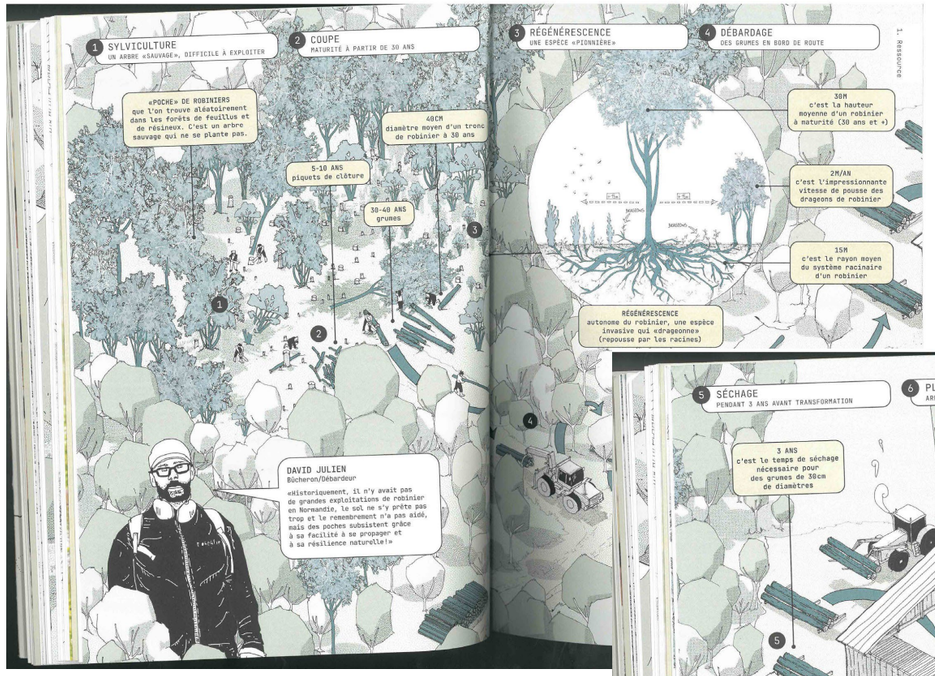
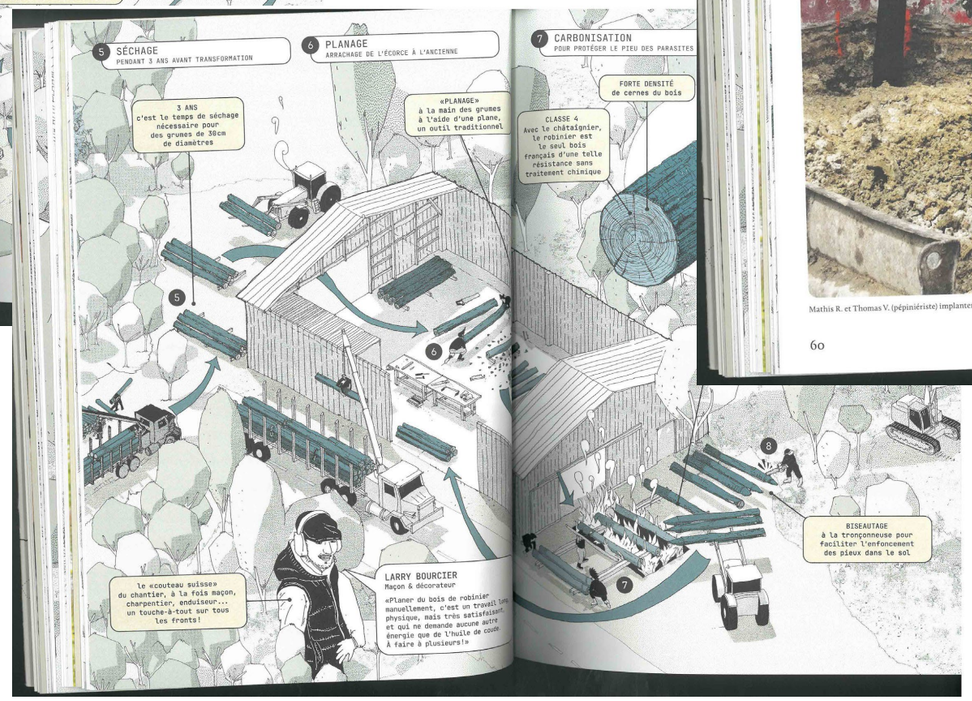
# SHORT LIST

