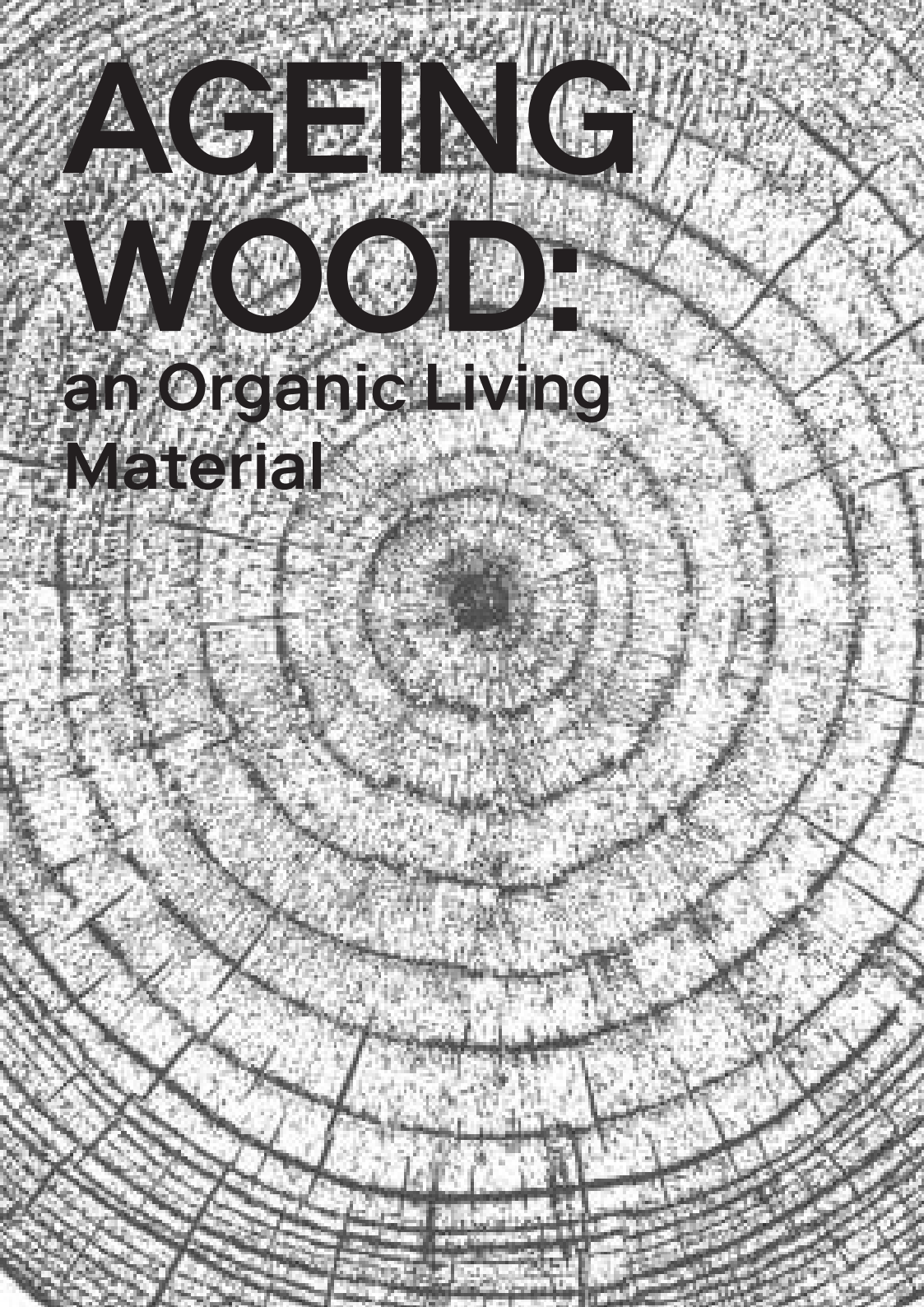
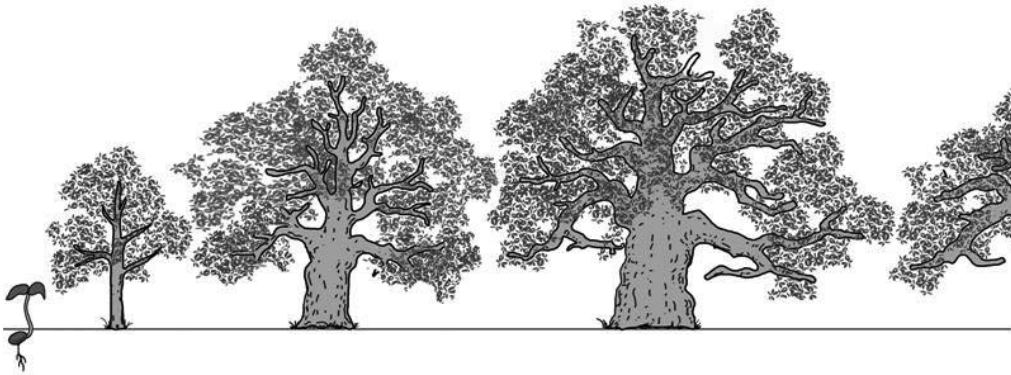
# AGEING WOOD:

