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Ecological Design Thinking
for a Circular Economy

Emma H. E. Fromberg

Ecological Design Thinking for a Circular Economy

Emma Hilda Elizabeth Fromberg

Ecological Design Thinking for a Circular Economy

Dissertation

for the purpose of obtaining the degree of doctor
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Keywords: Circular Economy, Sustainability, Circular Business, Conceptual Metaphor Theory, Forest Metaphor

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"Imagination
is the only weapon
in the war
against reality."

Lewis Carroll (1832–1898)

ENGLISH SUMMARY

In response to calls for fundamental transformation of the economy, the idea of a circular economy has emerged as a promising direction. However, in practice, this idea is still commonly understood through conceptual lenses that reflect the logic of linear and mechanistic systems. This study explores the role of conceptual metaphors in circular economy discourse, arguing that the metaphors that are used to understand the economy significantly influence the kind of solutions that one can imagine and value. This research investigates the potential of the forest metaphor to support alternative ways of conceptualising the circular economy.

The first part of this study was aimed towards the identification of current dominant metaphors in circular economy discourse. It found that the machine metaphor was the most dominant metaphor. This was followed by competitive metaphors (sports and war), the journey metaphor, and, to a limited extent, ecological metaphors. The textual analysis showed that the current academic discourse predominantly:

1. Makes sense of a circular economy in a mechanistic way, as the sum of resource inputs and outputs.
2. Sees the relationships between businesses in a circular economy as competitive.
3. Makes sense of change towards a circular economy as something that happens gradually and step-by-step.

The three most dominant metaphors are also dominant in current linear economy discourse and therefore reinforce similar patterns of thought. The ecological metaphor occurred less and was identified as a potentially interesting new line of enquiry, conceptualising nonlinear, complex and dynamic features, unlike the more dominant metaphors. This led to the main research question of this thesis:

How can ecology-inspired metaphors enrich circular economy discourse?

The second part of the research investigated the implications of using an ecology-based metaphor - specifically, the forest metaphor - to support conceptual development in circular economy learning. A case study was conducted on a postgraduate workshop, where participants engaged with the forest metaphor to explore circular business. Learners found the metaphor enriching, particularly in relation to ideas that incorporate the interconnectedness of businesses and the cooperation between different entities in the economy. However, many of the insights generated were general in nature and lacked specificity.

To further the exploration, a subdomain of the metaphor was explored in more detail: the technosphere as fruit from a tree. The technosphere refers to products, components and materials that are part of the human-made and managed realm, unlike biological nutrients. Through this study, products, components, and materials were understood as fruit from a tree. Unlike the machine metaphor, which tends to frame the economy as a closed and controllable system, this metaphor suggested more open flows of resources and information. The metaphor also allows social and environmental dimensions of a circular economy to be woven together more tightly in ideas and solutions.

In the third part of the study, a learning tool was developed to support the application of the forest metaphor to circular economy education. Eighteen subdomains of the forest metaphor were identified through interviews, each relating to one of three overarching themes: wholeness of the forest, the importance of relationships, and the response to change. These subdomains were reviewed by circular economy experts, who identified potential areas of application within existing circular economy discourse. Their input informed the development of a learning tool titled Ecological Design Thinking for a Circular Economy.

The fourth and final part of the study evaluated this tool through a comparative case study. A second workshop was conducted, similar in format to that of part two, but this time including the learning tool. Participant responses and workshop outcomes were compared with those from the earlier workshop. The findings suggest that the use of the tool contributed to more detailed and concrete ideas and that learners considered the engagement with the tool more enriching.

This thesis demonstrates the potential of the forest metaphor as an ecological metaphor for circular economy discourse. This metaphor prompts a reflection on the competitive nature of business and intellectual property rights and suggests ideas in line with more collaborative, decentralised and open approaches in business. In a generative way, the metaphor allows participants to focus more on community-led and place-based approaches to innovation, which allows businesses to tune into the local context surrounding their supply chain and business model, considering both social and environmental dimensions simultaneously.

Ultimately, this research reinforces that metaphors are not merely the decoration of language but can also be a learning tool. This can be used in a reflexive way, by challenging previously unquestioned assumptions, or in a generative way, by allowing new ways of thinking and developing novel solutions.

NEDERLANDSE SAMENVATTING

De circulaire economie wordt gezien als een veelbelovend idee voor een fundamentele transformatie van het economische systeem. In de praktijk wordt een circulaire economie echter vaak begrepen door dezelfde conceptuele lenzen als de huidige lineaire economie. Deze thesis onderzoekt de rol van conceptuele metaforen in hoe gedacht wordt over een circulaire economie. Het stelt dat de metaforen die worden gebruikt om de circulaire economie te begrijpen, de soort oplossingen die men kan voorstellen en waarderen, aanzienlijk kunnen beïnvloeden. Daarom onderzoekt deze thesis het potentieel van de bosmetafoor als een alternatieve manier om de circulaire economie te conceptualiseren.

Het eerste deel van deze thesis was gericht op de identificatie van de huidige dominante metaforen waarmee de circulaire economie wordt begrepen. Hieruit bleek dat de machinemetafoor de meest dominante metafoor was. Hierna volgden competitieve metaforen (zoals sport en oorlog), de reismetafoor, en in beperkte mate ecologische metaforen. De tekstanalyse toonde aan dat in de huidige dominante conceptualisering:

1. de circulaire economie op een mechanistische manier wordt begrepen, als de som van grondstoffen die in en uit de economie stromen.
2. de relaties tussen bedrijven in een circulaire economie voornamelijk als competitief worden gezien.
3. verandering richting een circulaire economie wordt gezien als iets dat geleidelijk en stap voor stap plaatsvindt.

De drie meest dominante metaforen zijn ook dominant in de conventionele lineaire economie en kunnen doordoor vergelijkbare denkpatronen versterken. De ecologische metafoor kwam minder vaak voor en werd daarom geïdentificeerd als een mogelijk interessante nieuwe onderzoeksrichting, waarin niet-lineaire, complexe en dynamische kenmerken worden geconceptualiseerd — in tegenstelling tot de meer dominante, huidige, metaforen. Dit leidde tot de centrale onderzoeksvraag van deze thesis:

Hoe kunnen door ecologie geïnspireerde metaforen het discours over de circulaire economie verrijken?

Het tweede deel van het onderzoek onderzocht de implicaties van het gebruik van een op ecologie gebaseerde metafoor, de bosmetafoor, ter ondersteuning van de conceptuele ontwikkeling tijdens het leren over de circulaire economie. Een case study werd uitgevoerd in de context van een workshop op masterniveau, waarin deelnemers de bosmetafoor gebruikten om de circulaire economie te verkennen. Deelnemers

vonden de bosmetafoor verrijkend, met name in relatie tot ideeën die de onderlinge verbondenheid van bedrijven en de samenwerking tussen verschillende entiteiten in de economie benadrukten. Veel van de gegenereerde inzichten waren echter algemeen van aard en misten specificiteit. Om de verkenning voort te zetten, werd een subdomein van de metafoor in meer detail onderzocht: de technosfeer als fruit van een boom. De technosfeer verwijst naar producten, componenten en materialen die deel uitmaken van het door mensen gemaakte en beheerde domein, in tegenstelling tot biologische nutriënten. In dit onderzoek werden producten, componenten en materialen begrepen als fruit van een boom. In tegenstelling tot de machinemetafoor, die de economie vaak weergeeft als een gesloten en controleerbaar systeem, suggereerde deze metafoor meer open stromen van grondstoffen en informatie. De metafoor maakt het ook mogelijk om sociale en ecologische dimensies van een circulaire economie nauwer te verweven in ideeën en oplossingen.

In het derde deel van het onderzoek werd een leermiddel ontwikkeld om de toepassing van de bosmetafoor in het onderwijs over de circulaire economie te ondersteunen. Achttien subdomeinen van de bosmetafoor werden geïdentificeerd via interviews, elk gerelateerd aan een van drie overkoepelende thema's: de integriteit en totaliteit van het bos, het belang van relaties, en de reactie op verandering. Deze subdomeinen werden beoordeeld door experts op het gebied van de circulaire economie, die vervolgens potentiële toepassingsgebieden binnen het bestaande discours over de circulaire economie identificeerden. Hun input heeft bijgedragen aan de ontwikkeling van een leermiddel met de titel *Ecological Design Thinking for a Circular Economy*.

Het vierde en laatste deel van het onderzoek evalueerde dit leermiddel via een vergelijkende studie. Een tweede workshop werd uitgevoerd, vergelijkbaar met de workshop uit het tweede deel van dit onderzoek, maar ditmaal met het leermiddel erbij. De reacties van de deelnemers en de uitkomsten van beide workshops werden met elkaar vergeleken. De bevindingen suggereren dat het gebruik van het leermiddel heeft bijgedragen aan meer gedetailleerde en concrete ideeën. Ook gaven deelnemers aan dat het gebruik van het leermiddel als verrijkender werd ervaren.

Deze thesis toont het potentieel aan van de bosmetafoor als ecologische metafoor voor het discours over de circulaire economie. Deze metafoor zet aan tot reflectie over de competitieve kenmerken van bedrijven en intellectuele eigendomsrechten, en suggereert ideeën die aansluiten bij meer samenwerkende, gedecentraliseerde en open benaderingen van het bedrijfsleven. Op een generatieve manier stelt de metafoor deelnemers in staat zich meer te richten op gemeenschapsgeleide en plaatsgebonden benaderingen van innovatie, waardoor bedrijven beter kunnen afstemmen op de

lokale context van hun toeleveringsketen en bedrijfsmodel, waarbij zowel sociale als ecologische dimensies gelijktijdig worden meegenomen.

Uiteindelijk onderstreept dit onderzoek dat metaforen niet slechts versiering van taal zijn, maar ook een leermiddel kunnen zijn. Dit kan op een reflexieve manier worden ingezet, door eerder niet-bevraagde aannames ter discussie te stellen, of op een generatieve manier, door nieuwe denkwijzen en innovatieve oplossingen mogelijk te maken.

OVERVIEW OF ABBREVIATIONS

CE Circular Economy
CMT Conceptual Metaphor Theory
IPR Intellectual Property Rights

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PROLOGUE

The Forest Clearing by Paul Cézanne 1839 – 1906
Fitzwilliam Museum, Cambridge

I used to wish I were a machine.

It was all I could think about during an art class when I was staring at a blank canvas in front of me. My style was meticulous: sharp angles, geometric forms and deliberate compositions etched into metal. There was a certainty in each line, the result of a deliberate decision.

I found myself at odds with my tools, my vision and my hands. A camera would be able to see everything – every single detail. A printer would replicate it flawlessly. My biology felt like a weakness: too imprecise and too fallible. I wanted a cold exactitude of a machine that could bypass my human imperfections entirely.

My teacher noticed my unease. *"Squint your eyes, try to see less to see more."*

The scene began to shift. By narrowing my gaze, the edges of entities softened, the noise of the detail dissolved, and its essence revealed itself: an interplay of light and shadow, its movement like the heartbeat of a composition.

It reminded me that this feeling is what inspired impressionists. They did not look for scientific perfection but aimed to capture a glimpse of a messy and real world. Impressionism taught me that clarity does not come from adding detail but from the wisdom of which details to leave behind.

Years later, as I work on my research, I still find myself squinting. The systems I study are deeply human: complex and full of contradictions. A machine might have analysed the data and given an exact report, but would miss what it means to be a human being in a changing world: the clearing in the chaos.

This is where my work begins: at the boundary where precision fades and humanity emerges.

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Chapter 1

Introduction

1.1. A CIRCULAR ECONOMY

In recent years, the idea of a circular economy (CE) has become a prominent phenomenon in sustainability discourse. This idea was presented to challenge the current so-called linear economy, which extracts and runs down natural and social capitals (Webster, 2021). A CE has emerged as part of a variety of agendas such as environmental policy (Camilleri, 2020), waste management (Pires & Martinho, 2019) and business strategies (Lüdeke-Freund et al., 2019). The CE promises radically different outcomes compared to the linear economy (Bocken et al., 2016; Murray et al., 2017; Geissdoerfer et al., 2017; Temesgen et al., 2021).

While the concept of a CE has a rich history (Tuladhar et al., 2022), the launch of the Ellen MacArthur Foundation and their first report *Towards a Circular Economy Vol.1* in 2013 sparked substantial increased interest from businesses and industry (Ellen MacArthur Foundation, 2013). Academia followed shortly after, and CE scholarship underwent an increase in 2017, as illustrated in Figure 1.1. (Alnajem et al., 2021). In 2017, Kirchherr et al. (2017) listed and analysed 114 definitions of a CE and updated this in 2023 to 221 definitions (Kirchherr et al., 2023), which demonstrates continuous development and debate about this concept.

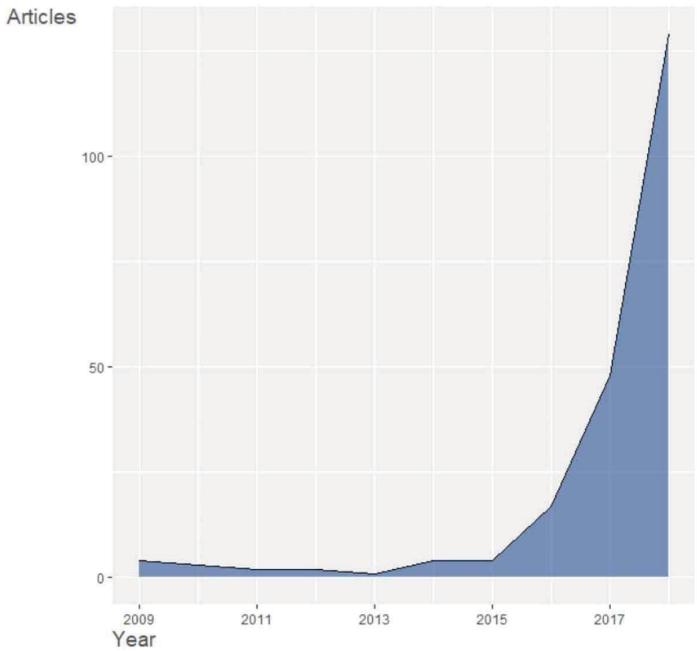

Figure 1.1. CE annual scientific production (2009-2018) by Alnajem et al. (2021)

Even though some point out the problems of these divergent views on a CE (Kirchherr, 2017), others view this as a sign that this is an umbrella concept (Merli et al., 2018) or should be seen as a heuristic (Webster, 2021). Despite these divergent views, the integration of CE in businesses is often seen through a narrow, technical lens. Friant et al. (2020) found that business-led circularity discourse typically engages with the concept at the lowest level of complexity. This level focuses on short-term, micro-scale interventions mostly aimed at reducing environmental impact, treating the idea of a CE as a tool for improving firm-level performance rather than challenging systemic economic issues, as elaborated upon in Table 1.1.

Table 1.1. Circularity discourse complexity adapted from Friant et al. (2020), selected rows shown.

Circularity vision	***Complexity level***	***Temporal scale***	***Spatial scale***	***Main goal/ objective***	***Narrative***
Circular Society	5	Very long term: multiple generations (beyond 50 years)	Macro-scale: planet Earth	Maintaining socio-ecological health and wellbeing for present and future generations of human and non-human life.	The Earth is borrowed from future generations of living beings, humans must preserve, respect, restore and share it in a fair manner, even if that entails changing lifestyles and consumption patterns.
	4	Long term: 1 to 2 generations (20-50 years)	Macro-scale: planet Earth	Preserving social wellbeing and the biophysical health of the Earth system in line with the SDGs.	Humans must ensure justice, fairness and participation in the sustainable stewardship of the Earth, even if that entails redistributing and changing consumption patterns.

Table 1.1.*Continued*

Circularity vision	***Complexity level***	***Temporal scale***	***Spatial scale***	***Main goal/ objective***	***Narrative***
Circular Economy	3	Long term: one generation (10-25 years)	Macro scale: planet Earth	Maintaining the biophysical health of the Earth system.	Reducing humanity's overall ecological footprint and balancing resource limits and constraints is key to ensure the stability of the biosphere and long-term economic prosperity.
	2	Mid-term: 1 to 2 government planning cycles (5 to 10 years)	Meso-scale (country, region, industrial park, city)	Securing and preserving critical resources and materials.	Strategically maximising eco-efficiency and balancing resource use is necessary to maintain resource security and ensure geopolitical stability.
	1	Short term: single product life cycle (1 to 2 years)	Micro-scale (single product, service, or firm)	Capturing opportunities to lower both environmental impacts and economic costs.	Ensuring optimum resource efficiency through eco-innovation leads to win-win solutions that reduce ecological harm and increase economic value.

To arrive at the initially intended and radically different outcomes compared to a linear economy, businesses must overcome many challenges that are deeply embedded in the way that the current regime is operating (Iacovidou et al., 2021). Temesgen et al (2021) indicate that these embedded issues require a close examination of our worldview, values, norms and practices. They describe the current neoclassical economic thinking as mechanical, influenced by Newtonian mechanics.

This same mechanistic sentiment is reflected in the critique of a CE by Corvellec et al. (2021). The "circle" in a CE seems to suggest a simplistic and elegant solution that can be achieved with mere tinkering of the current economic system. Corvellec et al (2021, p.429) reflect in their critique of a CE on the shape of a circle: *"There is an enticing promise of perfection, wholeness, and eternity, but the simplicity of its grounding metaphor is misleading as it evokes a modernist variant of the myth of eternal return"*. In his paper, *The circular economy is about the economy*, Ken Webster (2021) argues that in its current form, the concept retains a worldview in line with an engineered pipework and suggests a perspective inspired by nature as an alternative.

If not challenged, the CE is at risk of being "bolted" onto the machine of linear economy without any transformational change, as visualised in Figure 1.2.

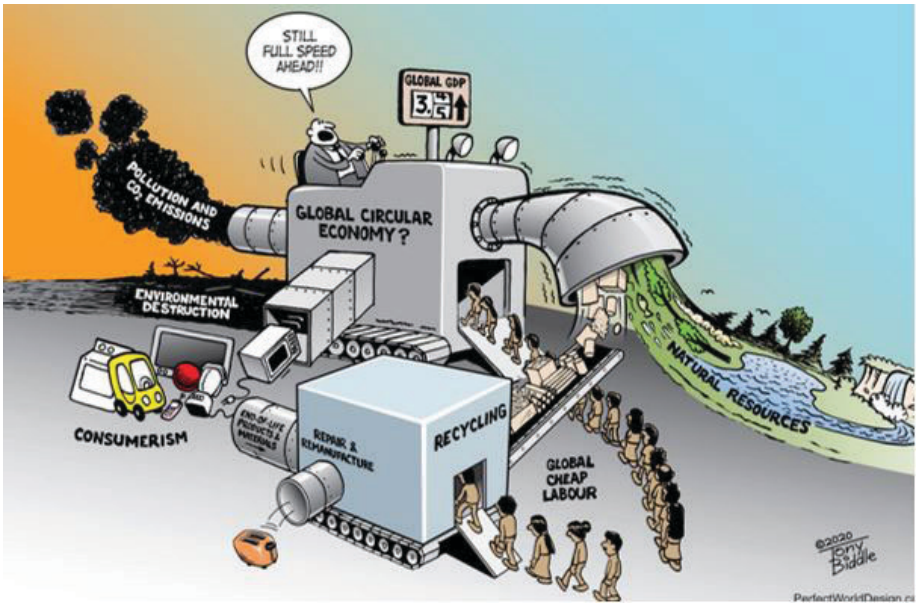

Figure 1.2. A global circular economy (Biddle, 2020)

Capra & Luisi (2014) share similar sentiments about mechanistic discourse, and they suggest eco literacy to break old habits of thought and see the economy as a complex system, unlike a machine. Eco literacy is a concept developed by David Orr (1991), and it refers to being proficient in the basic underlying principles of ecology and living systems because they believe these spaces show the answers for humans to live sustainably (Capra & Luisi, 2014). So far, the overall concept of a CE has been built on many insights from biology, but mostly by incorporating and building on the work of biomimicry. As Murray et al (2017, p.337) state: *"mimicry itself may not go far enough and implies that we need to pretend to be biological, rather than actually being biological."*

In their work on natural capitalism, Hawken et al (2013; p.9) explore the question: *"What if our economy were organised not around the lifeless abstractions of neoclassical economics and accountancy but around the biological realities of nature?"*. This doctoral thesis aims to contribute to this body of knowledge from a CE perspective by exploring the concept through the lens of nature and living systems. It does so by investigating this through the lens of metaphor.