## Le Costil











Anatomies d'Architecture

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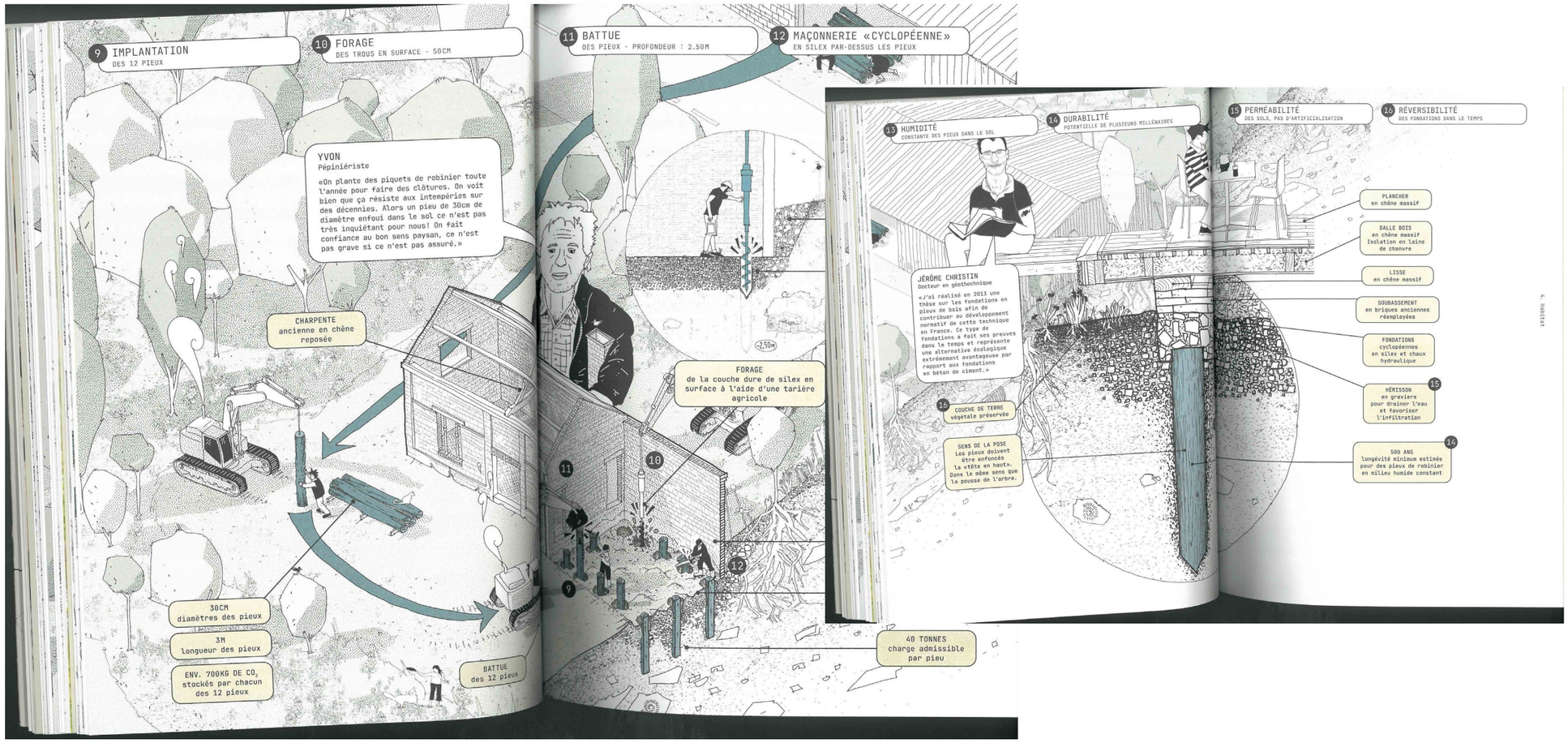
# SHORT LIST