## an Organic Living Material



# A LIVING MATERIAL?

moving
bending
growing
shrinking
expanding
decaying
splitting
rotting
cracking
changing
...



A B C D E

Keimling - sexuelle Reifepha-se

Jugend bis frühe Reifephase

volle bis späte Reifephase

frühe Altersphase

Entwicklungsphase

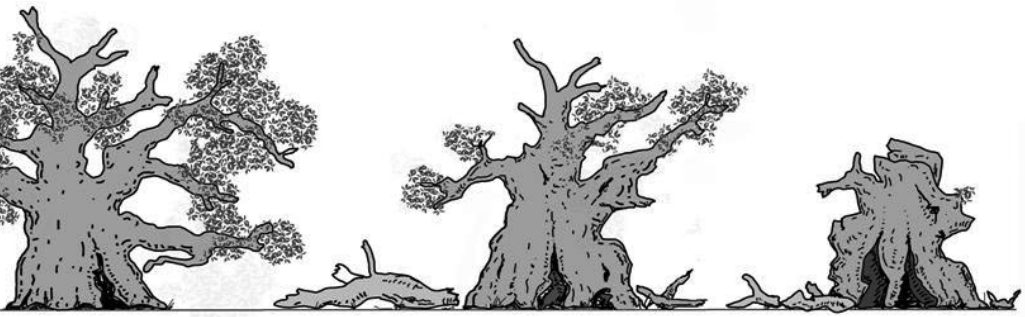
Reifephase

Keimung

*hohe Vitalität*

*geringe Habitatqualität*

1) Lifecycle of a tree



F G

Späte Altersphase Zerfallsphase (Greisenphase)