1.2. METAPHORS

Aristotle (384-322 BC) offers a formal definition for metaphors in his book *Poetics* (Kirby, 1997). The word "metaphor" comes from *metaphora,* which comprises "meta" referring to change and "phora" which means carry. Literally, it means "carrying across" or transference from one point (in this case, a source domain) to another (the target domain) (Levin, 1982). Some describe metaphors as a vehicle for conveying ideas (Davidson, 1978), whereas others describe them as a lens or filter through which the world is viewed (Black, 1979). This research contributes to the literature by using metaphors to explore and articulate different conceptualisations of a CE.

This is done through conceptual metaphors. Some metaphors are more than merely the decoration of language or idiomatic expressions (Gibbs, 2011). A specific type of metaphor, a conceptual metaphor, reveals insights about patterns of thought and ideas in a way where language is secondary (Lakoff, 1993). Conceptual Metaphor Theory (CMT) was established around 1980 by neurolinguist Professor George Lakoff and refers to the systematic metaphors that help to structure language and reasoning (Lakoff & Johnson, 1980). This theory can be used to understand and describe how humans think and make sense of abstract concepts (Lakoff & Johnson, 1980). It seeks to understand metaphors as a cognitive and cultural process (Kirby, 1997).

Kohak (1979) referred to such pervasive metaphors as *"a mask that moulds the wearer's face"* which demonstrates the potential to support the profound change within the person who engages with these. However, most conceptual metaphors that inform patterns of thought go unnoticed and unquestioned (Lakoff & Johnson, 1980). They slip in when a sentence is framed according to a certain conceptual metaphor and thereby reinforce this in the neurological pathway (Lakoff, 2010). Repetition reinforces the metaphor, which makes it more probable for it to be accepted (Lakoff & Johnson, 1980). This makes conceptual metaphor highly cultural and, therefore, somewhat "invisible".

To understand the implications of certain metaphors, these can be mapped, which shows the connection between the source domain (the domain where insights are being derived from) and how they help make sense of the target domain (the domain onto which the insights are projected) (Kovecses, 2010). Through this process of mapping, it is possible to explore what traditionally has been unrelated (Gibbs, 2011). An example of this would be the mapping in Figure 1.3. on the conceptual metaphor ARGUMENT IS WAR, expressed as SOURCE DOMAIN IS/AS TARGET DOMAIN. In this case, insights are used from the source domain "war" to make sense of "argument", the target domain.

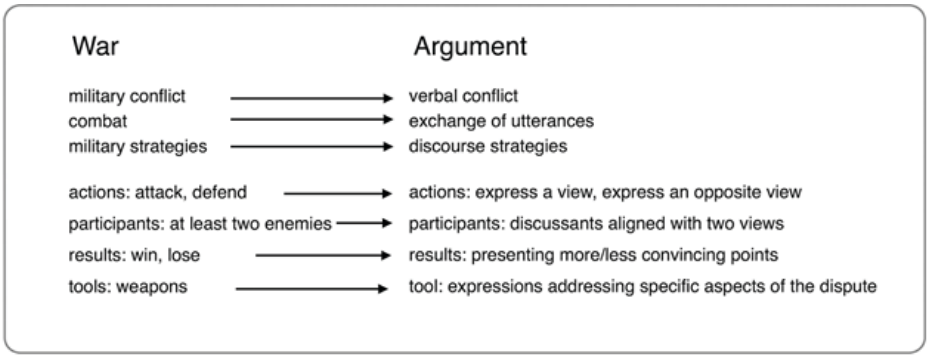

Figure 1.3. The conceptual metaphor ARGUMENT IS WAR (Dancygier, 2016).

Due to these systematic features, conceptual metaphors lend themselves well to discourse analysis and reflection on the hidden assumptions that underpin this discourse.

Metaphors can also be used to come up with new ideas and generate new perceptions and interventions. When this is done, metaphors are used in a generative way (Schön, 1979). Metaphors have proven to be helpful in many creative processes, especially when seeking novel understandings of the problem and solution space (Durgee et al., 2006). When metaphors are used in a generative way, examples often show a variety

of different source domains that prompt these new perspectives (Logler et al., 2018; Lockton et al., 2019). However, there are also interesting thought experiments that show the depth that a more systematic metaphor has to offer when used in a generative way. For example, Lomas & VanderWeele (2022) challenge Maslow's (1943) hierarchical pyramid of needs by proposing alternative conceptualisations through the garden metaphor and the orchestra metaphor.

There is little known about the metaphors that influence how a CE is viewed. However, some authors suggest the potential of engaging with ecology-inspired metaphors. For example, Zisopoulos et al. (2025) present ecological metaphors for a CE as a speculative and forward-looking approach to achieve a more resilient CE that grasps elements of complexity. This work builds on the work of Fath et al. (2019), which draws lessons from living systems and natural systems for a more regenerative economy. Webster (2021) suggests living systems metaphors for grasping the nonlinear and complex dimensions of a circular economy and allowing circular *economies* to emerge. Also, Hutchins (2022) suggests that the leadership for the future economy should be inspired by metaphors from nature.

This research seeks to use a conceptual metaphor in both a reflexive and generative way. First, to prompt a reflection on current CE discourse and its underlying assumptions. Then, to arrive at novel solutions and interventions.

1.3. RESEARCH GAP

Although some academics and thought leaders have proposed ecology-inspired metaphors as promising source domains for conceptualising the CE (Zisopoulos et al., 2025; Webster, 2021), sustainability leadership (Hutchins, 2022), and the economy more broadly (Hanauer & Beinhocker, 2014), these suggestions are often presented as a heuristic. While they represent valuable intellectual contributions, there is limited elaboration on their practical implications or systematic development.

At the same time, there is a growing body of practical work within the CE domain, particularly in areas such as business models, design, and waste management. However, these efforts risk perpetuating linear patterns of thought if they are not accompanied by critical reflection on the metaphors reiterated from linear economic models (Webster, 2021).

This research seeks to address this theory–practice gap by exploring the implications of a specific ecology-inspired metaphor (the forest) as a source domain for CE thinking, with a particular focus on circular business. It investigates how such metaphors can support reflexive engagement with current discourse and surface underlying assumptions. In addition, it examines how these metaphors can be used generatively to support the development of new insights and alternative lines of enquiry.

1.4. RESEARCH QUESTIONS

This research aims to fill the research gap, as stated in the previous section. It does so through a qualitative, mixed-method enquiry centred around the main research question:

How can ecology-inspired metaphors enrich circular economy discourse?

Throughout this research, the design goal is to establish a learning method or artefact that allows learners to engage with an ecology-inspired metaphor.

- Research Question 1: Through what conceptual metaphors does current academic discourse conceptualise the idea of a CE?
- Research Question 2: To what extent does the forest metaphor allow students to rethink the relationship between businesses in a CE?
- Research Question 3: What are the implications of the forest metaphor for the technosphere as a subdomain of a CE?
- Research Question 4: What new lines of enquiry can be explored for a CE through the forest metaphor?
- Research Question 5: To what extent does the tool for ecological design thinking for a CE support participants in obtaining new insights and discoveries?

1.5. ONTOLOGY

This work is no guarantee for improved sustainability outcomes, nor does it explore a conceptualisation of a CE superior to the current dominant metaphors. However, it seeks to explore a new and different line of enquiry, which could potentially result in different economic outcomes. The lens of ecology has the potential to view business in a CE as a complex phenomenon, therefore, this research seeks to contribute to pluralism in a CE discourse. It aims to investigate a line of enquiry which challenges some of the

subconscious patterns of thought perpetuating from the current linear economy. From an educational perspective, such provocations can help to reflect on assumptions that were previously unquestioned.

The ontology of research focuses on the nature of reality. This research recognises that the idea of a CE is not a fixed or objective entity but a socially constructed concept and can also vary across disciplines, individuals and economies. Relativists claim that there is no objective and singular truth to be known (Hughly & Sayward, 1987). Therefore, it adopts a relativist ontology because it acknowledges the diversity of interpretations about a circular economy and allows them to coexist.

1.6. EPISTEMOLOGY

This research is centred around the pluralistic conceptualisations of a CE. It assumes reality is subjective and therefore adopts an interpretivist epistemology (Alharahsheh & Pius, 2020). This paradigm considers humans as radically different from physical phenomena and the exact sciences and includes aspects such as culture (Alharahsheh & Pius, 2020).

Language supports the construction of knowledge through conceptual metaphors (McVittie, 2009). Therefore, this research aims to explore how different metaphors shape individuals' understanding of a CE and to gather rich and detailed insights about what an ecology-inspired metaphor could mean for a CE. An interpretivist epistemology gives space for the researcher to view the world through the lens of the participant and to acknowledge how their perceptions and experiences influence their view (Thanh & Thanh, 2015).

1.7. THESIS STRUCTURE

The research is structured around four phases: "identification", "exploration", "synthesis" and, "validation", as per Table 1.2. The first phase identifies current dominant conceptual metaphors in CE discourse through a textual analysis of the most often-cited research papers on CE.

In the second phase, the implications of the use of a specific ecology-inspired metaphor are explored: the forest metaphor. First, a teaching experiment is conducted and

reported upon through a case study. Then, a thought experiment is conducted on a challenging subdomain of a CE: the technosphere.

The third phase of the research results in the design of a learning tool. This is based on a qualitative enquiry into participants' intuitive understanding of a forest, and those insights are connected to domains in CE discourse where they could form the basis of new lines of enquiry. The insights of this research are presented as a learning tool: "Ecological Design Thinking for a Circular Economy", which can be found in Appendix F.

Finally, the learning tool is evaluated and validated through workshops in which participants engage with the tool. The impact of the tool is described in the final part of the research.

An overview of the research outline is presented in Table 1.2. which can be found on page 34.

Table 1.2. Research outline

Main research question: How can ecology-inspired metaphors enrich circular economy discourse?					
	Part 1 Identification	***Part 2 Exploration***		***Part 3 Synthesis***	***Part 4 Validation***
Objective	To identify current dominant conceptual metaphors in CE discourse	To explore the implications of the use of the forest metaphor for a CE.		To create a tool that allows learners to apply the forest metaphor to a CE.	To validate and evaluate the impact of the learning tool.
Chapter	2	3	4	5	6
Title	Conceptualising a circular economy: an enquiry into circular economy metaphors	Circular economy through the lens of the forest metaphor: a teaching and learning perspective	Conceptualising the technosphere of a circular economy through a living systems metaphor.	Transforming circular economy using the forest as a metaphor	Ecological design thinking for a circular economy: the impact of the forest metaphor for circular business.
Research Question	Research Question 1 Through what conceptual metaphors does current academic discourse conceptualise the idea of a CE?	Research Question 2 To what extent does the forest metaphor allow students to rethink the relationship between businesses in a CE?	Research Question 3 What are the implications of the forest metaphor for the technosphere as a subdomain of a CE?	Research Question 4 What new lines of enquiry can be explored for a CE through the forest metaphor?	Research Question 5 To what extent does the tool for ecological design thinking for a CE support participants in obtaining new insights and discoveries?

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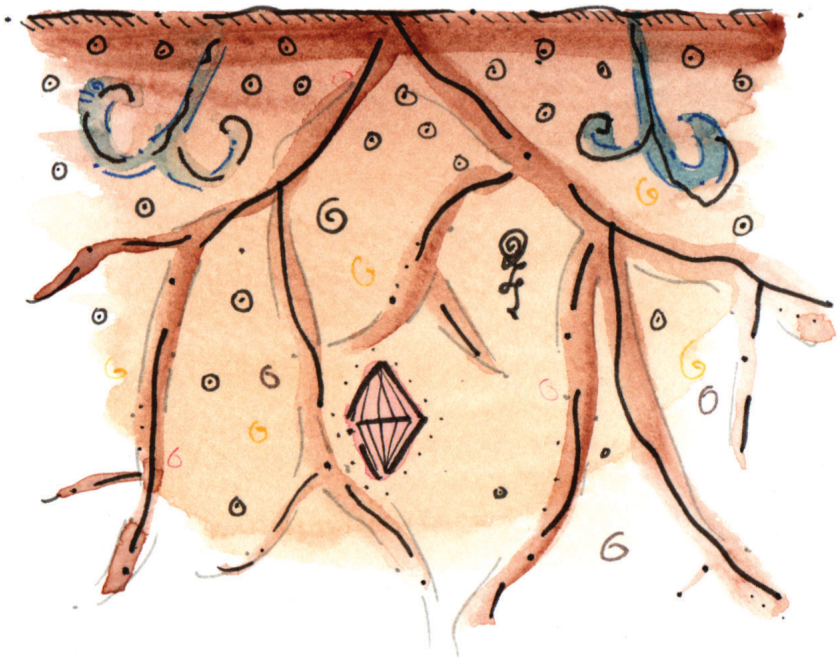
PART 1

Identification



The identification of current dominant conceptual metaphors in circular economy discourse.

Chapter 2

Conceptualising a Circular Economy - an Enquiry into Circular Economy Conceptual Metaphors

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SUMMARY

Numerous academic scholars argue for a radical transformation of the economy towards a circular model, in response to pressures from planetary and social issues such as energy, climate change, inequality, and resource depletion. This study examines how the academic community perceives the concept of a circular economy in comparison to traditional economic discourse, through the lens of conceptual metaphors. Conceptual metaphors have systematic properties that reflect one's understanding of abstract phenomena like a circular economy. Through a structured review of the literature, seven dominant conceptual metaphors were identified that shape the understanding of traditional economics. The study also conducted a textual analysis of the ten most frequently cited academic papers on the circular economy. The analysis revealed that certain dominant metaphors from traditional economics have been influential in shaping discourse on the circular economy. The most common metaphors were the machine metaphor, competitive metaphors, the journey metaphor, and ecological metaphors. Each conceptual metaphor has its strengths and weaknesses, which may include poorly explained areas or missing dimensions. These two aspects are referred to as misconceptions and blind spots, respectively, and the paper reflects on the implications of these for the current academic discourse on the circular economy.

2.1. INTRODUCTION

Over the past 10 years, academic publications on the concept of a circular economy have seen significant growth, with a pronounced increase in peer-reviewed publications since 2015 [1]. One central focus of this academic discourse is the need for a transformation of current economic systems towards circularity [5, 19, 44, 62]. This transformation entails moving away from a linear "take-make-waste" conventional economic model and transitioning to a circular economy that emphasises value retention.

According to Lumley [41], conventional economics discourse is a form of rhetoric, as arguments are presented in language intended to convince others of certain assumptions about human nature, such as rationality, predictability, and self-interest [52], or the existence of economic equilibrium [37]. Corvellec et al. [13] express concerns about the influence of conventional economics discourse on the current circular economy narrative. Understanding the extent to which the rhetoric of conventional economics permeates the circular economy discourse is crucial when conceptualising this phenomenon.

One approach that facilitates the exploration of rhetorical discourse is through conceptual metaphors. Metaphors are part of human thought processes, and this has been emphasised by rhetoricians, philosophers, and others for hundreds of years [23]. Conceptual metaphors were introduced via the development of the field of cognitive linguistics by Lakoff and Johnson [32, 33] in their book *Metaphors We Live By*. This work and publication are key in the development of this study, because in this field, conceptual metaphor theory provides important insights into the interactions of embodiment, language, thought, and culture [23].

The research in this study uses the format TARGET DOMAIN.... AS/IS.... SOURCE DOMAIN to express conceptual metaphors as prescribed by Lakoff and Johnson [32, 33]. To clarify this format, an example of a conceptual metaphor is LOVE IS A JOURNEY through which English speakers sometimes make sense of their relationships. In this instance, "love" can be considered the target domain and "a journey" can be considered the source domain.

Examples of expressions related to this conceptual metaphor, LOVE IS A JOURNEY, are as follows: *We're headed in opposite directions*. and *Our relationship is at crossroads*.

As elaborated upon in the work of Gibbs ([22], p. 531). These expressions should not be considered as clichéd idioms expressing literal meaning, but they reflect, and are

(partially) motivated by the conceptual metaphor [23]. Therefore, conceptual metaphor can be considered (part of) a rhetorical strategy [7]. It could potentially be unhelpful if conventional economic rhetoric and metaphors are part of the way of talking and thinking about a circular economy if the intention is for this idea to lead to economic transformation. The introduction of a new rhetoric, containing new conceptual metaphors, might thus be needed. This aspect is at the core of this study.

2.2. BACKGROUND

This research will use conceptual metaphor theory to explore the nature of conventional economics in comparison with current mainstream circular economy discourse. Metaphors help make sense of abstract ideas by drawing parallels between some of the phenomena or features. The word metaphor is derived from *metaphora* which is established by “meta” a prefix that often indicates a change of some sort and “phora” which means carry. Metaphora literally means “carrying across” or transference from one point (the source domain) to another (the target domain) [38].

Conceptual metaphors are a way to understand and describe how humans think and make sense of abstract concepts [32, 33]. Conceptual metaphors are systematic and help structure language and reasoning [23]. Therefore, they reveal insights about thoughts and ideas [14], and language is in this case secondary [34]. However, not all idiomatic expressions are based on conceptual metaphors [23].

Conceptual metaphors are also pervasive. When a sentence is framed according to a certain conceptual metaphor, it is reinforced in the neurological circuitry [35]. Repetition reinforces the conceptual metaphor which makes it more likely to be accepted [32, 33]. This makes conceptual metaphor also highly cultural in our understanding of abstract ideas and phenomena. It can also be considered a powerful tool for communication. Plato even identified metaphors as dangerous—a rhetorical device for deceiving [20]. Aristotle had a more optimistic stance and viewed metaphors as an effective teaching tool [54].

2.3. METHODOLOGY

This study consists of two parts. The first part aims to identify the dominant conceptual metaphors from economics discourse through a systemic literature review. This will indicate how this phenomenon has been studied to date [63]. This part will result in

a list of conceptual metaphors that inform economic discourse, including examples and how often these have been defined and identified in literature within the domain of conceptual metaphor theory.

The second part of the study explores what conceptual metaphors dominate circular economy discourse through the method of qualitative textual analysis. Textual analysis is a transdisciplinary method that can be used to understand the influence of external variables to the text [55]. Through the so-called Metaphor Identification Process, designed up by Steen et al. [57], this method can be used to find metaphors in natural discourse. This second part of the research, the textual analysis, will result in an overview of identified conceptual metaphors in the selected texts.

2.3.1. Systematic Literature Review

A systematic literature review was deployed to identify the main conceptual metaphors that inform the understanding of the economy. This literature review draws predominantly from the fields of linguistics, neuroscience, communication science, psychology, media studies, and human sciences. An initial body of literature is compiled from the search results returned by Google Scholar and iDiscover for search terms related to “metaphor*” and “economic*” and “economy”. A search string of “allintitle: metaphor* AND economy OR economic*” resulted in 123 results. All results were accessed and scan-read for relevance. After the scan-read, 59 papers were excluded due to not mentioning conceptual metaphor(s). The second round of review assessed all the remaining 64 papers in detail on all the inclusion and exclusion criteria (Table 2.1).

The final 64 papers were reviewed in detail. In total, 48 conceptual metaphors were identified and proposed in 18 papers. Another 4 metaphors were identified from 2 papers through snowballing. All conceptual metaphors were provided with an initial code and clustered according to conceptual overlap. The original authors named the conceptual metaphor as they identified this as a pattern in their studies. After a review of all the conceptual metaphor names, clusters emerged where these naming conventions overlapped.