## Le Costil




Anatomies d’Architecture

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# SHORT LIST

## Le Costil


Anatomies d'Architecture

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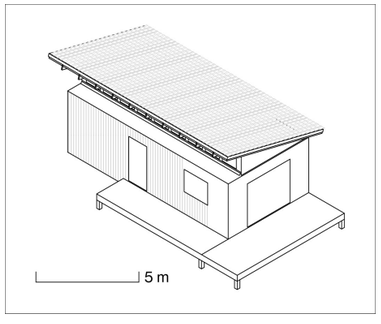
# SHORT LIST

## Tiny Varigheden






Køge Common Land

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## Tiny Varigheden

| | |
|---|---|
| Architect... | Community build, Vandkunsten |
| Site: | Køge, Denmark |
| Year: | 2025 |
| Status: | Finalisation |
| Typology: | Housing |
| Projet Type: | reuse /new build |
| Size: | 40 m² per unit x 16 units |
| Category: | Experimental, community-based, low-carbon housing |

**Short description:**

Utilizes local, biogenic, and recycled materials. Design strategies that allow for disassembly and material reuse. Aims for ultra-low carbon emissions (targeting 2.5 kg $CO_2$-eq/m²/year)

**Regenerative themes:**

- ecycled and biogenic materials in achieving low-carbon construction.
- Shared resources
- The landscape design emphasizes permaculture principles - diverse plantings, water management systems, and soil regeneration techniques

**Barriers:**

- Existing building codes may not accommodate innovative materials and small-scale housing models.
- Sourcing sufficient quantities of recycled materials can be challenging.
- Public perception and acceptance of non-traditional housing models may limit adoption.

# SHORT LIST

## Tiny Varigheden

## Køge FællesJord

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# SHORT LIST

## Wolves Lane

Material Cultures

...

## Wolves Lane Centre

| | |
|---|---|
| Architect... | Material Cultures |
| Site: | Wolves Lane, London (UK) |
| Year: | -2025 |
| Status: | On-going |
| Typology: | Mixed: Gardens and |
| Projet Type: | New built, addition |
| Size: | ? m² |
| Category: | Bio-regional, Community inv. |

**Short description:**

Wolves Ln Centre is a horticultural and community hub. They grow and distribute local and organic food and plants, and offer space for education, enterprise and community events. Managed by The Ubele Project, OrganicLea and BlackRootz.

**Regenerative themes:**

- Participatory
- empowered users with the necessary know-ledge to maintain their buildings themselves
- straw bales from fields in the periphery of the city
- Bioregional materials
- lightweight timber frame and straw infill

**Barriers:**

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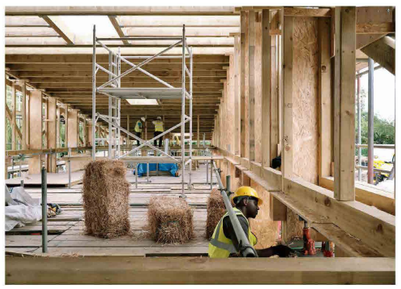