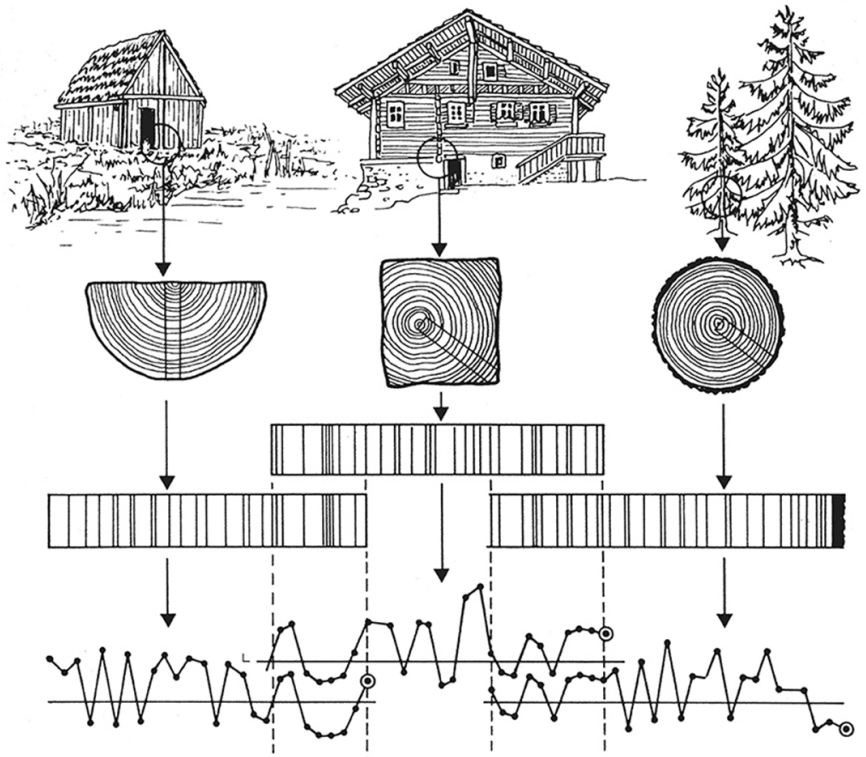
Altersphase

*sukzessiv abnehmende Vitalität*

Tod

*zunehmende Nährstoffgehalt für Besiedler*

*steigende Habitatqualität*



2) Dendrochronolgy

## Witness to the Past

Wood is a living, organic substance that not only serves as a building material but also as a witness to the past. Trees, through their growth and interaction with their environment, reflect the passage of time. Each growth ring holds stories of the tree's surroundings—droughts, seasons of abundance, and environmental changes. Through dendrochronology, these rings can be studied to reveal not only the age of the tree but also historical climate patterns and the architectural history of structures. This method allows us to trace when a building was constructed or renovated by analyzing the wood used, offering a window into the past. Thus, wood serves as both a dynamic, natural material and a vital record of historical building practices.

# AGEING OF CONSTRUCTION TIMBER

It takes about five years for timber to reach its optimum structural properties. Over time, a natural patina develops, turning the wood grey and protecting it from further weathering. This patina acts as a barrier to moisture and the environment, slowing down decay and naturally maintaining the structural integrity of the wood.

1)

1. Fresh Wood (Greenwood)

- Moisture: Very high, often over 30% (wood moisture content). Right after felling, the wood contains a large amount of water, making it heavy and prone to warping or deformation.

- Color: Vibrant and strong, with intense hues depending on the type of wood (e.g., light for spruce, reddish for pine).

- Smell: Fresh wood often has a strong, pleasant aroma, derived from resins and essential oils, particularly noticeable in softwoods like pine.

- Strength: The wood is relatively soft and flexible because it has not yet fully hardened due to the high moisture content.

- Susceptibility: Fresh wood is vulnerable to mold, fungi, and insect infestation, especially if stored in damp conditions.

## 2. AFTER 1–2 YEARS

- Drying Process: The wood begins to dry when stored correctly (in a well-ventilated and dry environment). The moisture content decreases to about 15–20% for air-dried wood or 8–12% for kiln-dried wood, depending on the storage method.

- Shrinkage and Cracks: As the wood dries, it shrinks and cracks may form, especially at the ends. The wood becomes harder and less flexible at this stage.

- Color Changes: The wood‘s color starts to fade and may gradually turn gray or dull due to exposure to UV radiation and oxygen.

- Protective Measures: Untreated wood becomes more susceptible to moisture and pests during this phase, which is why surface treatments such as varnishing, oiling, or impregnation are often applied.

3. After 5 Years

- Low Moisture Content: The wood has now reached a more stable moisture content, which is close to equilibrium with the surrounding air (approximately 8–15%, depending on the region and storage conditions). The wood has largely stabilized and will no longer shrink or crack significantly.

- Color and Patina: The wood shows a more pronounced color change, especially if used outdoors. Untreated wood develops a silver-gray patina, while treated wood may retain its original appearance, depending on maintenance.

- Hardness: The wood has reached its final strength and is now more resistant to mechanical forces.

- Deformation: Improper storage or use may lead to deformation (e.g., warping or twisting) as the wood adapts to its environmental conditions.