For example, the domain of ECONOMY AS MACHINE, includes the work from White [67] referring to ECONOMY AS MECHANICAL PROCESS and Telibasa [61] who addresses the same observations as ECONOMY IS A MECHANISM as well as Gustafsson [24] who names this conceptual metaphor ECONOMY IS A MACHINE. All conceptual metaphors underwent such a review process after which an umbrella name was generated in line with TARGET DOMAIN AS/IS SOURCE DOMAIN as indicated in Table 2.2., Column 2. This resulted in seven dominant conceptual metaphors for the economy in Table 2.2.

Table 2.1. Inclusion and exclusion criteria

Criterion	***Inclusion***	***Exclusion***
Content	Needs to present, observe, or synthesise a metaphor for the economy. These can be defined through the Metaphor Identification Procedure [50] or equievalent procedures. An example of the metaphor in practice must be provided, coherently with Conceptual Metaphor Theory.	Any metaphors presented, observed, and synthesised that are not conceptual metaphors, such as isolated single expressions.
Publication date	Work published after 1980 (when Conceptual Metaphor Theory was established).	Any work before 1980.
Language	English-written work.	Non-English publications.
Geographical context	Any geographical context.	
Data collected	Peer-reviewed journal papers and conference papers that present literature review, qualitative, and quantitative data.	Grey literature, books.

2.3.2. Textual Analysis

Table 2.2. and the understanding of the systematicity of the seven identified conceptual metaphors form a framework through which a textual analysis was conducted. Because of the nature of framing (repetition means the reinforcement of the metaphor) [32, 33], it is expected that the most-cited circular economy papers provide the conceptual metaphors that are dominating mainstream scholarly circular economy discourse. Therefore, the textual analysis consists of the most cited papers with “circular economy” in the title. All sentences consisting of “circular economy” or “CE” have been analysed for the pervasiveness of the conceptual metaphors identified in the literature review.

The conceptual metaphors in the papers have been identified by the Metaphor Identification Procedure, developed by the Pragglejaz Group [50]. Through a systemic approach as described, the Metaphor Identification Procedure allows the observation

of the patterns of conceptual metaphors through the procedure below [50], p.3). The Metaphor Identification Procedure refers to lexical units. This research looks at frequent recurrent uninterrupted strings of words as lexical units [15].

1. Read the entire text-discourse to establish a general understanding of the meaning.
2. Determine the lexical units in the text-discourse.
3. (a) For each lexical unit in the text, establish its meaning in context, that is, how it applies to an entity, relation, or attribute in the situation evoked by the text (contextual meaning). Take into account what comes before and after the lexical unit.
   (b) For each lexical unit, determine if it has more basic contemporary meaning in other contexts than the one in the given context. For our purposes, basic meanings tend to be:
   - More concrete [what they evoke is easier to imagine, see, hear, feel, smell, and taste];
   - Related to bodily action;
   - More precise (as opposed to vague);
   - Historically older;

   Basic meanings are not necessarily the most frequent meaning of the lexical unit.
   (c) If the lexical unit has a more basic current-contemporary meaning in other contexts than the given context, decide whether the contextual meaning contracts with the basic meaning but can be understood in comparison with it.
4. If yes, mark the lexical unit as metaphorical.

The criteria for the selection of the lexical units are as follows:

- The lexical unit contains either “circular economy” or “CE”.
- The lexical unit needs to be grammatically correct.
- In the lexical unit, “circular economy” or “CE” is not part of a list.
- The lexical unit is excluded when it uses “circular economy” or “CE” to refer to a group of individuals.
- The lexical unit explains a component of the circular economy (for example, by putting it in relationship with another component or through the selected verb).
- The lexical unit is not a quote.
- The lexical unit is not a table or figure name, nor a title or header of a section.

An example of a lexical unit would be: *“This will empower innovators in the business to fully capture the business potential of the circular economy”* ([5], p.315). In this case, “capturing the potential” reveals a conceptualisation that the idea of a circular economy is there to enhance the strategic performance of the company, in line with competitive metaphors.

The scope of the textual analysis was determined by reaching the data saturation point, “when new incoming data produces little or no new information to address the research question”. [17], p.2). The cut-off point was ten papers since no new conceptual metaphors were detected in paper 11.

2.4. RESULTS

2.4.1. Systematic Literature Review

Table 2.2. below elaborates on the insights from the literature review. After clustering, seven distinct conceptual metaphors for the economy have been identified in the literature. For each of these conceptual metaphors, features have been identified, the number of occurrences has been identified, and an explanation of the conceptual metaphor has been provided. This is supported by a series of examples from the original papers and an elaboration of misconceptions and blind spots as they were identified in the literature.

Table 2.2. Seven conceptual metaphors used to make sense of the economy

[1] Features	*[2] Conceptual metaphor*	*[3] Number of occurrences*	*[4] Identified by*	*[5] Explains*	*[6] Examples*	*[7] Misconceptions and blind spots*
Equilibrium-seeking	ECONOMY AS PATIENT	14	Imani et al. [27], Besomi [2], Boers and Demecheleer [6], Charteris-Black [10], Gao [18], Mutari [45], Norazit [46], Olivera and Pedro [48], Qin [51], Reinert [53], Stronach et al. [58], Telibasa [61], Wang et al. [65], White [67]	The health metaphor emphasises the importance of keeping up economic activity. Illness or injury undermines the patient's health and results in low activity. The economy is conceptualised as a body or soul that needs to be cured to get back to its original active state.	"The economy is healthy or strong."— Gao ([18], p. 2636) "Industries are the back-bone of the economy."— Telibasa ([61], p. 139) "Monopolies are diseases"— Imani ([27],p. 8) "Economic depression"— Telibasa ([61], p. 139) "Think about the economy as a beating heart, circulating resources that are needed to sustain life"— Mutari ([45], p. 10)	"As long as companies or industries are 'healthy' (i.e. active and making profits) there is no need for interference of any kind"— Boers and Demecheleer ([6],p.124) "it creates an important illusion among economists that they have control over events, and this reflects in the doctor-patient metaphor system."— Wang et al. ([66], p. 175)

[1] Features	[2] Conceptual metaphor	[3] Number of occurrences	[4] Identified by	[5] Explains	[6] Examples	[7] Misconceptions and blind spots
Competitive, strategic, protective	ECONOMY AS WAR	9	Boers and Demecheleer [6], Gao [18], Gustafsson [24], Imani et al. [27], Norazit [47], Olivera and Pedro [48], Qin [51], Stronach et al. [58], White [67]	The war metaphor makes sense of the relationship between businesses within the economy or a common enemy such as inflation or a political enemy.	"The competition between businesses is fierce."— Gao ([18], p. 2634) "The battle for control of the market."— White ([67], p. 134) "It seems unlikely that they [government] will intervene in the battle of the tax cuts."— ([51], p. 3)	"The metaphor clearly highlights the conflicting aspects of different ideologies, and it leaves potential common or compatible aspects in the dark."— Boers and Demecheleer ([6],p.126) "...war metaphors are notable for the fear that they evoke and their tendency to frame adversarial relation-ships."— Flusberg et al. ([16] p. 5)
Reductionist, mechanistic, deterministic	ECONOMY AS MACHINE	8	Boers and Demecheleer [6], Gustafsson [24], Lagueux [31], Mixon [43], Mutari [45], Pessali [49], Telibasa [61], White [67]	The machine metaphor conceptualises the economy as an accumulation of inputs (means) that go into the machine and outputs (ends). The machine follows "inexorable and amoral" laws to allow this [45]. Within this machine, the human is conceptualised as homo economicus, operating like a calculator [48].	"You need capital to fix business."—Telibasa ([61], p.138) "Growth is the driving force for societal develop-ment."— Gustafsson ([24], p. 201) "Germany remains the main engine of growth"—White ([67], p. 142) "The flow of money"— Lagueux ([30], p. 16)	"There is no real role for human agency, that is self-conscious action within a particular context."— Mutari ([45], p. 3) "The market institutions that constitute "the economy" are treated as separable from society, social factors are treated as exogenous variables."— Mutari ([44],p. 3)

Table 2.2. *Continued*

[1] Features	*[2] Conceptual metaphor*	*[3] Number of occurrences*	*[4] Identified by*	*[5] Explains*	*[6] Examples*	*[7] Misconceptions and blind spots*
Evolving, goal-oriented	ECONOMY AS JOURNEY	5	Boers and Demecheleer [6], Cibulskiene [11], Gao [18], Imani et al. [27], Qin [51]	The metaphor of a journey seeks to overcome difficulties along the road on the way to the destination [18]. The logic of a path is goal- oriented. Therefore, activities that serve a clear purpose are positively valued [6].	"Companies will be on the forefront of this journey."— Imani et al. ([27], p. 9) "The housing market remained a hurdle."— Gao ([18], p. 2633) "Obama barricaded the investment."— Gao ([18], p. 2633)	The metaphor of "a journey" is a way to avoid making specific and substantive commitments ([42], p. 825) "It is usually the shortest and quickest path to one's destination that is considered the best."— Boers and Demecheleer ([6],p. 121) "vague measuring tool and a justification for small actions without accompanying big action…"—Berry ([3], p.232)
Ecological, growing, evolving	ECONOMY AS GARDEN	5	Cortes de los Rios [12], Mixon [43], White [67], Charteris-Black [10], Telibasa [61]	The garden metaphor allows for a more long-term view of the economy. The government is conceptualised as the gardener and this metaphor suggests humility, but not inaction [43]. It is focused on bringing together the right system conditions for the economy to thrive.	"Reaping the benefits of the financial environment."— Cortes de los Rios ([12], p. 43) "Growth pushes up all sectors"—White ([67], p. 137) "Flourish, weed out, spread, growth, to put down roots, to soar, to blossom, fruitful are all frames supporting the garden metaphor"—Telibasa ([61], p. 139)	"This alternative metaphor points out the longer-term (and uncertain) nature of policy actions."—Mixon ([43], p. 297)—and therefore does not explain short- term radical decisions leading towards instant gratifications.

[1] Features	*[2] Conceptual metaphor*	*[3] Number of occurrences*	*[4] Identified by*	*[5] Explains*	*[6] Examples*	*[7] Misconceptions and blind spots*
Equilibrium-seeking	ECONOMY AS VICTIM OF NATURAL DISASTER	3	Norazit [46], Besomi [2], Stronach et al. [58]	This metaphor presents a negative situation that is unavoidable and unforeseeable. The origin of the disruption is given to an external factor. When this is over, the economy is assumed to return to its previous state.	"The government is avoiding further meltdown"— Norazit ([47], p.218) "The storm will gradually pass"—Besomi ([2], p. 77) "Relief flooded in"— Stronach et al. ([58], p. 321)	These metaphors allow a depersonification of the crisis and conceal the ones responsible for it. The phenomenon is described as natural and is not attributed to human action [58]
Competitive, strategic	ECONOMY AS SPORT	2	Gao [18], Norazit [47]	Alike the war metaphor, the sports metaphor is used to make sense of the relationship between businesses in the economy.	"Japanese messaging app aims to rival Facebook."— Gao ([18], p. 2633) "Shares kicked off this week on a solid plat- form."— Norazit ([47], p. 222) "The company is on a winning streak"— Norazit ([47], p. 222)	"[referring to a fighting metaphor] serve the ulterior survival motive that is conceptualised in antagonistic terms, as competition and struggle rather than cooperation and mutual benefit."—Koller ([28],p. 216) "...an important limitation of sports metaphors is their cultural resonance: Metaphorical "handoffs," "touchdowns," "punts," and "fumbles" are meaningful only to people who know the basics of American football."— Flusberg et al. ([16], p. 5)

It was clear from the number of mentions per conceptual metaphor in Table 2.2. that some were more prevalent than others. Table 2.3. shows the frequency of mentions of each conceptual metaphor identified in the literature.

Table 2.3. Conceptual metaphor prevalence in the literature review

	PATIENT	***WAR***	***MACHINE***	***JOURNEY***	***GARDEN***	***VICTIM OF NATURAL DISASTER***	***SPORT***
Number of identifications	14	9	8	5	5	3	2

The most prevalent conceptual metaphor in the systematic literature review was ECONOMY AS PATIENT, with equilibrium-seeking features.

2.4.2. Textual Analysis

Some of the conceptual metaphors shown in Tables 2.2. and 2.3. were recognised in the textual analysis of the ten most-cited papers that mention “circular economy” in the title. Due to the strong similarities shared between CIRCULAR ECONOMY AS WAR and CIRCULAR ECONOMY AS SPORT, these “competitive” metaphors have been put together as one in the data collection. These are referred to as “SPORT/WAR (including other competitive metaphors)”.

A similar broader cluster was developed for CIRCULAR ECONOMY AS GARDEN, since it was not possible to definitively identify all metaphors with ecological or eco-systemic features as part of the garden metaphor. For example, a lexical unit in Geissdoerfer et al. [19] refers to the cross-fertilisation of the concept of circular economy with other schools of thought. In this case, cross-fertilisation could relate to the metaphor of a garden or other ecological metaphors such as a forest or a farm. Therefore, these metaphors are referred to as “GARDEN (including other ecological metaphors)”.Table 2.4. provides an overview of how many conceptual metaphors have been identified in each of the analysed papers.

Table 2.4. Results from the textual analysis

	MACHINE	***SPORT / WAR (including other competitive metaphors)***	***JOURNEY***	***GARDEN (including other ecological metaphors)***	***VICTIM OF NATURAL DISASTER***	***PATIENT***
Geissdoerfer et al. [19]	19	17	4	6	0	1
Ghisellini et al. [21]	23	18	5	14	2	0
Kirchherr et al. [28]	18	6	5	2	0	0
Korhonen et al. [30]	29	21	6	4	1	2
Bocken et al. [5]	11	14	11	0	1	0
Murray et al. [44]	24	12	5	1	0	0
Lieder & Rashid [39]	3	2	1	0	0	0
Stahel [56]	6	3	0	0	0	3
Tukker [64]	4	1	0	0	0	0
Su et al. [59]	27	22	0	2	3	0
Total	164	117	37	29	7	6

The machine metaphor was most often identified in the selection of papers. Competitive metaphors, the journey metaphor and ecologic metaphors were identified in most papers, and these have been elaborated upon in Table 2.5.

Table 2.5. Conceptual metaphors in circular economy discourse

Conceptual Metaphor	***Number of occurrences***	***Used by***	***Explains***	***Insights from the source domain***	***Example of lexical units***
CIRCULAR ECONOMY AS MACHINE	164	Geissdoerfer et al. [19], Ghisellini et al. [21], Kirchherr et al. [28], Korhonen et al. [30], Bocken et al. [5], Murray et al. [44], Lieder and Rashid [39], Stahel [56], Tukker [64], Su et al. [59]	The circular economy is the sum of resource inputs and outputs	The purpose of the machine is to turn inputs into outputs efficiently	"CE-type arrangements of the physical flows of materials and energy would reduce virgin inputs to the system and waste and emissions outputs from the system."— Korhonen et al. [30], p. 40)
				Flows of throughput run through the pipework of a machine	"They proposed a closed-loop of material flow in the economy, which was named, circular economy"— Su et al. [59], p. 215)

Conceptual Metaphor	***Number of occurrences***	***Used by***	***Explains***	***Insights from the source domain***	***Example of lexical units***
CIRCULAR ECONOMY AS MACHINE	164	Geissdoerfer et al. [19], Ghisellini et al. [21], Kirchherr et al. [28], Korhonen et al. [30], Bocken et al. [5], Murray et al. [44], Lieder and Rashid [39], Stahel [56], Tukker [64], Su et al. [59]	The circular economy is the sum of resource inputs and outputs	Fuel is the driving force of a machine	"They [business models] are the driving force in the shift towards [CE]"— Kirchherr et al. ([28], p. 228)
				The aim is to maximise outputs	"In a circular economy, the objective is to maximise value at each point…"— Stahel ([56], p. 436) "Most authors conceptually simplify the circular economy to resource input, waste and emission output"— Geissdoerfer et al. ([19], p.765)
				A machine is constructed from parts that enable throughput	"Circular economy is constructed from societal product-consumption systems."— Korhonen et al. ([30], p. 39)
				The machine and the environment are not embedded but disconnected from each other	"The material flow released from the economy to nature should be in a form in which nature can utilise them in its own functions."— Korhonen et al. ([30], p. 40)

Table 2.5. *Continued*

Conceptual Metaphor	***Number of occurrences***	***Used by***	***Explains***	***Insights from the source domain***	***Example of lexical units***
CIRCULAR ECONOMY AS MACHINE	164	Geissdoerfer et al. [19], Ghisellini et al. [21], Kirchherr et al. [28], Korhonen et al. [30], Bocken et al. [5], Murray et al. [44], Lieder and Rashid [39], Stahel [56], Tukker [64], Su et al. [59]	The circular economy is the sum of resource inputs and outputs	A machine is or components of the machine are installed with a single purpose	"These policies, in turn, inspired China to install the Circular economy as its major framework for delivery of increased growth but with decreased environmental damage."— Murray et al. ([44], p. 11–12)
				A machine can be put together and maintained by tools	"The new paradigm of a circular economy requires new concepts and tools to describe and support this paradigm."— Bocken et al. ([5], p. 309)
CIRCULAR ECONOMY AS WAR / SPORT (Including other competitive metaphors)	117	Geissdoerfer et al. [19], Ghisellini et al. [21], Kirchherr et al. [28], Korhonen et al. [30], Bocken et al. [5], Murray et al. [44], Lieder and Rashid [39], Stahel [56], Tukker [64], Su et al. [59]	The relationship between businesses in a circular economy is only competitive	The aim is to increase performance	"The relationship between the circular economy and sustainability and their influences over the performance of supply chains, business models and innovation systems."— Geissdoerfer et al. ([19], p. 764)
				All sides are determined to take the lead	"[...] that indicated that a few players have taken the lead in the conceptual development of this emerging topic".— Geissdoerfer et al. ([19], p. 760)

Conceptual Metaphor	***Number of occurrences***	***Used by***	***Explains***	***Insights from the source domain***	***Example of lexical units***
CIRCULAR ECONOMY AS WAR / SPORT (Including other competitive metaphors)	117	Geissdoerfer et al. [19], Ghisellini et al. [21], Kirchherr et al. [28], Korhonen et al. [30], Bocken et al. [5], Murray et al. [44], Lieder and Rashid [39], Stahel [56], Tukker [64], Su et al. [59]	The relationship between businesses in a circular economy is only competitive	Commitment is necessary to win	This country seems strongly committed and attracted by a CE."— Ghisellini et al. ([21], p. 12)
				Certain strategies can enhance the performance or likelihood of winning	"Building on the product design and business model strategies to enhance the circular economy…"— Bocken et al. ([5], p. 315) "The circular economy is emerging as a possible strategy that companies of all sizes might adopt to allow them to engage with such challenges."— Murray et al. ([44], p. 4)
			The idea of a circular economy is in competition with other ideas or interests	Different sides draw attention from the audience by being popular	"The Ellen MacArthur Foundation has helped popularise the move to a circular economy with business."— Bocken et al. ([5], p.308) "The circular economy (CE) is trending both among scholars and practitioners."—Kirchherr et al. ([28], p. 221)
				The opposite side creates resistance	"Although there was resistance from some business lobbies, the adoption was carried out."— Murray et al. ([44], p. 18)