# SHORT LIST

## Wolves Lane

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Material Cultures

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# SHORT LIST

## Wolves Lane

Material Cultures

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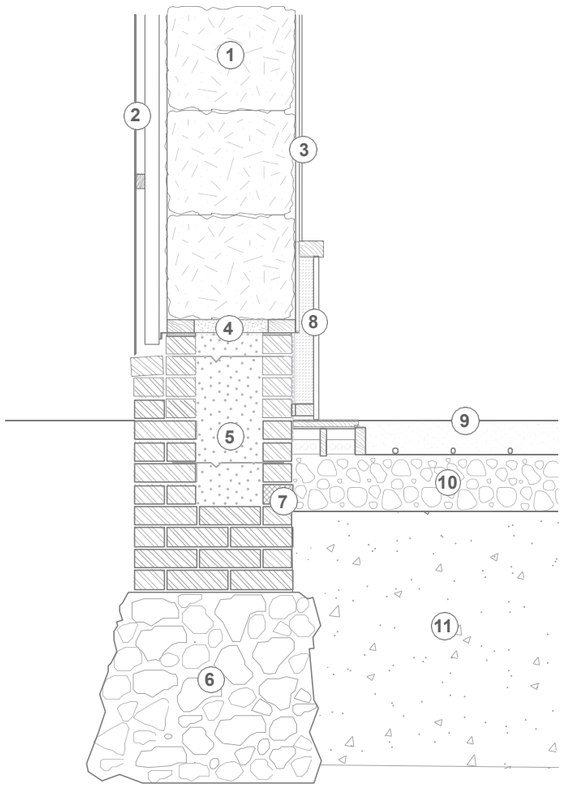
# SHORT LIST

## Wolves Lane

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Aarhus Architectur e Week

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Material Cultures

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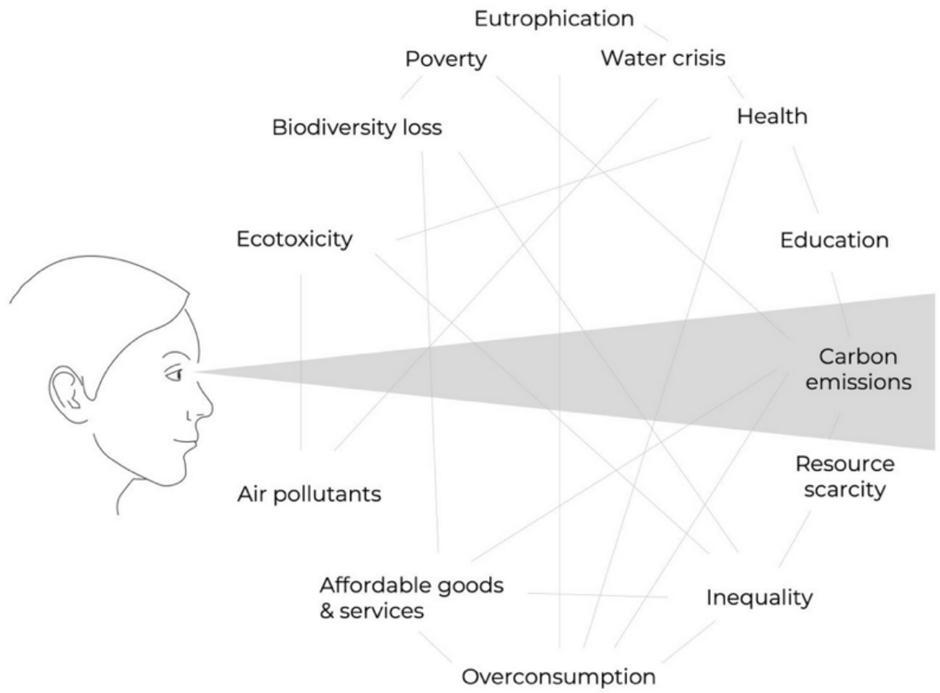
# HOW DO YOU MEASURE REGENERATION?

# QUANTIFYING REGENERATION

How is Building measured today?

"$CO_2$ eq/$m^2$/year."




Carbon Tunnel Vision

*Graphic by Jan Konietzko*
*https://www.sei.org/perspectives/move-beyond-carbon-tunnel-vision/*

# QUANTIFYING REGENERATION

How is Building measured today? And in a regenerative future?

Measure outcomes by ecosystems heath and regenerative capacity not only efficiency or certifications

"partner with place" where success is measured by its ability to *"seek to build the evolutionary capability of the systems into which it is designed"* - establish baseline.

Measurement is undermined by data limitations. there are insufficient datasets and challenges in monitoring long-term ecological and social performance.

Yet opportunities exist in the development of place-specific rubrics, standardised "handprint" metrics, and open-data platforms.