4. After 10 Years

- Stable Structure: The wood has fully stabilized. If it has been well maintained, it remains stable and functional. However, it may show early signs of material fatigue under heavy loads or poor maintenance.

- Surface Changes: Cracks, warping, or shrinkage may become more noticeable. Without regular maintenance, untreated wood can become brittle and more susceptible to damage.

- Protection Against Decay: Outdoors, the wood may exhibit signs of weathering, moisture effects, or pest infestation if it has not been regularly treated or protected.

5. After 20 Years

- Weathering: Untreated wood exposed to outdoor conditions will have experienced significant weathering, with a pronounced gray patina and potentially deeper cracks or surface damage. For indoor applications, oak remains largely stable but may show signs of fatigue, such as discoloration or wear.

- Strength: Structural strength may decline depending on the wood species and load, particularly for construction wood subjected to mechanical stresses or weather conditions.

- Pests:Without protective measures, there is a higher likelihood of insect infestation or decay, especially in areas exposed to moisture.

6. After 30+ Years

- Fatigue: The wood is likely to show significant signs of fatigue, particularly in load-bearing elements. It may lose strength and, depending on usage, could become brittle.

- Decomposition Processes: Outdoors, decay and rot are probable, especially at the ends or in areas where moisture has penetrated. Mold and fungal infestation can further deteriorate the wood.

- Possible Repairs or Replacement: After several decades, the wood may require repairs or replacement, especially in load-bearing structures or under intense use.

# PERFORMANCE AND AGEING

Wood is an organic material composed of cells and ages similarly to the human body. Just as our bodies undergo changes with age, wood experiences natural aging processes that affect its appearance, performance, and properties over time.

## Aging Processes

### 1. Fatigue

- Description: Wood fatigue refers to the weakening of strength due to repeated loads or mechanical stress. Over time, repeated stress or loading can create cracks and micro-defects that compromise the structural integrity of the wood.
- Effects:The wood's strength and stability can decrease, and under continued stress, it may become brittle or fail. This is particularly important for load-bearing elements in structures.

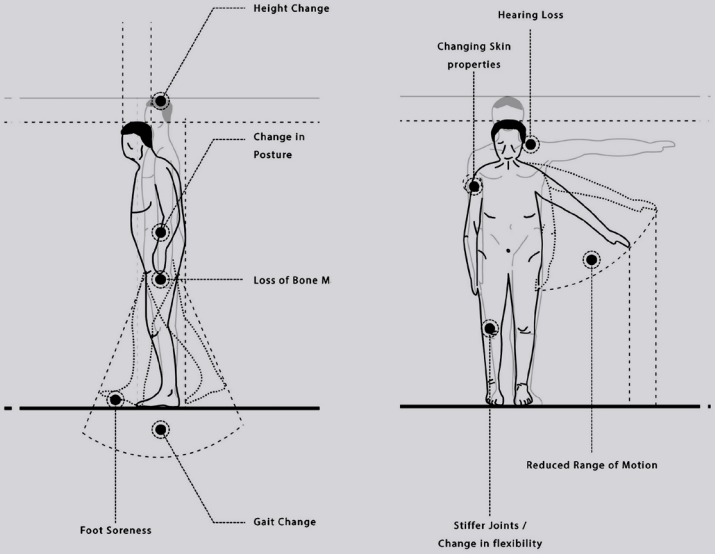
### 2. Weathering

- Description: Weathering is the process by which wood is damaged by environmental factors such as UV radiation, rain, wind, and temperature fluctuations. This leads to visible changes in the wood's surface and color.
- Effects: The wood's color may fade, and a silver-gray patina may develop. The surface can become rougher, with cracks or flaking. Weathering can impact the structural integrity of the wood, especially if it remains untreated.