Table 2.5. *Continued*

Conceptual Metaphor	***Number of occurrences***	***Used by***	***Explains***	***Insights from the source domain***	***Example of lexical units***
CIRCULAR ECONOMY AS WAR / SPORT (Including other competitive metaphors)	117	Geissdoerfer et al. [19], Ghisellini et al. [21], Kirchherr et al. [28], Korhonen et al. [30], Bocken et al. [5], Murray et al. [44], Lieder and Rashid [39], Stahel [56], Tukker [64], Su et al. [59]	Pollution and waste are opponents to be defeated by a circular economy	When one does not reach the desired outcome, one fails	"Such a very limited point of view may lead CE to fail..."— Ghisellini et al. ([21], p. 12)
				The opponent needs to be defeated	"The recognition of the limits to planetary resource and energy use, and the importance of viewing the world as a "system" where pollution and waste are viewed as a defeat, lay at the foundation of circular economy thinking."— Bocken et al ([5], p. 308)
CIRCULAR ECONOMY AS JOURNEY	37	Geissdoerfer et al. [19], Ghisellini et al. [21], Kirchherr et al. [28], Korhonen et al. [30], Bocken et al. [5], Murray et al. [44]	The circular economy is a destination that is reached gradually and step by step	Reaching the destination is the purpose of the journey	"Circular economy could help society reach sustainability and wellbeing."— Ghisellini et al. ([21], p. 12)
				The accumulation of different steps allows the move to a new destination	"[Progress] is perhaps gradually and step-by-step"— Korhonen et al. ([30], p. 42)
				The participants on the journey want to reach their destination in the safest and quickest way possible	"Firms may take the path of least resistance to adopt CE if waste hierarchies are not explicated."— Kirchherr et al. ([28], p. 227)

Conceptual Metaphor	***Number of occurrences***	***Used by***	***Explains***	***Insights from the source domain***	***Example of lexical units***
CIRCULAR ECONOMY AS JOURNEY	37	Geissdoerfer et al. [19], Ghisellini et al. [21], Kirchherr et al. [28], Korhonen et al. [30], Bocken et al. [5], Murray et al. [44]	The circular economy is a destination that is reached gradually and step by step	There is a path to follow that leads to the destination	"Authors increasingly see business model innovation as the key pathway to the necessary socio-technical transitions."— Geissdoerfer et al. ([19], p. 764)
				During a journey, barriers are overcome in order to reach the destination	"Detailing these practices must also include analyses of how barriers encountered were overcome."—Kirchherr et al. ([28], p. 230)
				Areas yet to be encountered are unexplored	"The scientific research content of CE remains largely unexplored."— Korhonen et al. ([30], p. 37)
				A journey follows directions	"[...] with no driver at the steering wheel in our point of view."—Kirchherr et al. ([28], p. 228)

Table 2.5. *Continued*

Conceptual Metaphor	***Number of occurrences***	***Used by***	***Explains***	***Insights from the source domain***	***Example of lexical units***
CIRCULAR ECONOMY AS GARDEN (including other ecological metaphors)	29	Geissdoerfer et al. [19], Ghisellini et al. [21], Kirchherr et al. [28], Korhonen et al. [30] Murray et al. [44], Su et al. [59]	The circular economy is an idea or concept that is growing and evolving	The ideas underpinning the circular economy are the roots of the idea	"While the roots of the topic are European, much of this recent surge started with Chinese authors."—Geissdoerfer et al. ([19], p. 776) "The CE concept show to be rooted in very diverse theoretical backgrounds."—Ghisellini et al. ([21], p. 24)
			The circular economy is an idea or concept that is growing and evolving	A circular economy emerges when the right conditions come together	"In Europe, CE primarily emerged in Germany in the early 1976 [...]."—Ghisellini et al. ([21], p. 15) "One interesting difference between circular economy as most of the other schools of sustainable thought is that it has largely emerged from legislation."—Murray et al. ([44], p. 12)
				A circular economy can be understood by looking at its patterns	"Circular Economy in China and worldwide seem to follow very different patterns."—Ghisselini et al. ([21], p. 18)

Conceptual Metaphor	***Number of occurrences***	***Used by***	***Explains***	***Insights from the source domain***	***Example of lexical units***
CIRCULAR ECONOMY AS GARDEN (including other ecological metaphors)	29	Geissdoerfer et al. [19], Ghisellini et al. [21], Kirchherr et al. [28], Korhonen et al. [30] Murray et al. [44], Su et al. [59]	The circular economy works in similar ways as natural ecosystems	The goal is to create better ecosystemic outcomes	"[...] CE aims to increase the efficiency of resource use, with a special focus on urban and industrial waste, to achieve a better balance and harmony between economy, environment and society" — Ghisellini et al. ([21], p. 11)
				A circular economy can be established through grassroots or bottom-up change	"NGOs, which have easy access to grassroots, possess large, if not current, potential influence on promotion of the CE in society."— Su et al. ([59], p. 218) "[...] from the roots up the world of the future could be transformed towards something similar to the CE vision [...]."— Korhonen et al. ([30], p. 42)

Table 2.5. *Continued*

Conceptual Metaphor	***Number of occurrences***	***Used by***	***Explains***	***Insights from the source domain***	***Example of lexical units***
CIRCULAR ECONOMY AS GARDEN (including other ecological metaphors)	29	Geissdoerfer et al. [19], Ghisellini et al. [21], Kirchherr et al. [28], Korhonen et al. [30] Murray et al. [44], Su et al. [59]	The circular economy works in similar ways as natural ecosystems	Effective circular economy systems contain elements around symbiosis and collaboration	"The lesson learned from successful experiences is that the transition towards CE comes from the involvement of all actors of society and their capacity to link and create suitable collaboration and exchange patterns"— Ghisellini et al. ([21], p. 11) "[...] enterprises could strengthen their mutual understanding and friendship through information exchanges, which will be the solid foundation for further collaboration on promoting the CE."— Su et al. ([59], p. 223)
				Materials flow in a circular economy as they do in nature	"It is interesting that the CE model too seems to follow that of nature in light of the physical flows of materials and energy."— Korhonen et al. ([30], p. 45)

2.5. DISCUSSION

The aim of this research was to explore the extent to which metaphors in conventional economics currently permeate the circular economy discourse. In eight out of ten of the Circular Economy papers that were part of the textual analysis, the machine metaphor was the dominant conceptual metaphor. Competitive and journey metaphors were most pervasive after the machine metaphor. It was noticeable that CIRCULAR ECONOMY AS PATIENT was the least identified conceptual metaphor, even though ECONOMY AS PATIENT was found most often in conventional economics literature. No new metaphors or clusters of metaphors emerged during the textual analysis. This section reflects on the conceptual metaphors that were most pervasive in the analysed texts.

2.5.1. The Machine Metaphor

How the conceptual metaphor of the machine was used in circular economy discourse can be found in Table 2.5. This conceptual metaphor finds its origins in physics and exact sciences [49], especially Newtonian mechanics [45]. Capra and Luisi [8] identified that the influence of exact sciences and Newtonian mechanics resulted in a more pervasive "mechanistic worldview" which aims to seek understanding by removing complexity and focusing on the detail, simplifying. This can be regarded as a reductionist approach, which is the opposite of a holistic approach (understanding by looking at the bigger picture and the relationships between different entities). Literature also identified limitations of the conceptual metaphor of the machine. Mutari [45] reflects on when using the machine metaphor to understand economics, there is no role left for human agency: self-conscious action within a particular context. They also reflect on the disconnection between "the machine" and its surroundings. They mention that the institutions that constitute the economy are treated as separable from society and social factors [45]. The lack of attention to the social dimension in the current circular economy discourse has also been identified by Corvellec et al. [13] as well as Murray et al. [44] who argue that the circular economy is "virtually silent on the social dimensions" and is concentrating only on the redesign of manufacturing and service systems.
Some authors have also observed and named the reductionist nature of parts of the circular economy discourse, Murray et al. ([44], p. 23) reflect on this: "*over-simplification arises both from reductionist thinking and from mathematical modelling, wherein we remove most variables in order to produce manageable concepts*". When engaging with systems that have complex features, a balance between simplicity (reductionism) and complexity (holism) is necessary [65].

2.5.2. The Sports and War Metaphor (Includes Other Competitive Metaphors)

Other often-used conceptual metaphors in circular economy discourse are the cluster of competitive metaphors. They refer to businesses that compete within a market or to business that needs to overcome an external challenge such as a supply disruption. There is also a discourse in which the concept of a circular economy needs to compete with alternative sustainability ideas and can be "popularised", even be "trending". Finally, there is a discourse around the idea of a circular economy which aims to defeat its "opponent" which includes waste and pollution.

This conceptual metaphor lends itself particularly well when the user is mostly concerned about relevance in the marketplace and staying ahead of the competition as indicated in Table 2.5. However, this leaves little room for pre-competitive collaboration, establishing and sharing common infrastructure, and open sourcing of information and intellectual property. It emphasises "us" versus "them" thinking and has a blind spot for interdependent and reciprocal relationships [26], especially in the context of business in a circular economy. However, when the understanding of business in the economy is deepened, there are many inter-relational, networked, cooperating, and symbiotic behaviours that happen, which cannot be explained by such competitive metaphors only [6].

2.5.3. The Journey Metaphor

The journey is often used to explain the change that the economy should undergo. This is often expressed as "the move to a circular economy" [5]. Also, many governments, businesses, and regions have developed or are developing "roadmaps" to support change towards a circular economy. How this conceptual metaphor is used in the current discourse is described in Table 2.5. However, there are concerns about the use of a journey to express this change. First, it makes it seem like there are already-established roads that businesses can follow in their journey as if a circular economy is not context-driven. Milne et al. [42] add that the conceptual metaphor of a journey is a way to avoid making specific and substantive commitments towards positive societal and environmental outcomes. Also, Berry ([3], p. 232) observed that the journey metaphor within sustainability discourse was used as a "*vague measuring tool and a justification for small actions without accompanying big action[...]"* It seems that through this conceptual metaphor, a well-coordinated and managed, gradual accumulation of different steps, one happening at a time, ultimately helps to achieve the goal. This may be unrealistic and potentially problematic when rapid and wider-system change is needed to allow a circular economy to emerge.

2.5.4. The Garden Metaphor (Includes Other Ecological Metaphors)

The fourth most frequently occurring cluster of conceptual metaphors that is used in the circular economy discourse is ecological metaphors. Out of the 29 identified lexical units that follow the logic of ecological metaphors, 14 came from Ghisellini et al. [21]. They occurred far fewer times in the other texts that were analysed. One part of the discourse that uses ecological metaphors discusses the idea or concept of a circular economy growing and evolving. The other part of the discourse refers to how a circular economy could work and draws lessons from natural systems. The importance of the latter has been emphasised in other literature.

Webster [68] proposes the use of conceptual metaphors from living systems to grasp the nonlinear and complex dimensions in a more appropriate way. Hanauer and Beinhocker [25] suggest that an emerging twenty-first-century view should draw inspiration from natural ecosystems, such as a garden. Mixon [43] suggests that using the garden metaphor instead of the machine metaphor to understand the economy is more neutral, focused on providing the right environment, and provokes humility but not inaction. Hutchins [26] suggests that leadership for such an economy should be inspired by metaphors from natural ecosystems.

2.5.5. Reflections on Mainstream Discourse

Our research shows that current academic discourse makes sense of the circular economy in a mechanistic way, as the sum of resource inputs and outputs (machine metaphor), the relationship between businesses in a circular economy is predominantly competitive (competitive metaphors) and the change towards a circular economy happens step-by-step (journey metaphor). A common thread between these conceptual metaphors is the under-emphasis of complexity and dynamic, nonlinear behaviour using similar conceptual metaphors through which we conceptualise the linear economy. Only a few metaphors have been identified that have nonlinear or ecological components which embrace complex and dynamic features, mostly observed in the work of Ghisellini et al. [21].

This does not mean that the wider research community that engages in circular economy research does not value features such as holistic thinking, collaborative endeavours, or more sudden, radical, and transformative change. It merely demonstrates that the metaphors that are used to make sense of this abstract phenomenon favour and enhance reductionism, competition, and gradual change and allow the user of these metaphors to express these features often in a successful way. Most individuals are unaware of the conceptual metaphors that govern their thinking [32], and therefore,

it could be helpful to intentionally engage with new metaphors that enhance certain features that are not enhanced through the mainstream metaphors.

2.6. LIMITATIONS OF THIS RESEARCH

This study has potential limitations. The textual analysis of circular economy papers requires interpretation from the researcher on the conceptual metaphor that is used. In some cases, there are ambiguous boundaries between different conceptual metaphors. To mitigate this, the competitive and ecological metaphors have been analysed as one group, and all data has been analysed twice to ensure a correct judgement. In addition, CMT as a framework and methodology also has limitations. Spoken and written discourse is complex, and this makes separating isolated, single expressions from the systemic nature of conceptual metaphor challenging [22]. Also, the lexical units have been identified and interpreted by the authors only and this has not been independently validated.

2.7. CONCLUSION

Metaphorical thinking is part of how the brain works and makes sense of abstract phenomena. Understanding the extent to which the rhetoric of conventional economics permeates the circular economy discourse is crucial when conceptualising this phenomenon. The conceptual metaphors that are accepted, utilised, and often repeated determine the mainstream conceptualisation of a circular economy and have the potential to leave unnoticed (and potentially problematic) blind spots. This research aimed to understand the extent to which metaphors in conventional economics permeate circular economy discourse.

We found that circular economy discourse is currently most influenced by the machine metaphor, followed by competitive metaphors, the journey metaphor, and to limited extent ecological metaphors. These metaphors are also used for the conceptualisation of the current, linear economy and reinforce the same patterns of thought. The ecological metaphor occurred fewer times but contributes to potentially interesting new lines of enquiry, especially when the circular economy is conceptualised in a natural ecosystemic way, with nonlinear components and complex and dynamic features.

With this study, we contribute to increased recognition of how language and conceptual metaphor in particular inform the conceptualisation of a circular economy. Pluralism in the thinking around a circular economy can help move the conversation away from the dominant CIRCULAR ECONOMY AS MACHINE and break free from old habits of thought. In an educational context, these conceptual metaphors could support educators to allow learners to develop a conceptualisation that is in line with their values and beliefs. By opening the conversation and celebrating the diversity of circular economy conceptualisations, proponents can be empowered to consider different ideas and enhance novel features.

2.8. REFERENCES

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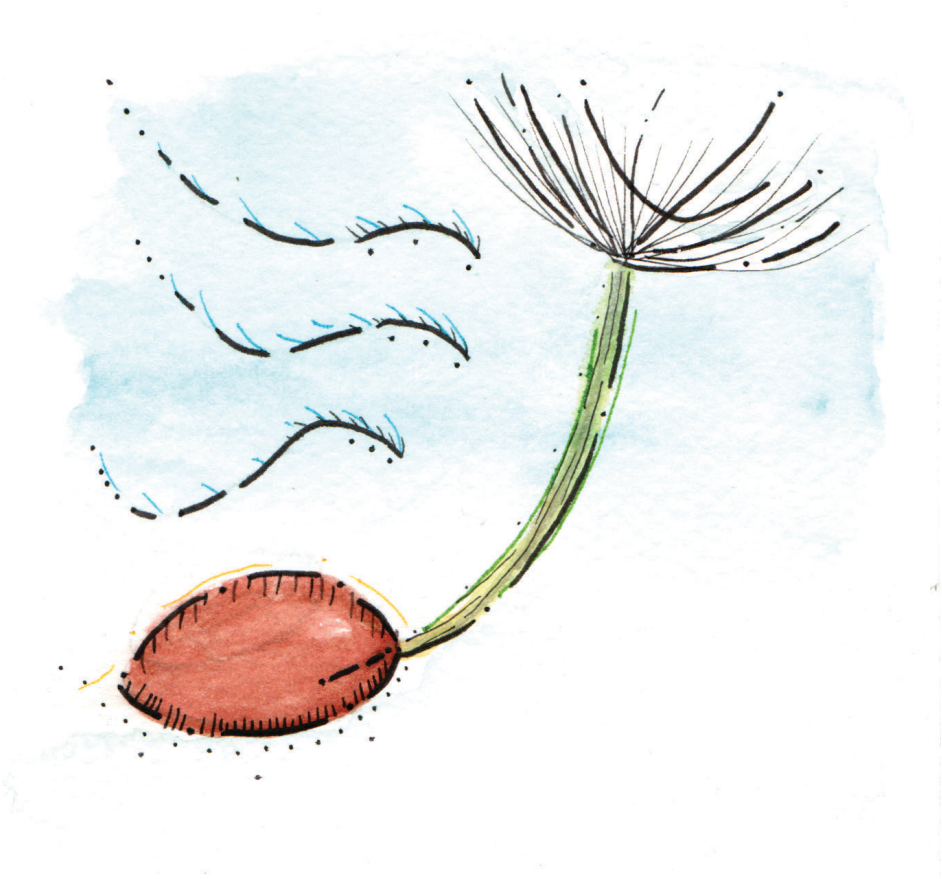
PART 2

Exploration



The exploration of the implications
of the use of the forest metaphor
for a circular economy.

Chapter 3

Circular economy through the lens of the forest metaphor – a teaching and learning perspective

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SUMMARY

The idea of a circular economy promises radically different outcomes compared to the current, linear economy. To explore new lines of enquiry to achieve these different outcomes, metaphors can be used to allow students to think differently about a circular economy compared to the current economy. Conceptual metaphors are especially powerful for this purpose since they influence most abstract patterns of thought, and they have systemic properties. Therefore, this research describes an intrinsic case study about the engagement of a group of students with the metaphor of a forest during a two-day postgraduate-level course. This research addresses the question: "*to what extent does the forest metaphor allow students to rethink the relationship between businesses in a circular economy?*" Through this intrinsic case study, the insights, experiences, and perspectives of the students are analysed, before and after they interacted with the forest metaphor.

3.1 INTRODUCTION

The “circular economy” is an antonym for the linear economy, referring to the conventional economy which is characterised by extraction and degeneration. The circular economy promises radically different outcomes (Bocken et al., 2016; Murray et al, 2017; Geissdoerfer et al., 2017; Temesgen et al., 2021). However, some reductionist habits of thought from the linear economy, have influenced circular economy thinking (Fromberg et al., 2023; Murray et al., 2017).

Reductionist metaphors, such as the machine metaphor, tend to make sense of the economy as an entity that is removed and protected from society and the environment (Mutari, 2018). This causes the focus to be on tangible and measurable factors (such as products, emissions, and materials) instead of more social or dimensions, such as wider systemic change, which is more challenging to quantify.

To explore what an alternative conceptualisation may look like, this paper will explore what happens when postgraduate students engage with holistic metaphors with nonlinear qualities. A nonlinear metaphor that is receiving attention within the context of a circular economy is the forest metaphor (Tate et al., 2019). Therefore, in this case study, the “source domain” (meaning the domain where insights are derived from) is the forest metaphor. The “target domain”, which is an abstract phenomenon that one tries to make sense of, is the idea of a circular economy.

Using the forest metaphor to make sense of a circular economy has the potential to provide more nuance compared to the currently dominant competitive metaphors, such as the sports metaphor and the war metaphor (Fromberg, 2023). Expected insights that may be derived from this source domain will be around the symbiotic relationships, the interdependency between different entities in the forest and the communication that happens through the mycelium networks. All these features exist in parallel to the competition for potentially scarce resources such as nutrients and sunlight.

This paper outlines the results of a case study where students explored relationships between businesses in a circular economy through the forest metaphor. It addresses the research question: “*to what extent does the forest metaphor allow students to rethink the relationship between businesses in a circular economy?”* The paper describes the case of a two-day, workshop-style course on systems thinking, as part of the Postgraduate Diploma in Sustainable Business at the University of Cambridge Institute for Sustainability Leadership. During this course, 36 students actively engaged with the forest metaphor to understand relationships between businesses within a

circular economy. The students signed up for the study, the participants, completed an experiential learning worksheet and a survey before the course started and completed a survey after the course ended.

3.2. BACKGROUND

Although metaphors are often seen in literature as individual linguistic expressions, or as the decoration of language, a more profound interpretation based on cognitive science reveals that metaphors are key to the conceptualisation of abstract ideas. Around 98% of an individual's reasoning is unconscious, requires emotion and uses the "logic" of conceptual metaphors (Lakoff, 2010). Most individuals are unaware of the metaphors that govern their thoughts and the extent to which those metaphors can influence the product of those thoughts (Lakoff. 2010). Engaging with new metaphors may allow individuals to come up with novel ideas, or value already-existing ideas differently (Saffer, 2005) or explore new lines of enquiry (Strike & Posner, 1982).