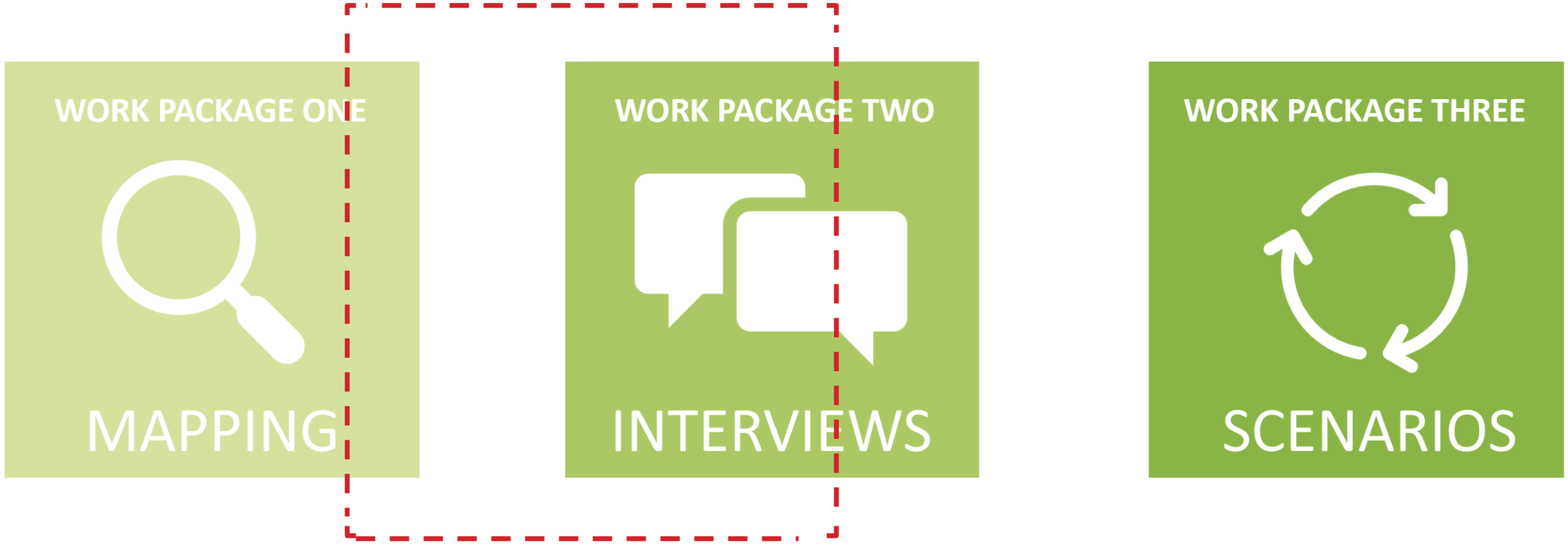
In this project:

Consequential LCA + Biodiversity assessment – August Sørensen, Ekolab, Ane Kirstine Brunbjerg (AU)
+
Absolute sustainability (impact per person) – Pil Brix, Steffen Petersen, Aarhus University
+
Workpackage 3 – new ways to establish baselines of nested natural processes of a place

# CHALLENGES, BARRIERS, AND OPPORTUNITIES

# REGENERATIVE Building

## About the Project




- Literature review and definitions
- Quantification of regeneration?
- Long List
- Short List

- Opportunities and obstacles – findings from interviews
- Why did the selected cases not reach a regenerative level?
- What would it take?

- Regenerative Speculations
- Baseline for a regenerative design process
- A regenerative student house
- Robotic Regeneration

Three Work Packages

# CHALLENGES, BARRIERS, AND OPPORTUNITIES

Implementation of regenerative Building

1. Difficult to shift paradigm from "sustainability" (and business as usual) to regenerative practice
2. Fragmented knowledge and limited interdisciplinary collaboration
3. Building regulations and legislation
4. Lack of education/experienced professionals
5. Challenges in terms of practical implementation and scaling
6. Absence of standardized definitions and measurement methods
7. **Economics, materials, and time frames (and responsibility)**

Thank you

# REGENERATIVE Building

Examples, processes, and stories
from an ongoing paradigm shift

Aarhus Center for Regenerativt Byggeri

Realdania