### 3. Decay

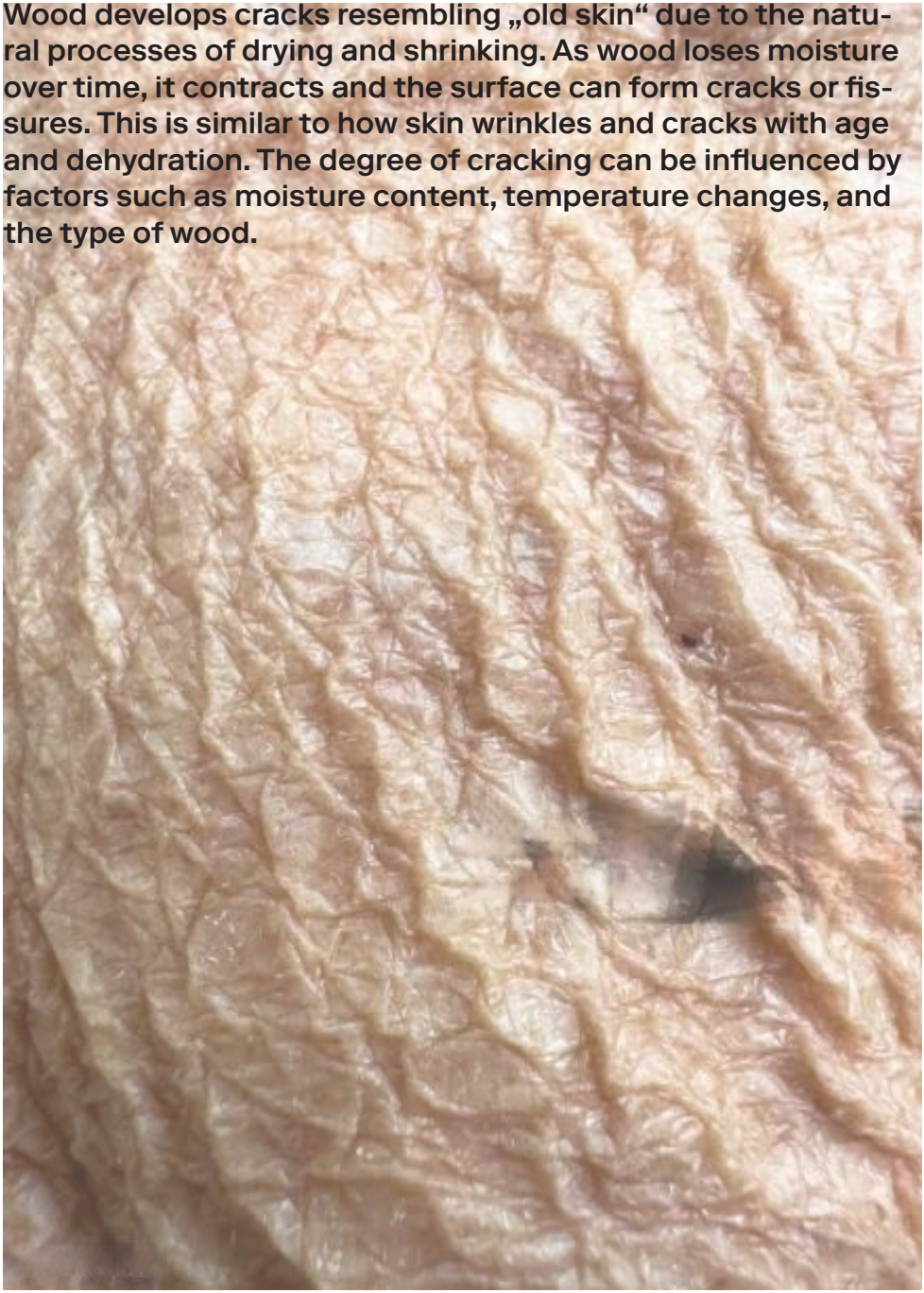
- Description: Decay is the process by which wood is broken down by biological activity, particularly by fungi and microbes. Moisture is a crucial factor that promotes the growth of mold and rot.
- Effects: Decay leads to the breakdown of the wood structure, making it soft, brittle, and porous. This can significantly reduce the wood's load-bearing capacity and mechanical properties, eventually leading to structural failure.