Current mainstream circular economy discourse uses mostly sports and war metaphors to understand the nature of the relationships between businesses in a circular economy (Fromberg et al., 2023). However, this creates a clear tension with at least principle 8 of a regenerative economy as described by Fath et al. (2019):

1. Maintain robust, cross-scale circulation of critical flows including energy, information, resources, and money.
2. Regenerative re-investment.
3. Maintain reliable inputs.
4. Healthy outputs.
5. Maintain a healthy balance and integration of small, medium, and large organisations.
6. Maintain a healthy balance of resilience and efficiency.
7. Maintain sufficient diversity.
8. Promote mutually beneficial relationships and common-cause values.
9. Promote constructive activity and limit overly extractive and speculative processes.
10. Promote effective, adaptive, collective learning.

The forest metaphor could have the potential to provide insights beyond the promotion of mutually beneficial relationship and common-cause values. However, the designed learning experience of this case study will focus on conceptual development related to principle 8 in specific.

The two-day course was aimed at the development and accommodation of the conceptualisation that follows the logic of the forest metaphor. To ensure that a new conception is accommodated by the learner, the following conditions are to be met (Strike & Posner, 1982):

- There must be dissatisfaction with existing conceptions.
- A new conception must be intelligible.
- A new conception must appear initially plausible.
- A new conception should be fruitful.

This research will evaluate these conditions in the context of the forest metaphor in circular economy learning.

3.3. METHODOLOGY

A qualitative methodology is most appropriate for exploring complex issues (Creswell & Poth, 2016) such as the interaction with conceptual metaphors by students. More specifically, the research is conducted through the methodology of an intrinsic case study. Through an intrinsic case study, an unusual or unique situation is presented (Stake, 1995). The case study in question will be the engagement with the forest metaphor during a two-day Sustainability Leadership Laboratory on *Systems Thinking*, organised by the University of Cambridge Institute for Sustainability.

This course took place on 27 and 28 February 2023 in Cambridge, United Kingdom and is part of the Postgraduate Diploma in Sustainable Business (a part-time, level 7 course). The course is not compulsory. As such, all students self-selected for participation in this course.

On the first morning of the course, lectures were presented on systems thinking and systemic problems in the context of the economy, and a reflection on the difference between systemic transitions and transformations was provided. The afternoon programme started with a lecture about metaphors and an elaboration of the learning design of the 2.5-hour workshop that followed. This 2.5-hour workshop allowed the students to engage actively with conceptualisation of a forest for a circular economy and this is the scope of this research. A second day of systems thinking content that followed this workshop is considered out of scope for this research.

3.3.1. Participant selection

All students on the course have been invited to join this study. The course requirements are a minimum of 3 years of relevant work experience; however, most students will be mid-to-senior managers from a variety of sectors, industries, and geographies. Of the 36 students joining the course, 30 signed up to be participants in this study and filled in the consent form (Appendix A). Eventually, 27 participants filled in the first survey and completed the two days of the course. Of these 27 participants, 20 also completed the post-workshop survey.

3.3.2. Data collection

The study draws from three points of data: two surveys and the pre-course preparation worksheet. The first survey (Appendix B) was sent over after signing up to the research and this was followed by an invitation to complete the pre-course worksheet. During the pre-course worksheet, the students were asked to go to a forest to activate the metaphor. The worksheet asked them to capture thoughts on how and when nature inspired them as well as to observe how different entities in the forest interact with each other. The second survey (Appendix C) was sent to the participants after the workshop.

3.3.3. Data analysis

The qualitative data was analysed according to grounded theory (Bryant et al., 2007). All responses were coded and clustered.

For example, when participants were asked what insights from the forest metaphor were realistic to implement, one of the clusters was defined as “interconnectivity” based on the coding of the following answers:

> *“We need to understand that all elements of an organisation are connected, like the roots of the trees and the fungi networks, and therefore look at the system as a whole.”*
> *“More thoughtful cooperation inside the organisation to reveal the potential of each employee and design interconnections internally.”*
> *“The forest metaphor was helpful to consider the inter-connectedness of organisations and institutions”*

3.4. RESULTS

3.4.1. Participants

Most of the students were taking the course as part of their part-time studies. Participants declared to be in their 20s (4), 30s (7), 40s (9), 50s (6) and 60s (1). All participants were in employment during the time of the study. 14 out of the 27 participants work in “business”, followed up by “policy” (3), “advisory” (3), “NGOs” (2), “academia and research” (2), “education” (2) and “finance” (1). When asked to self-assess their competencies related to the “circular economy” the participant’s responses ranged mostly from moderately competent to competent.

3.4.2. Initial circular economy conceptualisation

In the first survey, the participants were asked to choose between four experimental sentences that demonstrated two competitive metaphors and two forest metaphors. 24 students found that the following sentence resonated most with them: “By implementing circular economy, businesses can create a flourishing ecosystem to thrive in.” as demonstrated in Figure 3.1.

25 Out of 27 participants were to some degree comfortable with a conceptualisation that follows the logic of the forest metaphor.

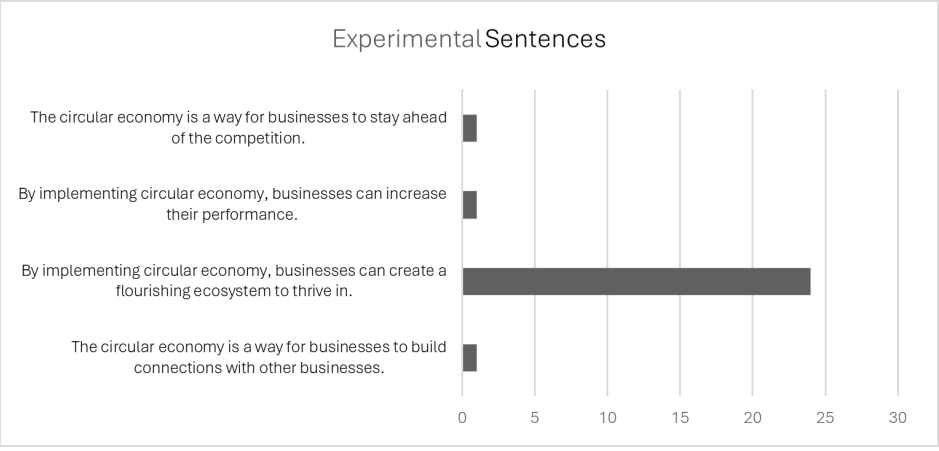

Figure 3.1. Overview of the selection of the experimental sentences by the participants.

When asked to elaborate on why they chose this sentence, participants mentioned alignment with their personal views, because they view businesses as part of an ecology, and because it refers to the conditions for life as a starting point for thinking about the economy.

Only two participants selected an experimental sentence that displayed a competitive metaphor. The main reason for their choice is that they believe business needs to act sustainably to ensure that they can stay ahead of the competition and increase their performance.

After the selection of the experimental sentences above, the participants were asked if they thought most individuals in their organisation would agree with them. 11 Participants expect they would, and 16 participants were either unsure or did not expect they would agree with them. The main reason why participants were unsure about the stance of other individuals in the organisation is due to a lack of knowledge, interest, or awareness about the circular economy. The second reason was that they expect that others would value competitive features more and prefer the most profitable way possible.

3.4.3. Metaphor activation

Before the course officially started, the participants were asked to venture into a forest and complete an experiential learning worksheet. Most participants confirmed that they were able to complete this exercise, but some experienced challenges accessing an ecosystem such as a forest when residing in an urban area.

The purpose of this element of the course was to activate their present knowledge about the forest, which helps them prepare for the workshop during the course. During this exercise, features were prompted around interdependency, connectivity, resilience, and symbiosis.

3.4.4. Workshop experience

After the workshop, most participants agreed or somewhat agreed that engaging with the forest metaphor had been enriching and brought new insights. The graph in Figure 3.2. shows that participants agreed that the metaphor has been enriching. However, this response was less strong for the insights that this metaphor brought to them.

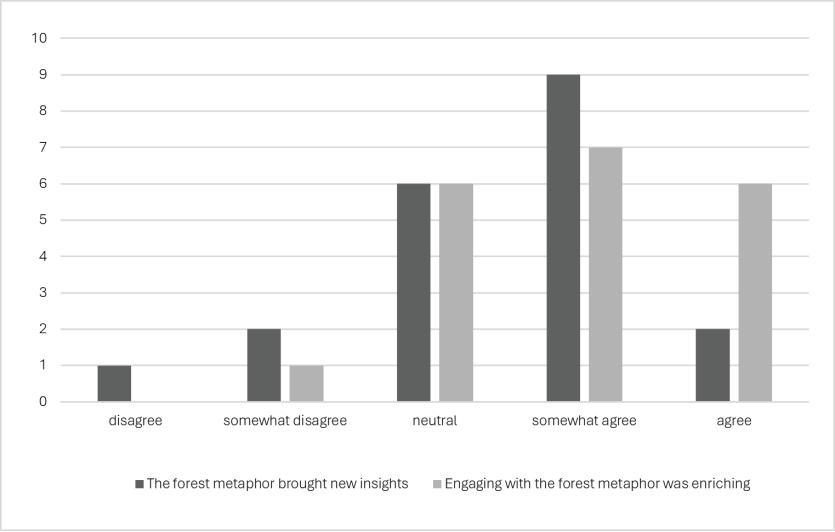

Figure 3.2. A comparison of the result of the statements: "the forest metaphor brought new insights" and "engaging with the forest metaphor was enriching".

When participants were asked to elaborate on this, qualities like the interconnectedness of organisations and institutions were mentioned most frequently together with cooperation between different entities in the economy.

At the same time, most participants also felt tension between the insights of the forest metaphor and the reality of their business or organisation as indicated in Figure 3.3.

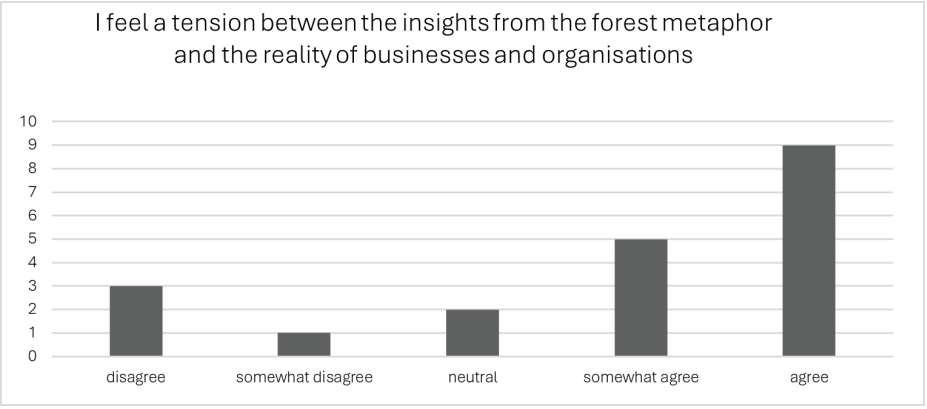

Figure 3.3. There was a tension identified between the forest metaphor and the reality of businesses and organisations.

3.4.5. Conceptual development

In the second survey, the experimental sentences were presented to the participants again and as expected, a similar outcome was generated to the pre-course survey. In a later question, as visualised in Figure 3.4., the participants expressed that they either found their understanding or conceptualisation of a circular economy unaffected or deepened.

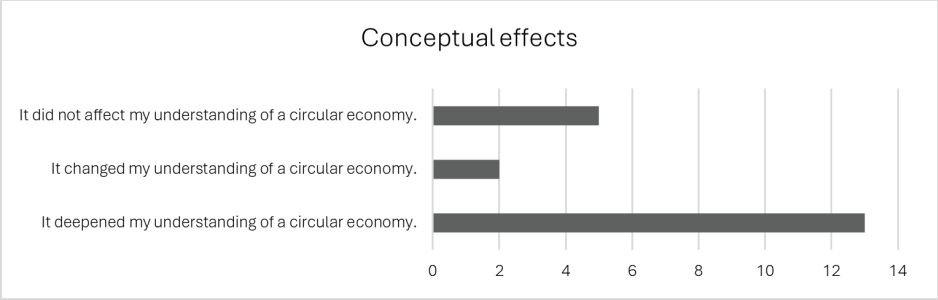

Figure 3.4. The conceptual effects of the learning experience.

3.4.6. Features of the forest metaphor

Finally, the participants were asked to review the principles of a regenerative economy (Fath et al., 2019) and rate how relevant they find the forest metaphor for this principle.

The forest metaphor has been rated between somewhat relevant and very relevant for all principles by the participants. This indicates that there could be a shared understanding of the forest metaphor that would be in line with the idea of a regenerative economy.

3.5. DISCUSSION

Insights from the forest metaphor that stood out to the participants were mostly around the interconnectedness of organisations and institutions as well as cooperation between different entities in the economy. However, the participants of this study seem to face challenges applying the insights of the forest metaphor and most indicate a tension between the insights of the forest metaphor and the reality of their organisation.

To evaluate the nature of this so-called reluctance to accommodation, the four conditions for conceptual change from Strike and Posner (1982) are evaluated considering the engagement with the forest metaphor.

3.5.1. Condition one and two

The dissatisfaction with existing conceptions and the condition that the new conception must be intelligible are assumed to be met when the students signed up to the course since the sign-up page had a clear descriptor of the learning activities that would take place.

3.5.2. Condition three

The third condition requires that a new conception must appear initially plausible. Strike & Posner (1982, p.235) mention that *"a new idea [...] is less likely to be accepted if it is inconsistent with current [...] knowledge, or if it has no clear physical account"*. In other words, there could be a reluctancy in the acceptance of new conceptualisations if there is an inconsistency with other knowledge.

Cobern (1996) describes the phenomenon when learners isolate the concepts that do not fit their natural way of thinking (see Figure 3.5.). After pressure is relieved, such as an exam or occasion where the new concept was fruitful, the conception deteriorates, and the learner reverts to their natural way of thinking. This is due to the pressure and orientating effect of the overall worldview.

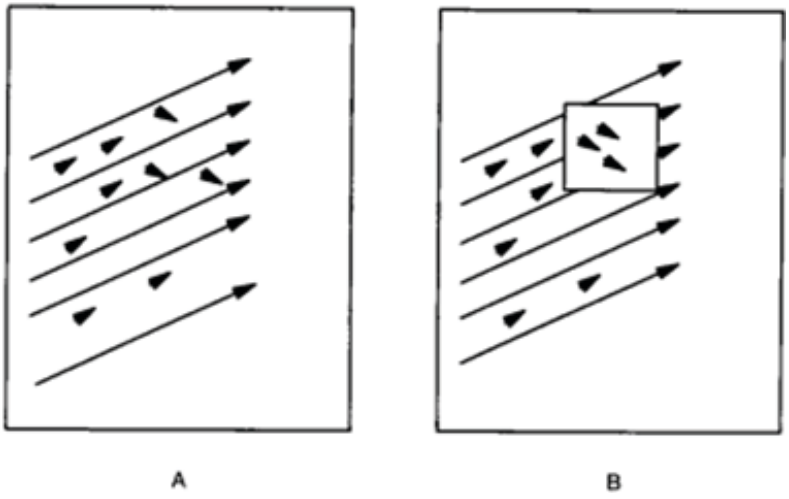

Figure 3.5. The orientating effect of worldview (Cobern, 1996)

Insights from the forest metaphor could be conflicting with the participants' current conceptualisation of the relationship between businesses in a circular economy and lead this cognitive isolation. However, in the pre-course survey, it was identified that 25 out of 27 participants were comfortable to some degree with the logic of the forest

metaphor. This could be further and more robustly investigated, but it suggests that their worldview could accommodate and support more nonlinear metaphors, such as the forest metaphor.

3.5.3. Condition four

The fourth condition is that a new conception should be fruitful. As part of the fourth condition, *"the new conception must do more than solve its predecessors' difficulties. It should have the potential to be extended, to open up to new areas of inquiry."* (Strike & Posner, 1982, p.235). The participants claim that the engagement with the forest metaphor enriched their understanding of circular approaches, however, most also felt a tension between the reality of their organisation and the insights of the forest metaphor.

This was especially expressed by participants that felt that the competitive nature of the company would always receive priority. During the workshop, participants raised how some of the insights seemed unrealistic to their specific context. One of the participants raised the recent cases where ESG (Environmental, Social, Governance) collaboration has been accused of violating anti-trust laws (O'Sullivan, 2023). Several others raised the importance of their shareholder responsibility would be a barrier to several of the features of the forest metaphor.

3.6. PEDAGOGICAL IMPLICATIONS

The fourth condition around the fruitfulness of the conceptualisation particularly requires attention from a teaching perspective, since participants raised challenges when applying the insights into their business context.

To address this, Strike and Posner (1982) suggest that the teacher should take the role as Socratic tutor. A traditional interpretation of Socratic practice leads to a situation where the teacher insists on consistency among beliefs and confronts learners with the implications of their thoughts through a dialogue. However, a more contemporary practice of a Socratic exchange is used as a teaching method for critical thinking (Boghossian, 2006).

In the case of the use of the forest metaphor to make sense of the relationship between businesses in a circular economy, this could mean that the teacher is part of an exchange with the learner to seek specific areas where their ideas could align with the reality of their business or organisation.

3.7. CONCLUSION

This study aimed to evaluate to what extent the forest metaphor allows students to rethink the relationship between businesses in a circular economy. The forest metaphor was chosen due to its features around balancing competition and interdependency, which could lend itself well to an alternative conceptualisation of businesses in a circular economy. The study was addressed through a case study of a course which attracted students who seemed comfortable with the logic of the forest metaphor.

The engagement with the forest metaphor in the context of the circular economy was considered enriching by the participants. It seemed relevant to the principles for a regenerative economy by Fath et al. (2019). Therefore, the initial insights that come with the forest metaphor could be considered a promising line of enquiry in the development of a conceptualisation of a circular economy inspired by a nonlinear metaphor.

However, most participants experienced tension between the insights of the forest metaphor and the reality of businesses and organisations. When asked about areas where they were able to implement insights from the forest metaphor, many were not able to identify clear areas within their business or organisation. This tension mostly affects the fruitfulness of the new conceptualisation and requires attention from a teaching perspective.

This could mean that more practical features from the source domain (the forest) could be proposed to the learner when engaging with this metaphor. Learning through a Socratic exchange may support the identification of more concrete areas for the application of this metaphor in a circular economy business context.

Further research could explore areas within the target domain of sustainable business where specific insights from the forest domain are fruitful and applicable.

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Chapter 4

Conceptualising the technosphere of a circular economy through a living systems metaphor

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SUMMARY

This chapter explores a circular economy through the metaphor of a living system: a forest. The technosphere of a circular economy is an entirely human-made and managed realm. This research aims to explore how a common understanding of how a forest works can be used to conceptualise the products, components and materials that circulate in the technosphere as "fruit". This exploration entails four aspects of the metaphor: (1) the recipient needs to know what it is "eating", (2) the fruit needs to be "non-toxic" for the recipient, (3) the fruit needs to be nutritious and, (4) the wider system needs to be able to "metabolise the nutrients". This metaphor allows for a more interconnected and holistic understanding of different economic and societal actors, their relationships and overall productivity.

4.1. INTRODUCTION

It was the American author Wendell Berry who said: *"We don't have a right to ask whether we're going to succeed or not. The only question we have a right to ask is: what's the right thing to do? What does this earth require of us if we want to continue to live on it?"* It is a plea for an enquiry into different ways of thinking, acting, and driving change.

One way to do so is by exploring new ways of thinking through conceptual metaphors. Research in cognitive science by Lakoff & Johnson (1980) posits the core role of conceptual metaphor in all our abstract thinking. It can affect how we think of abstract ideas, such as the economy, but also what kind of solutions we come up with (and what we do not think of).

Within the discourse of circular economy, it is the machine metaphor that currently dominates (Fromberg et al., 2023a). This metaphor emphasises material flows as inputs and outputs of the economy through the logic of pipeworks. The consequences of this metaphor are an emphasis on resource inputs and outputs and a lack of attention to the social implications (Mutari, 2018). This same metaphor is used frequently in current economic discourse and therefore any putative circular economy has the potential to repeat the same patterns of thought as the current unsustainable economy (Fromberg et al., 2023b).

This paper will follow the implications of a radically different, living systems metaphor to explore a subdomain of a circular economy: the technosphere. This refers to products, materials and components where order is rebuilt by human intention and facility rather than natural ecosystems (Braungart & McDonough, 2002). The purpose of doing this is to explore new lines of enquiry that might challenge the status quo and provide a critical reflection on current discourse.

4.2. A LIVING SYSTEMS METAPHOR: THE FOREST

As Tate et al. (2019) explore in their work, the forest metaphor has been indicated as an insightful line of enquiry in circular economy discourse. Within this metaphor (elaborated upon in Table 4.1.), the economy is conceptualised as the "forest floor" on which the economic actors are seen as "creatures" on the forest floor such as scavengers or decomposers (Tate et al., 2019).

Table 4.1. Comparison of roles between natural networks and the business ecosystem by Tate et al. (2019)

Role	***Natural networks***	***Business Ecosystem***
Producer: take sunlight and use the energy to make sugar	Any kind of green plant	Mining (primary); manufacturing (secondary)
Consumer: Feed on producers or other consumers to survive	Predator animals	Wholesalers (primary); retail (secondary); end-customer (tertiary)
Scavenger: Contribute to the decomposition by breaking them into small pieces of organic material	Animals feeding on dead animals or dead plant matter	Dismantling, sorting, and transportation of used materials
Decomposer: Release the organic and inorganic molecules in the form of nutrients for the plants and animals	Bacteria and fungi	Transformation of used materials back into the system

In addition to this, through this metaphor, products, components, and materials could be conceptualised as “fruit”, released by businesses, conceptualised as “fruit trees”. This sub-metaphor will be the scope of this paper.

Biological materials that can be composted and given back to the soil, may lend themselves better to the forest metaphor since it is more than just a metaphor in this case. However, this paper will outline the logic of the more challenging TECHNOSPHERE PRODUCTS, COMPONENTS AND MATERIALS AS FRUIT. This consists of materials that are configured, unlike biological materials in natural ecosystems, and therefore present unique challenges. In the work of Cradle to Cradle, the question of configuration revolves around how order is rebuilt. In the 'technosphere', it is by human intention and facility rather than natural ecosystems (Braungart & McDonough, 2002).

The existing technosphere often intends to operate like a closed system, especially in cases where ownership remains at the Original Equipment Manufacturer. Through business models where the performance of or access to the product is sold to the customer, businesses act like a stand of trees, asking for their fruits back after they drop them.

This closed systems approach may be suitable for certain products that, for example, require specialist tools for maintenance or where user involvement could pose a safety risk. Where a closed system is not a necessity, the forest metaphor uncovers the potential of open systems for this domain. Therefore, some of the features of this metaphor that will be explored in this paper are:

- The recipient needs to know what it is "eating".
- The fruit needs to be "non-toxic" for the recipient.
- The fruit needs to be nutritious.
- The wider system needs to be able to "metabolise the nutrients" too.

4.3. THE RECIPIENT NEEDS TO KNOW WHAT IT IS "EATING"

Fruits are often released by fruit trees to be consumed by other entities so that the seed can be released and fertilised in a different place. They have two main functions: to protect the seed and to support the dispersal. Bright colours indicate a ripe fruit, ready to be released.

Animals such as birds or mammals observe the fruit and have a bite. However, not everything that eats fruit is beneficial for the tree and, therefore, some fruits contain a defence mechanism that prevents certain entities from consuming them. After the first look, the first bite gives the animals additional sensory information (smell, taste and texture) that indicates whether they expect this fruit to be good and safe for them to consume.

Answering the question of whether something is good and safe for use, can be a challenge for technosphere materials. Not because these will necessarily harm the one that initially uses it, but because of the complexity of the ingredients. The technosphere offers a vast array of different materials. Many products within the technosphere can be considered an "omelette" of materials – often challenging to deconstruct back into constituent elements. A smartphone can typically comprise 257 different parts (metallic and non-metallic) (Singh et al., 2018). These materials cannot flow as freely as the nutrients of natural systems if it is not exactly clear what it is, especially after the product has been used. When certain contents enter material streams (such as copper in aluminium alloy streams), contamination can happen which possibly degenerates the functional or structural aspects of material stocks (Syberg et al., 2022). This is ultimately where the harm may occur through the degeneration and contamination of material stocks.

To allow for appropriate identification of these technosphere products, components, and materials, transparency and traceability must exist at every phase.

Standardisation of the palette of materials that are used for products that contain technosphere materials would make it easier for the system to act like nature and prevent the degeneration of material flows. However, this is not always realistic because there are functionality and performance reasons for the diversity of material configurations (Anastasiades et al., 2021). Composites in the technosphere bring other challenges on top of this variety in that they might be difficult or operationally impossible to disentangle. Therefore, the disclosure of the exact ingredients of these products – a materials or product passport - can allow different entities to make an informed decision about whether to use the materials or not (Adisorn et al., 2021).

Arguments against disclosure of materials ingredients emphasise the role of intellectual property rights (IPR) - this is no surprise since 30% of global value is mostly attributed to IPR and goes together with an increase in applications for patents worldwide (World Intellectual Property Indicators, 2022).

Product passporting through public blockchains could support the disclosure of crucial information about the material's ingredients with some protection for the information that is considered intellectual property by the business (Kouhizadeh et al., 2020).

However, such a system would only truly work when it is openly accessible to all entities in the ecosystem. This would allow not just “the big trees” (businesses and the formal economy) to use the nutrition that is contained in its “fruit” (materials) but also “scavengers” (informal, smaller-scale initiatives) and “decomposers” (recycling facilities) to fully access all information that they need to ultimately understand whether the input is beneficial.

4.4. THE FRUIT NEEDS TO BE “NON-TOXIC” FOR THE RECIPIENT

Poisons found in fruits are often specifically designed to make sure that some specific hungry entities back off and leave enough for the right ones to eat. Some fruits that are safe for consumption by, for example, birds, can be unsafe for consumption by other, specifically targeted animals, microbes and fungi. Where trees pick their “customers” and use poisons to repel the unwelcome ones, the technosphere contains toxins or substances of concern. These are usually part of materials and chemicals to achieve a

certain effect (for example: functionally or aesthetically). The toxicity can be considered an unintended consequence of these choices.

Examples of such substances of concern are fire retardants, endocrine disruptors and the family of PFAS materials (CHEMtrust, 2023). Especially unnecessary substances of concern, such as BPA, need to be designed out to avoid exposure and contamination of material flows. This also applies to “forever-chemicals”: a group of approximately 9000 materials that do not naturally break down in the environment (Buttle et al., 2023).

To allow for products, components, and materials to be safe by design, substances of concern must be designed out of the product as well as the value chain.

It is important that first the substances of concern are identified not only in the final product but also within the value chain. Often, in the manufacturing and production process chemicals are used to create a desired outcome. There is therefore a potential to create waste and pollution at this stage as well, with the potential to damage the ecosystemic health of the environment surrounding the factory and beyond (Lyu et al., 2021).

However, when these substances cannot be designed out, they need to be managed through a closed pipework system where they are kept in isolation from substances that are not harmful (Beekman et al., 2020). Therefore, it would be useful to conceptualise this domain through a different metaphor instead. For example, a machine metaphor where the focus lies on managing a closed system through the control of inputs and outputs (Braungart & McDonough, 2002). During the use phase, it is important that the exposure of the substances of concern to the user is minimised and that there is a duty of care of the manufacturer to collect and manage the product at the end of life.

4.5. THE FRUIT NEEDS TO BE NUTRITIOUS

When safe for consumption by a recipient, some fruits may be more nutritious and richer in vitamins and antioxidants than others. After eating these nutritious fruits, they can cause a range of benefits for a variety of biological processes which can be seen as value that is derived from the fruit. In the technosphere, this value can be seen as the utility or value of the products, components and materials that go around.

To allow products, components, and materials to deliver a high value, they need to have an increased utilisation. Products in the technosphere have the most value (compared

to materials and components) and therefore product longevity is the most effective way of retaining the highest value (Den Hollander, 2018). After keeping the product utilised for as long as possible, the inertia principle (Stahel, 2010) can be followed to allow the retention of as much value as possible, as elaborated upon in Figure 4.1.

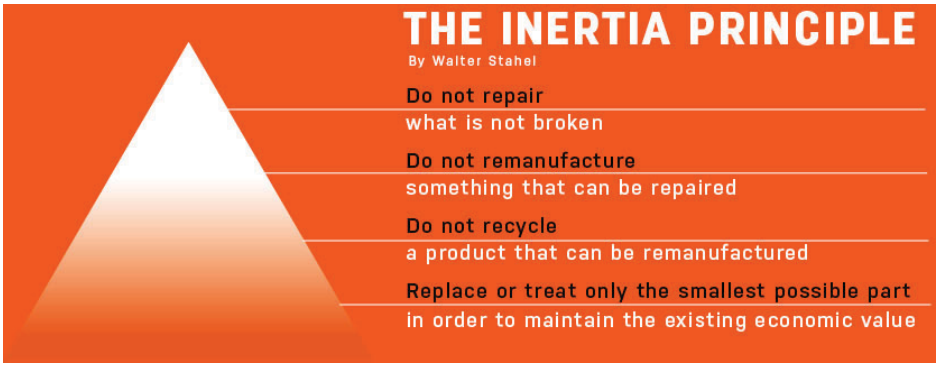

Figure 4.1. The inertia principle by Walter Stahel (2010)

Sometimes value can be identified in the technosphere, but it is inaccessible. An example can be found in the recycling of jeans - which ideally happens after this product has cascaded through all previous possible lifespans. When jeans arrive at a recycling facility, one of the first things that tends to happen is that they cut the top of the jeans off: the part that contains the button, zipper and rivets. This is being done because it takes too long to remove these manually and therefore this part of the jeans is considered waste. The problem here is a lack of convenient access, making it more likely for that value to be lost.

The right-to-repair movement sparked many conversations around design for disassembly, which would help mitigate many accessibility issues. The movement focuses on *"supporting people's freedom to repair and customise their gadgets, such as smartphones. To make diagnostic tools, repair manuals, and replacement parts available to the public, the movement continues to push for laws requiring manufacturers to do so."* (Ozturkcan, 2023; p.1). Convenient access is an important enabler for increased utilisation and product longevity but does not stop at designing for disassembly. To allow customers to have genuine agency over the product, this also means access to blueprints of components to repair, customise and upgrade.

The inertia principle comes back to increased longevity which requires a change in the "sell more, sell faster" mentality of some businesses and allows for productivity to slow down so that all that has been produced can be utilised appropriately first.

4.6. THE WIDER SYSTEM NEEDS TO BE ABLE TO "METABOLISE THE NUTRIENTS"

The fruit has an important value to deliver after the initial consumption and digestion: fertilisation of the area where the seed will settle. Important nutrients are delivered together with the seed to ensure the right conditions for new life to thrive. These nutrients do not necessarily have to be used by the seed but are available to other entities in the ecosystem as well: it is an open system. Open systems allow nutrients to flow freely and be of use to a variety of entities in the wider ecosystem.

To allow the wider system to benefit from products, components and materials that are available, these should be able to be utilised independently and without the need to ask for consent or approval from an external party.

When products, components and materials become accessible to use independently from the Original Equipment Manufacturer, a wealth of creativity could be unleashed on a more local and distributed level. For example, through repair cafes, maker spaces, tool libraries and other more decentralised manufacturing capabilities, more informal economies can thrive on these stocks.

In open systems, nutrients may end up in a place where they are not needed. In nature, fungi fulfil an important role in the redistribution of these, which they do in return for sugars from photosynthesisers (Mason-Jones et al., 2022). This possibility for redistribution is an important feature that could enhance accessibility. A similar function needs to be developed in a circular economy, where nutrients can go where they are needed to fulfil crucial functions.

These are comparable with the so-called "gap exploiters" in the technosphere, which are often small-scale economic entities that recognise opportunities that others tend to overlook. They utilise and redistribute the leftover value of products, components, and materials. In addition to this, they often see opportunities in unsold goods or reinvigorate the value of "old" products by turning them into different objects where they can deliver more value (Bakker et al., 2014). Therefore, the importance of these gap exploiters may increase with more open systems.

Nevertheless, the build-up of certain resources may still happen leading to a stock that is not fully in use. Some cycles in the forest may take many years to be converted. This slow pace of conversion in the technosphere could be due to resource-efficient technologies, changing demands and population shrinkage, for example. When

products, components and materials become available for use in the system, they may not immediately be utilised.

It may require some time to build up a community of “decomposers” (Tate et al. 2019) around materials that are abundant in certain areas. This may lead to the increased need for appropriate storage (and maintenance if necessary) (Mao et al., 2018) for, in some cases, extended periods. This might look like under-utilisation or inefficiency of materials. However, redundancy has an important role to play in resilience, ultimately contributing to the health of the wider ecosystem (Fath et al., 2019).

The introduction of the notion of Total Product Liability (Webster, 2021) or Total Product Responsibility may incentivise participation in this system because manufacturers will be held responsible for the recovery of their products, components and materials. This does not mean that manufacturers will act as trees, asking for their fruits back, but rather if the contents of their fruits are not useful (or even harmful) for other entities in the ecosystem, they will be penalised for dispersing them in the first place.

4.7. CONCLUSION

This paper explores the implications of applying a living systems metaphor, the forest, to the technosphere by reimagining products, components and materials as “fruit from a tree”. Unlike the currently dominant metaphor of a machine, which conceptualises the economy as a closed system of controlled inputs and outputs, the forest metaphor suggests an open flow of resources and information. Treating materials in the technosphere as 'fruit' is not a trivial task and requires profound changes such as restrictions to intellectual property rights and the adoption of transparent practices that, for example, disclose material ingredients, blueprints and other essential data. In an open nutrient system, these elements must circulate freely to support the diverse needs of multiple actors within the wider circular economy.

Designing technosphere products as “fruit from a tree” has implications for how these products are conceived, developed and used. Designers should not only focus on introducing new “nutrients” that can be repurposed across various configurations but also on utilising local and abundant resources to meet production needs. This approach requires a new way of thinking, where design goes beyond simply serving the end user and instead considers the needs and contributions of all entities involved in the value chain, from production to disposal and reuse. By celebrating local resources and capabilities, designers can foster more resilient and self-sufficient communities,

reducing the dependency on global supply chains and promoting a place-based circular economy. Ultimately, adopting this metaphor may challenge designers to reframe their role from creators of isolated objectives to contributors to a dynamic, interdependent ecosystem of economic activity.

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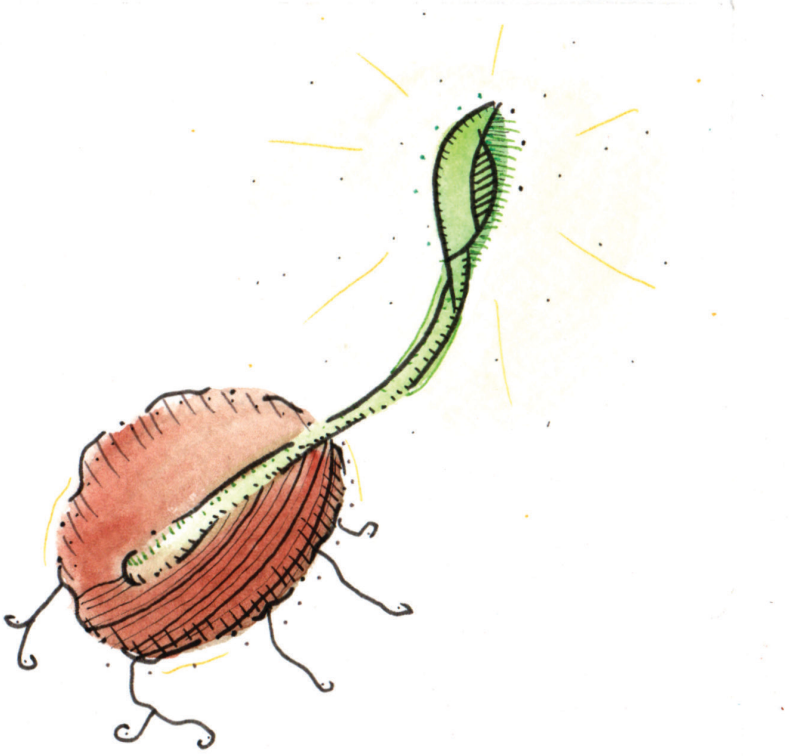
PART 3

Synthesis



The creation of a tool
that allows learners to apply the forest metaphor
to a circular economy.

Chapter 5

Transforming circular economy thinking using the forest as a metaphor

This chapter has been published as:
Fromberg, E. H. E., Bakker, C. A., & Peck, D. (2025). Transforming Circular Economy Thinking Using the Forest as a Metaphor. *Sustainability*, *17*(5), 1858
DOI: https://doi.org/10.3390/su17051858

SUMMARY

Current circular economy discourse is largely shaped by metaphors similar to the ones used for a linear economy: the machine metaphor, competitive metaphor and the journey metaphor. Metaphors influence patterns of thought; what ideas and solutions are valued (and which are not). Therefore, if a radical economic change is desired, it is important to explore which radically different metaphors could inform this thinking.

This study explores the use of the forest as a source domain to enrich circular economy discourse. First, through a qualitative enquiry, intuitive knowledge about a forest is mapped out. Then, circular economy experts were asked to project these insights onto circular economy discourse. The results are presented as practical subdomains that can be applied within design, business and educational contexts.

The findings show rich insights related to *dealing with wholeness, the importance of relationship, and response to change*. The results section presents concrete prompts for activating these source domains and applying these as a prompt for ideation. This research contributes to circular economy education by using metaphors derived from nature as a tool for reflection and novel circular economy conceptualisations.

5.1 INTRODUCTION

Humans rely largely on metaphors to make sense of most abstract phenomena [1]. Because metaphors are an inherent part of human cognition, one must learn to live with their metaphors, understand them and evolve them in times of change. In the wider sustainability domain, the circular economy discourse promises a radical shift away from the current linear economy [2]. This discourse is currently dominated by metaphors "borrowed" from the linear economy, such as the machine metaphor, competitive metaphors (war and sport), and the journey metaphor [3]. This may lead to patterns of thought that emphasise reductionism, competition, and incrementalism, which have been criticised by some academics [3, 4, 5]. New metaphors have the potential to allow the user to reflect on their current conceptual ecology as well as explore new lines of enquiry [1].

Nature is an inspiration for many who seek metaphors that could counterbalance the current "mechanistic" discourse [6]. Hanauer & Beinhocker [7] suggest metaphors that draw from natural ecosystems, such as gardens, in which governments are conceptualised as the gardeners that tend to the garden. Webster [8] proposes living systems metaphors for grasping the nonlinear and complex dimensions of a circular economy and allowing a plurality of circular economies to emerge. Hutchins [9] elaborates on how leadership for the future economy should be inspired by metaphors from natural ecosystems.

Insights from natural systems and biology are already utilised in some areas within circular economy discourse, for instance through the ideas of biological nutrient cycles, regenerative agriculture, and biomimicry. Using an ecology-inspired metaphor may be more intuitive for those active in these areas since it is more than just a metaphor [10]. However, this research aims to conceptualise the broader idea of a circular economy through the lens of the ecology-inspired metaphor, not just biological nutrients. It addresses more general "patterns of thought" instead of following a literal interpretation of nature. It goes further than biomimicry because it does not evolve around *pretending to be biological* [5] – it is about actually being biological.

In their paper titled *Seeing the forest and not the trees: learning from nature's circular economy*, Tate et al. [11] present the discrepancy between insights from natural ecosystems – such as a forest- versus the reality of the current business ecosystem as described in Table 5.1.