Over time, wood can shrink, warp, or develop a bent shape, much like the physical changes that occur in aging humans. Just as joints and connections in the human body may become less flexible or misaligned with age, wooden structures can face issues with their joints and connections becoming less effective. These aging processes in wood can impact the stability and performance of structures.



Wood turns gray, similar to aging hair, primarily due to the effects of UV radiation and oxidation. Just as hair loses pigment and turns gray with age, wood‘s color fades when exposed to sunlight, causing the breakdown of pigments and the development of a silver-gray patina. Additionally, environmental factors like rain and wind contribute to this aging effect, giving wood a weathered appearance over time.

Wood develops cracks resembling „old skin“ due to the natural processes of drying and shrinking. As wood loses moisture over time, it contracts and the surface can form cracks or fissures. This is similar to how skin wrinkles and cracks with age and dehydration. The degree of cracking can be influenced by factors such as moisture content, temperature changes, and the type of wood.



# AGEING JOINTS

Strickbau

Loged  connections are relatively flexible and can accommodate tolerances to a certain extent. However, over time, moisture changes, mechanical loads, and natural wood deformations can affect the accuracy and stability of these connections. Especially in outdoor settings, where moisture can penetrate at the ends of beams, these connections are particularly vulnerable. Excessive moisture fluctuations or heavy loads can lead to wear, loosening, and cracking, which can impair the long-term stability of the connections.

In timber frame constructions, beams and connections are often intricately interlinked, making the removal or replacement of a single beam or component complex. In many cases, the entire building or a larger section of it may need to be temporarily supported to safely replace the affected parts.

## Tongue-and-Groove

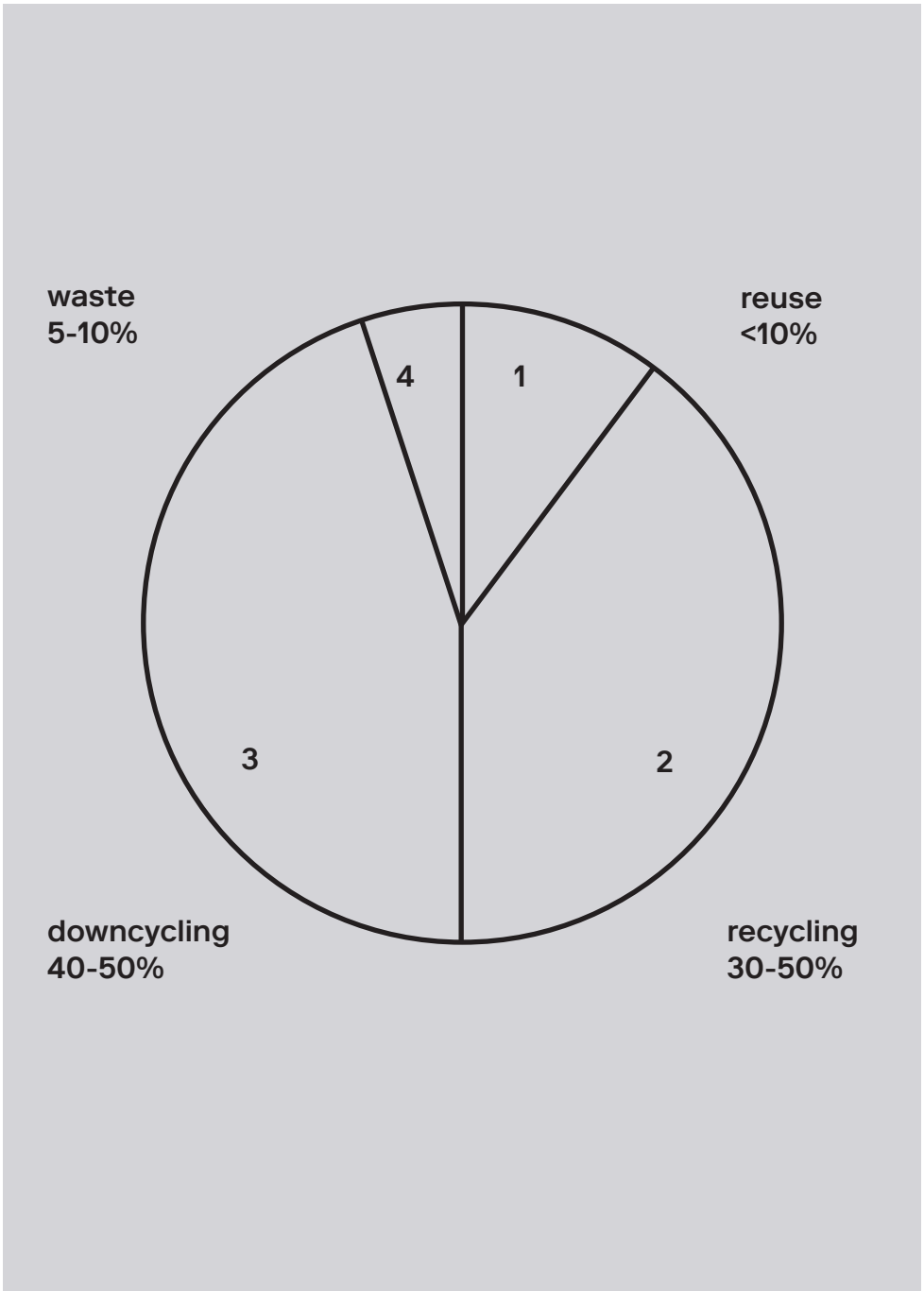
Tongue-and-groove connections are particularly susceptible to aging processes. Over time, wood can shrink or swell due to changes in moisture, affecting the accuracy of the connection. The wood may warp or deform, causing the precise fit of the tongue-and-groove joint to be lost. Additionally, cracks and gaps can developat the joint, weakening the stability of the connection. Mechanical stress and repeated use also contribute to wear and tear. These changes necessitate regular maintenance to preserve the functionality of the connections.

## Blattverbindung

Even in Blattverbindung, movements of the wood, such as swelling and shrinking, can affect the connection and lead to wear over time. Plate connections are primarily designed for stabilizing the position of wood components and can accommodate gaps and tolerances, being secured with bolts. This flexibility allows plate connections to compensate for minor inaccuracies and movements in the wood. If parts of the connection need to be replaced, the process is generally straightforward; it usually involves simply tightening or replacing the bolts to restore the connection.

# REUSE OF CONSTRUCTION TIMBER?

In Switzerland, timber components are rarely reused due to both technical challenges and economic unfeasibility. This is partly because timber connections are often specific and precisely crafted, and there are not many techniques to join old and new parts or different joinining-systems together. Additionally, movements of the wood complicate reuse, as new connections often cannot accommodate the tolerances that have developed over time.


waste
5-10%
reuse
<10%
4
1
3
2
downcycling
40-50%
recycling
30-50%

## Lifecycles of Construction Timber

**1. Reuse of Construction Timber: below 10%**
**The proportion of reused construction timber is relatively low compared to total wood consumption, usually under 10%. This is because much construction timber is unsuitable for reuse due to mechanical damage, weathering, or contamination, and also because wooden joints are made to fit precisely.**

**2. Recycling of Construction Timber: 30-50%**
**Wood recycling refers to the conversion of demolition wood into new wood products or other materials. This can be done by shredding the wood into chips or fibers, which are then used in products like particleboard, fiberboard, or insulation materials. In Switzerland, around 30-50% of construction timber is recycled.**

**3. Downcycling and Use as Fuel: 40-50%**
**Downcycling means that wood is used for less valuable purposes, such as fuel in power plants or for biomass energy. Unfortunately, a large portion of construction timber waste is used this way, as it is often more economically viable than reuse or recycling. Switzerland utilizes about 40-50% of construction timber waste for energy recovery, particularly in the form of biomass for energy production, as it represents a cost-effective and efficient energy source and the country has a well-established forestry industry.**

**4. Timber Sent to Landfills: 5-10%**
**Thanks to strict Swiss waste regulations, only a very small portion of construction timber waste is landfilled. In Switzerland, the share of construction timber sent to landfills is below 10%, and in some regions, it is even significantly lower.**