Table 5.1. Comparison of roles between natural networks and the business ecosystem by Tate et al. (2019)

Role	***Natural networks***	***Business Ecosystem***
Producer: take sunlight and use the energy to make sugar	Any kind of green plant	Mining (primary); manufacturing (secondary)
Consumer: Feed on producers or other consumers to survive	Predator animals	Wholesalers (primary); retail (secondary); end-customer (tertiary)
Scavenger: Contribute to the decomposition by breaking them into small pieces of organic material	Animals feeding on dead animals or dead plant matter	Dismantling, sorting, and transportation of used materials
Decomposer: Release the organic and inorganic molecules in the form of nutrients for the plants and animals	Bacteria and fungi	Transformation of used materials back into the system

This study explores the implications of specifically the forest metaphor for three reasons: (1) many in the general public have developed intuitive knowledge about this domain in their life (2) research about how this domain applies to circular economy, such as by Tate et al. [11], demonstrates that this is potentially a fruitful metaphor for the target domain (3) within this metaphor, there is no single entity with agency (in contrast with the garden metaphor where the gardener has agency). It is assumed that when there is an absence of "a gardener", this could open the potential for more creative and bottom-up ideas, that do not necessarily require governments to be progressive to lead.

A previous study by the authors [12] showed that a forest metaphor in a learning context helps to emphasise interdependency, connectivity, resilience and symbiosis. Even though ecological metaphors offer new insights to many, this teaching case study showed that some learners experienced a tension between these higher-level and more abstract insights of the metaphor and the reality of the business they work for [12]. In this case study, learners also came up with more ambiguous concepts that left them without clear agency to drive change [12]. To address this tension, this research aims to break down the heuristic of the forest metaphor into more applied, concrete and manageable subdomains that still use the logic and familiar knowledge from the source domain, the forest, but are more accessible for business professionals to apply.

To harvest a wide range of insights that can form the basis of this metaphor, the first part of this research focused on mapping intuitive knowledge about how a forest works through interviews. During the second part of the research, these insights were transposed onto circular economy discourse with circular economy experts. The authors aim to present the insights in a format conducive to educational and learning contexts.

It addresses the main research question:

- What new lines of enquiry can be explored for a circular economy through the forest metaphor?

To answer this question, the following sub-research questions will be explored:

- Sub-research question 1: How do participants express their intuitive knowledge of a forest ecosystem as an integrated whole?
- Sub-research question 2: How can the areas of intuitive knowledge about a forest be transposed onto contemporary circular economy discourse?

This research contributes to Conceptual Metaphor Theory (CMT) and aims to investigate the forest metaphor as a heuristic for business in a circular economy. The insights of this study can be used as a tool that challenges current circular economy discourse as well as for educative purposes aimed towards business and design professionals.

5.2. BACKGROUND

A metaphor describes an abstract phenomenon (target domain) through the knowledge of a more intuitive or familiar domain (source domain). These insights do not prompt a real physical resemblance, but rather an abstract one [13]. CMT does not only elaborate on aspects of language but describes fundamental parts of human thought processes [14]. Therefore, this makes CMT an effective approach to support conceptual development from a pedagogical perspective by helping identify learning obstacles as well as providing productive entry points for instruction [15]. This study uses insights from CMT in a generative way to prompt new ways of thinking about a circular economy.

This study seeks to identify intuitive areas from the forest as a source domain and projects these insights onto circular economy discourse, the target domain. The metaphor that is analysed in this research is CIRCULAR ECONOMY AS FOREST

through the formatting TARGET DOMAIN AS SOURCE DOMAIN [1]. Capitals are used for the technical representation of the conceptual metaphor [16].

A forest is considered a suitable source domain because it is an ecosystem that many have interacted with at some point in their life. However, making sense of a forest may be different from person to person – depending on how they conceptualise this phenomenon. Urlica et al. [6] (p.135) elaborate: *"While some metaphors construct Nature as an integrated whole, others conceptualise it as an assemblage of parts or as a resource"*. This research will seek to investigate the interpretation of a forest as an integrated whole, from an ecological worldview. It will address areas of intuitive knowledge as suggested by Du Plessis & Brandon [17]: (1) dealing with wholeness, (2) the importance of relationship and, (2) response to change.

The approach that was taken in this study explores the conceptual metaphor CIRCULAR ECONOMY AS A FOREST in a generative way – as a so-called "generative metaphor" which is an often-used ideation tool in the design discipline. Donald Schön [18] describes these as metaphors that *"generate new perceptions, explanation and inventions"*.

Not all generative metaphors are conceptual metaphors. For example, the work of Logler, et al. [19] demonstrates a design tool that prompts designers to consider the abstract phenomenon of "international injustice" through generative metaphors: "hospital", "museum", "theatre", "company", "startup" and "laboratory". Many, if not all, of these proposed metaphors do not have the systemic underpinnings of a conceptual metaphor but can act as a generative metaphor. They are often used in quantities to prompt new types of ideas and different lines of enquiry.

The purpose of this study is to offer a way for participants to engage more deeply with a single conceptual metaphor: CIRCULAR ECONOMY AS A FOREST. By creating subdomains that act as generative metaphors, participants can obtain a rich understanding of the implications of this conceptual metaphor.

Viewing an abstract domain, such as a circular economy, through the lens of an ecological metaphor may require a conceptual change [20] from closed, engineered systems towards more open, non-linear systems. It may feel inconsistent, contradictory and unhelpful to engage in these metaphors if one is not open to this wider conceptual change [21]. However, by engaging with different conceptual metaphors, learners can decide themselves if they are open to developing their ideas or not. This research aims to develop insights that could support this process.

5.3. METHODOLOGY

This research is split up into consecutive parts to answer each of the sub-research questions. The research design is visualised in Figure 5.1.

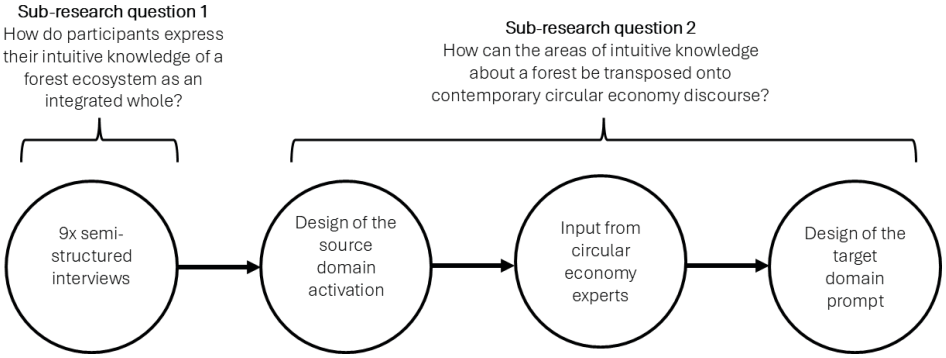


Figure 5.1. Research design

5.3.1. Semi-structured interviews

The sub-research question answered in part one is: How do participants express their intuitive knowledge of a forest ecosystem as an integrated whole? Nine business professionals were selected as participants for this study, each with varying knowledge about natural ecosystems. An overview of the interviewees can be found in Table 5.2. Most interviewees were residents of the United Kingdom at the time of interviewing. Interviews were conducted in a virtual way with the first interview starting in August 2023 and the final one in June 2024. Participants voluntarily signed up for the study and did not receive any financial gains or other for participating in the study. Upon signing up for the study, participants completed an informed consent form (Appendix D) and were able to access a Participant Information Sheet which also included information on how to withdraw from the study, if they wished to do so. This information sheet also explained that all data was to be pseudonymised from the point of transcription and anonymised after all data has been collected. Finally, participants were asked to report their understanding of nature from a limited, everyday understanding to a deep understanding, for example, when this relates to their field of expertise. This allowed the participants to declare the extent of their prior knowledge about nature.

Table 5.2. Overview of the interview participants

Participant	***Season when visiting the forest for the interview***	***Gender***	***Geographical Location***	***Self-reported understanding of nature***
1	Summer	Male	United Kingdom	Medium
2	Summer	Female	United Kingdom	High
3	Fall	Female	United Kingdom	High
4	Fall	Female	United Kingdom	Medium
5	Fall	Male	United Kingdom	Medium
6	Winter	Male	United Kingdom	Medium
7	Winter	Male	United Kingdom	High
8	Spring	Female	United States	Medium
9	Spring	Male	Italy	Medium

Before the interview, participants were asked to visit a natural ecosystem such as a forest. During this visit, they were asked to complete a worksheet. On the worksheet, there were instructions for an exercise called *Wide Angle Vision* where participants were prompted to move from looking at a single entity in the ecosystem, towards the wider integrated whole that constitutes the ecosystem. This was followed by questions such as: *How do the different elements of your selected area interact with each other?* And: *If the place you chose had a voice, what might it say about why it is acting or "operating" the way that it does?* This activity was designed to activate any knowledge concerning the forest so this could surface during the interview. Since the season of the visit may impact the kind of observations the participants would bring up, the interviews were evenly allocated over different seasons. Participants were asked to complete this exercise a week before their interview.

During the one-hour, semi-structured interview (Appendix E) the participants were asked about their experience in this natural ecosystem. The participants were invited to explore the phenomenon of a forest through the following themes: (1) dealing with wholeness, (2) the importance of relationship and, (3) response to change [17].

The data was analysed using Atlas.ti with the help of the transcription feature of Microsoft Word and Zoom. All transcriptions were analysed using Grounded Theory [22]. The data was analysed according to the three themes (wholeness, relationship and change) and these were used as structuring elements. The final clusters are displayed in Table 5.4-6, Column 1 of the Results Section.

5.3.2. Source domain activation

To activate prior knowledge of the source domain, in this case, a forest, the authors grouped together clusters that resulted from the interviews. For example, the clusters: "redundancy", "(bio)diversity", "fragility", and "resilience" were grouped during this process and the following activation was designed to address these:

> *Diversity can lead to functional redundancy where multiple entities fulfil the same role in the ecosystem – such as the many leaves on one tree. If some are lost due to a disruption, there may be enough left to maintain functions.*
> *Another way how diversity contributes to the resilience of a forest is in a complementary way where entities are slightly different and therefore dependent on, for example, different resources.*
> *Think of an example of diversity in a forest and reflect on how this contributes to the overall health and resilience of the wider ecosystem.*

These texts that form the activation of the source domain are shown in Column 2 and are generated for each of the 18 domains.

5.3.3. Expert input

The results from Table 5.4.-6., column 3 were presented to 7 circular economy experts (Table 5.3.). Most of these experts were recruited during a "circular economy retreat", which was a weekend-long event on 7-9 June 2024, in which individuals personally signed up to think and discuss progressive ideas related to a circular economy.

Table 5.3. Overview of the circular economy expert participants

Participant	***Gender***	***Geographical location***	***Occupation***
1	Female	Sweden	Entrepreneur
2	Female	Russia	Business professional
3	Female	Norwegian	Entrepreneur
4	Male	United Kingdom	Freelancer
5	Female	The Netherlands	Student
6	Female	United Kingdom	Academic
7	Male	United Kingdom	Designer

Through a qualitative survey, the experts reviewed the source domain activations and were asked: *how would you apply these insights to the domain of business in a circular economy?* The survey consisted of an instruction together with a time estimate for

completion of the total survey which was estimated at approximately 1 hour. All the participants had to complete a consent form and confirm that they understood the instructions before continuing to the open questions.

If a participant was unable to answer one of the questions, they were allowed to move on and therefore some of the source domain activations were more populated than others. The input was coded and clustered according to grounded theory.

5.3.4. Target domain prompt

Finally, the authors used the thematic areas from Column 3 to develop a prompt that could allow learners to transpose their intuitive knowledge about a forest onto circular economy discourse.

In a previous case study [12] it was concluded that prompting a very broad source and target domain is too ambiguous and not sufficiently fruitful. However, being too prescriptive with metaphor can be unhelpful as well because even though we can think about a target domain through a source domain, these two phenomena are different and separate. A metaphor remains figurative.

Therefore, the prompt was framed as a question rather than a statement. A proposed target domain prompt is presented in Column 4 in the results section.

5.4. RESULTS

In total, 18 source domain activations were established: “diversity and redundancy”, “open nutrient networks”, “ecological niche”, “experimentation and the right conditions for life”, “communities in enmeshed layers”, “emergence and gap dynamics”, “self-organisation”, “opportunism and enhancing utilisation”, “reciprocity and interdependency”, “cooperation and co-evolution”, “competition”, “community and information sharing”, “invasion and conflict”, “evolving through feedback”, “metamorphosis”, “microclimate and homeostasis”, “adaptation and seasonal changes”, “reactive change to disruption”.

These were transposed onto circular economy discourse in Table 5.4-6. The results section consists of three different tables, corresponding to the areas set out by Du Plessis & Brandon [17]: dealing with wholeness, the importance of relationships and the response to change. The first column presents a group of clusters resulting from the semi-structured interviews. This is followed by a source domain activation prompt as

presented in column 2. The insights from column 2 were presented to circular economy experts which resulted in the topics being raised in column 3. The content in the final column is designed by the authors, based on the insights from the expert input.

Table 5.4. presents the insights of the clusters that address “dealing with wholeness”. The insights here relate to the holistic and nested interpretation of a wider system. Whereas mechanistic discourse mostly addresses measurable inputs and outputs [3], these insights show a more integrated approach, where social dimensions play a more critical role.

Table 5.4. Dealing with wholeness

Column 1	***Column 2***	***Column 3***	***Column 4***
Interview Clusters	***Source domain activation proposal (by the authors)***	***Target domain themes raised by circular economy experts***	***Prompt for transposition onto the target domain (by the authors)***
Diversity and redundancy			
Redundancy	Diversity can lead to functional redundancy where multiple entities fulfil the same role in the ecosystem – such as the many leaves on one tree. If some are lost due to a disruption, there may be enough left to maintain functions. Another way how diversity contributes to the resilience of a forest is in a complementary way where entities are slightly different and therefore dependent on, for example, different resources. Think of an example of diversity in a forest and reflect on how this contributes to the overall health and resilience of the wider ecosystem.	Enhance supply chain resilience by being able to utilise a diversity of inputs.	Reflect on how your business contributes to a diverse, resilient and healthy economic ecosystem. Think of: • Are you able to use a diversity of inputs? • How flexible is your business model? Are there elements that have a variety of purposes (healthy redundancy)? • Are the people in your ecosystem building diverse sets of skills and capabilities? • Is there spare capacity available in case of disruption (for example, disruption in the supply chain)?
(Bio)diversity		Increase the number of elements that can fulfil a variety of purposes to ensure flexibility.	
Fragility		Allow people to build a diversity of skills and capabilities to enhance creativity.	
Resilience		Ensure spare capacity in case of disruption.	
Open nutrient networks			
Lack of boundaries	Mycelium networks in the forest floor connect tree roots and facilitate the exchange of nutrients and information. These mycelium networks can help young seedlings to connect to mature trees. Through this mature tree, they can access necessary nutrients which enhances their ability to survive. Reflect on how these structures allow the redistribution of nutrients, for example, when a tree requires nutrients, or when there is an excess of nutrients in certain parts of the system.	Provide transparency of information such as material contents or repair blueprints	Instead of being like a tree, asking for your leaves back after they drop, try to think of ideas that ensure that these “leaves” (or product, components / materials) are useful in an open system. Think of: • Offering transparency of information such as details on material contents or open-sourcing product blueprints to enable user-repairs. • Ways to enhance the standardisation or interoperability of products, components and materials. • Ensuring that learning and knowledge sharing is supported between different entities in the system.
Concentrations of life		Enhance the interoperability of products, components and materials.	
Cyclical		Allow learning and knowledge sharing to happen between different players in the system.	

Table 5.4. *Continued*

Column 1	***Column 2***	***Column 3***	***Column 4***
Interview Clusters	***Source domain activation proposal (by the authors)***	***Target domain themes raised by circular economy experts***	***Prompt for transposition onto the target domain (by the authors)***
Ecological niche			
Growth	Many factors determine the right size of a single entity in nature. One factor that influences this is the niche: different entities may occupy different roles and positions in a forest. Imagine the largest or the smallest entity that you can think of in a forest. Processes on a micro-level such as nutrient cycling can influence meso-level dynamics (think of plant growth and interactions between species) and even macro-level (such as the role that it plays in the global carbon cycle). Reflect on how micro-, meso-, and macro-systems in a forest are deeply integrated.	Create business systems that can adapt to work at a local level and fit the local conditions.	As a business, how would you describe your "ecological niche"? Think of: • Whether your business is attuned to diverse local conditions or whether it prefers a "one-size-fits-all" approach. • Reflecting on the business operations, what scale would allow the most effective response to the needs of the system (micro-, meso-, or macro-level)? • How aware is the business of the positive and negative impacts of its core activities on a micro-, meso-, and macro-level?
Size		Find the right scale for business operations to respond most effectively to the needs of the system.	
Niche		Consider both the positive and negative impacts of the business on all levels in the system: on a micro, meso and macro level.	
Experimentation and the right conditions for life			
Experimental	When trees disperse their seeds, only a couple make it to an adult tree – if any. Many fall prey to birds, rodents, and insects or they could face environments that are not conducive to life. The dynamics of the forest floor act as a ground for experimentation. Reflect on the nature of a successful succession, which requires the right conditions for life to come together. This may entail sufficient light, water, and nutrients, for example, as well as protection against external threats.	Tune into the local conditions when shaping new ideas and activities (for example: the social, cultural, economic, and infrastructural nuances).	How does your business attune to the systems conditions and participate in shaping them? Think of: • In what ways do you allow your core activities to be shaped by the context and availability of local resources, infrastructure and expertise? • How do you allow room for business ideas to fail as well as thrive? • How do you take part in the creation of the right conditions for circular activities to arise?
		Allow ideas to be shaped by the context and availability of local resources.	
Conditions for life		Take part in the creation of the right conditions for the desired activity to arise.	
		Allow room for business ideas to fail as well as thrive.	

Column 1	***Column 2***	***Column 3***	***Column 4***
Interview Clusters	***Source domain activation proposal (by the authors)***	***Target domain themes raised by circular economy experts***	***Prompt for transposition onto the target domain (by the authors)***
Communities in enmeshed layers			
Fuzzy boundaries	When leaves fall on the forest floor they can create a rich layer of organic matter. Decomposers break the leaves down, releasing nutrients that can be taken up again by other entities. Community is built around nutrient availability, and this makes social and material dimensions deeply intertwined. Reflect on how social activity has the potential to enhance and direct nutrient flows. What would happen in an ecosystem if there was not this social activity?	Leverage decentralised supply chains to allow for creative and diverse community engagement as well as place-based innovation.	Reflect on how you can support a thriving local community around your business activity: Think of: • Celebrate the skills and expertise that are present in communities. • Making the opportunities to engage in decentralised supply chains and/or value chains accessible and inclusive. • Utilising and supporting the Commons and publicly owned assets and infrastructure.
Layers beneath layers		Celebrate the skills and expertise that are present in communities.	
Different levels of life		Enhance distributed ownership and participation.	
Decomposers		Support the "Commons" and publicly owned assets and infrastructure.	
Emergence and gap dynamics			
Desire lines	Imagine a tree falling in a forest. This event leads to a series of consequences also referred to as "gap dynamics". This is because a gap in the canopy appears which allows juvenile trees to race towards this light. The temporary increase of light on the forest floor also allows for increased growth of the understory (plants that live closer to the forest floor) which typically receives less light. The decomposing tree releases nutrients into the forest floor which creates unique conditions for pioneering species and new growth to thrive. Reflect on how this sudden event creates a knock-on effect that is noticeable at many levels in the ecosystem.	Seek for opportunities where the current linear economy is failing to deliver.	What kind of transformational events could create positive knock-on effects for circular businesses to thrive? Think of: • Opportunities where the current linear economy is failing to deliver. • Ways to engage with policy makers to change the "rules of the game" and open up new circular business opportunities. • Engagements with users and the wider public that could allow for a cultural shift to a different, circular model through awareness.
Pioneering species			
Canopy			
Dynamic circumstances			

Table 5.4. *Continued*

Column 1	***Column 2***	***Column 3***	***Column 4***
Interview Clusters	***Source domain activation proposal (by the authors)***	***Target domain themes raised by circular economy experts***	***Prompt for transposition onto the target domain (by the authors)***
		Self-organisation	
Emergence Ant colonies Self-organisation	Ant colonies have organised social structures that allow the group to work together to sustain the colony. The behaviour of each ant is influenced by local information and simple rules. For example, ants lay down pheromones which create a pathway that other ants can follow (internal communication). There are also specialisations in different roles such as foragers and waste managers – led by environmental cues that allow the colony to adapt to changing conditions. Reflect on how this form of self-organisation is influenced by communication and environmental cues that allow the colony to stay in tune with novel and changing conditions.	Nurture local value networks. Drive change through pre-competitive collaboration and industry-wide initiatives.	How does your business engage in the self-organisation of the wider system? Think of: • Engagement with industry-wide initiatives to create a large-scale movement of change at once - and the ability to prepare for this. • The role of pre-competitive collaboration to create standards that allow a wider system to move towards circularity. • Collaboration and engagement with local residents and communities that could benefit from your business activity.

In *dealing with wholeness*, the source domains "diversity and redundancy" led to most ideas among participants, followed by "open nutrient networks". Least ideas were generated for source domain "self-organisation".

Table 5.5. presents the insights of the clusters that relate to "the importance of relationship". In current circular economy discourse, there is an emphasis on competition through sports and war metaphors [3] and through the forest metaphor competition remains an important feature. However, in this conceptualisation there is an interplay between collaborative/cooperative relationships and competing behaviour.

Table 5.5. The importance of relationship

Column 1	***Column 2***	***Column 3***	***Column 4***
Interview Clusters	***Source domain activation proposal (by the authors)***	***Target domain themes raised by circular economy experts***	***Prompt for transposition onto the target domain (by the authors)***
Opportunism and enhancing utilisation			
Opportunism	Some animals can support the transportation of seeds by, for example, eating fruit and defecating the seeds often far from the original location. Alternatively, seeds can attach themselves to certain animals' coats and hitch a lift to a completely new ecosystem. Reflect on other opportunistic relationships that you could find in natural systems.	Seek to increase the utility of existing resources through sharing.	How can you do more with what is available and already there? Or how can you enable others to utilise and repurpose what you put out in the system? Think of: • Seeking opportunities to use existing resources as input for your business model. • Ensuring interoperability and transparency of what you put out in the system. • Designing your outputs in a way that allows others to use and reuse them in different ways.
Purposeful relationships		Enhance the interoperability of products, components and materials.	
		Enhance the interoperability of products, components and materials.	
Reciprocity and interdependency			
Symbiotic relationships	There is a symbiotic association between the roots of a plant and the mycelium structures in the soil – these are two separate entities, but deeply and evolutionary entangled. In this relationship, trees provide the fungi with carbohydrates (sugars) produced through photosynthesis. In return, the fungi enhance the trees' ability to absorb water and nutrients. Reflect on the interdependence that exists in natural ecosystems.	Identify ways to create symbiotic collaborations with external entities in the value chain.	How can you create mutual benefits and reciprocal relationships within your ecosystem of economic activity? Think of: • Creating benefits and value outside of the transactional nature of the supplier-customer relationship. • The reciprocal partnerships with entities that the business depends on and how these can be deepened. • Exploring the opportunities for more place-based partnerships which leverage what is already there.
Reciprocity		Allow for activity outside of the transactional nature of the supplier/customer relationship.	
(Inter) dependency		Work on stable, reciprocal and effective partnerships with entities that the business relies upon.	

Column 1	***Column 2***	***Column 3***	***Column 4***
Interview Clusters	***Source domain activation proposal (by the authors)***	***Target domain themes raised by circular economy experts***	***Prompt for transposition onto the target domain (by the authors)***
Cooperation and co-evolution			
Co-creation	Pollinators such as bees, butterflies and birds visit flowers to obtain food by seeking nectar. Flowering plants benefit from this visit by transferring pollen from the male parts of one flower to the female parts of another. This important process contributes to the genetic diversity of the plant species. Therefore, flowering plants and pollinators have co-evolved with adaptions that enhance this cooperation. Reflect on how deeply the survival of both pollinators, as well as flowering plants, relies on this cooperation.	Enhance supply chain resilience by being able to utilise a diversity of inputs.	How can you tune into the needs of the wider business ecosystem around you and adapt to this? Think of: • How you can respectfully acknowledge dependencies and power dynamics that come with cooperation and co-evolution. • Building spaces to openly engage in the evolution of the wider economic ecosystem and its change towards circularity. • Anticipating and evolving to utilise inputs that may be considered by-products or "waste" by other entities.
Cooperation		Anticipate and evolve to receive inputs considered by-products or "waste" by other entities in the business ecosystem.	
		Engage and build deep relationships in the wider supply chain to accommodate new ideas in line with a circular economy and address challenges collectively.	
Competition			
Competition	During dry seasons, plants compete for the limited available water resources. Some deep-rooted entities may be able to access groundwater, whilst other entities with more shallow roots could rely on surface water and puddles. The process of competition could prompt plants to grow different root systems – with specialised relationships between plants and fungi to ensure reliable access to essential nutrients. Reflect on how competition is everywhere in a forest where there are limited resources.	Avoid using similar scarce inputs that other desirable business activity relies upon (for example: ensure that the production of biomaterials is not food competitive).	How can you ensure that competition is used for good? Think of: • Seeking to compete with unsustainable products and services and aim to replace these with solutions in line with a circular economy. • Supporting emerging entities to compete fairly with established entities – such as renewable energy resources replacing heavily subsidised fossil fuel-based energy. • Avoid using similar scarce inputs that other businesses rely upon (for example: ensure the production of biomaterials is not food competitive).
Dominance		Seek to compete with unsustainable products and services.	
		Support emerging entities to compete fairly with established entities.	

Table 5.5. *Continued*

Column 1	***Column 2***	***Column 3***	***Column 4***
Interview Clusters	***Source domain activation proposal (by the authors)***	***Target domain themes raised by circular economy experts***	***Prompt for transposition onto the target domain (by the authors)***
Community and information sharing			
Community Communication	When trees are under attack, for example by an insect or parasite population, they can send distress signals to their neighbouring trees to warn them about this threat. These trees can then start to produce enzymes to protect themselves against this threat, which could result in enhanced stability of the forest ecosystem – including the likelihood of survival for the signalling tree. Reflect on this "invisible" sense of community, the wealth of information shared between trees and how, at first sight, trees seem to operate as individual entities.	Enable community spaces and repair cafes to allow citizens to repair their own projects as well as learn new skills or share their skills with their community members.	How can you invite and empower external stakeholders into your ecosystem of economic activity? Think of: • Enable community spaces and repair cafes to allow citizens to repair their own projects as well as learn new skills or share their skills with community members. • Ensure that materials, components and products stay local whilst information is shared widely and in an accessible way. • Open up information that is considered intellectual property to serve the good of society.
Sharing		Ensure that materials stay local whilst information is shared widely and in an accessible way.	
Relationships in the forest floor		Open up and redesign intellectual property to allow for collaboration for the good of society.	
Invasion and conflict			
Conflict Fall out Parasitical relationships Hostile environments	Invasive species are non-native organisms that are introduced to a new environment and could cause harm to this ecosystem. Often, they grow rapidly due to the lack of natural predators, and this can displace or reduce native plants and animals. Some invasive species can alter nutrient cycling processes. For example, invasive nitrogen-fixing plants like the black locust can increase nitrogen levels which further disrupt some native plant communities. Reflect on how quickly an invasive species can lead to a cascading effect in the wider ecosystem.	Use performance or access business models to sell or lease high-quality products in an accessible way. Allow thriving second-hand markets to disrupt first-hand markets. Encourage a more long-term view from investors to allow businesses to focus on ambitious ideas instead of generating immediate income.	How can you disrupt unsustainable systems through your business activities? Think of: • Positioning the business against an unsustainable industry and seeking direct alternatives for popular and unsustainable products. • Exploring how you can use different business models such as selling performance or access allowing you to offer high-quality or more sustainable products in an accessible way. • How you could allow thriving second-hand markets to disrupt first-hand markets and enable higher utilisation of already-existing assets.

In *the importance of relationship*, almost all source domain led to an equal number of ideas among participants, except for “invasion and conflict” which was the most challenging source domain.

Table 5.6. presents the insights of the clusters that relate to “response to change”. In current circular economy discourse, there is a focus on incremental, step-by-step change through the journey metaphor, for example through roadmaps [3]. The forest metaphor seems to emphasise a wide diversity of how change can happen. Incremental change is still conceptualised through evolutionary processes but so is more spontaneous and sudden change through metamorphosis.

Table 5.6. Response to change

Column 1	***Column 2***	***Column 3***	***Column 4***
Interview Clusters	***Source domain activation proposal (by the authors)***	***Target domain themes raised by circular economy experts***	***Prompt for transposition onto the target domain(by the authors)***
Evolving through feedback			
Managing with a light touch	Certain stressful events for trees can create a change in the DNA of the tree. Experiences such as droughts, diseases, and extreme temperatures have the potential to affect certain genes and therefore allow the tree to adapt to its unique circumstances and challenges. These changes in DNA are called epigenetic changes. This form of feedback allows the tree to learn lessons from the past and shape itself to fit better in the wider system. Reflect on other examples of feedback within a forest ecosystem that shapes and changes the development of certain entities or relationships.	Seek to understand the wider context in which the business operates, such as the community or the wider supply network.	How can you make your business, product, idea or supply chain more context-specific? Think of: • How do contexts such as the local community or the wider supply chain affect how the business operates? • What kind of feedback is available, and how this could allow the business to evolve? What kind of information is currently guiding the business? • Tuning into place-specific challenges that require businesses to respond in creative ways.
Feedback loops		Reflect on what kind of feedback is available and how this could allow the business to evolve.	
Evolving		Tune into unforeseen challenges and disruptions that require businesses to respond in creative ways.	
Metamorphosis			
Sudden change	Tadpoles undergo a process of metamorphosis to transform into adult frogs. Through the different stages of the metamorphosis, the tadpole undergoes profound changes orchestrated by hormonal signals. This transformation enables the entity to thrive in different ecological circumstances throughout its life. Reflect on the profoundness of the changes that suddenly happen, from a metabolic shift (from herbivorous to carnivorous) as well as the development of hind legs and lungs to function successfully above water.	Allow the business model and wider industry collaborations to be in service of changing the economy.	How can the business contribute to abrupt and sudden changes in the economy? Think of: • How can business models and wider industry collaboration be in service of a changing economy? • Take part in a wider movement of activity to contribute towards a “tipping point”. • Engage with governments to set the right conditions to make a circular economy the new status quo.
		Take part in a wider movement of activity to contribute towards reaching a “tipping point”.	
Metamorphosis		Engage with governments to set the right conditions to make a circular economy the new status quo.	

Column 1	***Column 2***	***Column 3***	***Column 4***
Interview Clusters	***Source domain activation proposal (by the authors)***	***Target domain themes raised by circular economy experts***	***Prompt for transposition onto the target domain(by the authors)***
Microclimate and homeostasis			
Canopy	A microclimate is a localised climate that differs from the surrounding regional climate. This can be due to the influence of factors such as vegetation and bodies of water. Microclimates play a crucial role in helping a forest to self-regulate and maintain homeostasis. The canopy cover is a natural insulator, moderating temperatures by providing shape. This allows a forest to be cooler in the summer and warmer in the winter in comparison to areas that do not have this cover. Reflect on how you experience the microclimate of a forest when you enter and leave the forest during a hot day.	Seek inviting contexts where experimentation and learning can happen.	What would you consider a progressive "microclimate" for your business to exist in? Think of: • What kind of contexts would be safe for experimentation and learning to happen? • How can policymakers, (local) government, and municipalities support the environment where new varieties of value can emerge? • What type of community-maintained infrastructure (the Commons) would support these creative endeavours?
Homeostasis		Engage with policymakers and government on how they can allow new varieties of value creation to emerge.	
Microclimate		Encourage the development of community-maintained infrastructure that can support a wide set of creative endeavours.	
Adaptation and seasonal changes			
Cyclical/cycles Seasons Growing Evolving	In the Northern Hemisphere, when fall approaches, deciduous trees begin the process of leaf abscission, where the leaves change colour, die and eventually fall off. This process is triggered by environmental cues such as decreasing daylight hours and cooler temperatures. This allows the tree to conserve water and energy over the winter and avoids the risk of damage that could affect the overall health of the tree. Similar environmental cues signal to the tree when it is time to promote leaf growth in the spring. Reflect on the effect of climate change on these seasonal changes which may prompt trees to drop leaves too late or grow them again too early.	Consolidate or scale up business activities depending on the changes in legislation or supply and demand.	How flexible and resilient is your business model when facing changing circumstances? Think of: • Policy changes or requirements. • Changes in supply such as supply disruptions or price volatility. • Changes in demand such as trends, changing customer behaviours or purchasing power.

Table 5.6. *Continued*

Column 1	***Column 2***	***Column 3***	***Column 4***
Interview Clusters	***Source domain activation proposal (by the authors)***	***Target domain themes raised by circular economy experts***	***Prompt for transposition onto the target domain(by the authors)***
Reactive change to disruption			
Recovery	When a wildfire occurs, this can destroy trees, understory and other vegetation. Immediately after the event, the ecosystem appears barren and charred. However, shortly after the fire, pioneer species – which are often well adapted to disturbed environments, begin their colonisation. These could be grasses or certain types of shrubs. Some trees like certain pine species, have seeds that require the heat of a fire to germinate. Over time, the initial colonisers are replaced by other species that allow more complex structures to emerge within the ecosystem. Reflect on different stages of recovery and the reaction to disruption	Minimise "monocultures" of businesses.	What role could your business play in the recovery after a major disruption? Think of: • How can you use your core competencies as a business to support the response to disruption such as disasters and population displacement? • How are you contributing to a diversity of business activities in the wider economy to ensure resilience – and avoid fragility? • Building in multi-purpose uses for your products, components and materials.
Reactive		Support and value "dormant" or niche business ideas that have possibilities to scale up or out when necessary.	
Decay			

In *response to* change, the source domain "evolving through feedback" led to most ideas among participants. The least ideas were generated for the source domain "reactive change to disruption".

5.5. LIMITATIONS

This study acknowledges several limitations that should be considered when interpreting the findings. As indicated in the background section, people's perceptions of nature, and the forest in particular, can vary [6]. To mitigate this to a certain extent, the activation exercise and the interview questions were intentionally designed to prompt insights from an ecological worldview perspective as outlined by Du Plessis & Brandon [17].

Among the participants, the accessibility of natural environments varied. Some had limited access to forests and instead visited managed parks or gardens that contained parts of woodland. This may have influenced the depth and diversity of the ecological insights they provided, as these managed environments differ in some respects from wild(er) ecosystems in structure, biodiversity and natural processes.

The study sample was geographically and culturally limited. The majority of the participants were based in the Global North, primarily in Europe and the United Kingdom. Expanding participation to include individuals from diverse cultural and ecological backgrounds – particularly Indigenous communities – could offer richer perspectives.

More circular economy experts, from diverse industries, cultures and geographies could have further detailed the insights of Column 3 and 4 of Table 5.4.-6. While the experts provided valuable insights, a broader range of professionals across industries, disciplines, and regions could help refine the applicability of the forest metaphor to different business contexts.

Finally, as Ken Webster and Alex Duff [23] remind us, the circular economy already has *"too many lists and not enough stories",* quoted originally from Bill Law [24] (p.25). The result of this research, and especially the insights from Table 5.4.-6., Column 3, have the potential to end up as a list and be used in a reductive manner. To mitigate this, within these Tables, Columns 2 and 4 are designed as a basis for interaction instead.

5.6. DISCUSSION

The results show that the forest metaphor can be considered a rich source domain from which insights can be derived and projected onto circular economy discourse. Most intuitive areas were within the area of *dealing with wholeness,* and the least were in *response to change*. Especially the source domain related to *open nutrient networks* prompted a wealth of ideas from the circular economy experts.

Many areas of insight provided more nuance compared to current circular economy discourse as described by Fromberg et al [3]. For example, relationships in current circular economy discourse are often conceptualised through competitive metaphors. The forest metaphor does showcase competitive behaviour, but in interplay with collaborative and cooperative relationships. The same was visible for the cluster "response to change", where in addition to step-by-step incremental change, many other forms of change were conceptualised (spontaneous, cyclical, disruptive, etc).

A noticeable area of contrast is how material flows are conceptualised through the forest metaphor in comparison to the currently used machine metaphor. Through the metaphor of a machine, material flows are conceptualised as if they were operating in a closed pipework. Through the forest metaphor, this is seen as a much more open system with many social elements playing a more important role compared to the machine metaphor.

Due to these conceptual differences, engaging with the forest metaphor has the potential to lead to different outcomes and support the discontinuation of some of the habits of thought that originate from a linear, or unsustainable economy. Through the generative nature of the subdomains that have been found in this research, the insights from the forest metaphor have the potential for participants to arrive at new ideas, or value existing ideas differently.

This research concluded in 18 source domain activations that have the potential to allow the conceptual metaphor CIRCULAR ECONOMY AS A FOREST to be activated in a generative way. However, this is not an exhaustive list, and further research would have the potential to expand this list. These 18 source domains encompass intuitive knowledge that was present within most of the interviewees and has the potential to allow learners to tap into a rich domain of already-existing knowledge.

Like every metaphor, there are limitations and areas unexplained that need to be considered [1]. As outlined in his book *Economics and Evolution*, Hodgson [25] highlights

an important limitation of "natural metaphor": when something is considered "natural" it does not lend itself to questioning – it seems inevitable – and therefore could allow a hidden ideological agenda.

Also, as previously mentioned in the introduction, in an ecosystem that is considered "wild" there is no entity with considerable agency, such as a gardener in the garden metaphor. Therefore, these wilder natural metaphors, including the forest metaphor, may suggest that the economy is a self-sustaining system that does not need governing or contribute to a narrative around small government.

There is also an emphasis on public or common infrastructure which can set the right systems conditions for more distributed ideas to emerge. These could be established by communities, the private sector or on a municipality- or governmental level. The stewardship of these infrastructures is not (clearly) conceptualised through the forest metaphor and the authors suggest that a garden metaphor would be more appropriate for this.

Also, engaging with the forest as outlined, however, does not guarantee sustainability. As one of the circular economy experts reflected upon: many of the insights from Column 3 are highly applicable to the decentralised and resilient nature of the organisation of the mafia. The insights from this research continue to require human interpretation and do not outline a moral direction for business necessarily.

5.7. CONCLUSION

The main research question that this research seeks to address is: *What new lines of enquiry can be explored for a circular economy through the forest metaphor?* By applying the lens of the forest metaphor, this study highlights how circular economy discourse can be enriched through a more holistic, interconnected and non-linear perspective.

Within the wider topic of *dealing with wholeness*, the source domains identified were: "diversity and redundancy", "open nutrient networks", "ecological niche", "experimentation and the right systems conditions for life", "communities in enmeshed layers", "emergence and gap dynamics", "self-organisation". Within the wider topic of *the importance of relationship*, the source domains identified were: "opportunism and enhancing utilisation", "reciprocity and interdependency", "cooperation and co-evolution", "competition", "community and information sharing", "invasion and conflict". Within the wider topic of *response to change*, the source domains identified

were: “evolving through feedback”, “metamorphosis”, “microclimate and homeostasis”, “adaptation and seasonal changes”, “reactive change to disruption”.

The findings suggest that the forest metaphor could serve as a generative tool for business professionals, designers, and educators to explore novel or overlooked ideas and solutions. Some of the source domains led to more ideas and inspiration for a circular economy than others, for example, “open nutrient networks” was considered intuitive and “reactive change to disruption” was the most challenging source domain in its application. In certain instances, similar ideas could originate from different source domains such as “enhance the interoperability of products, components and materials” that came out of “open nutrient networks” as well as “opportunism and enhancing utilisation”.

However, the proposed source domains do not form an exhaustive list and are presented to illustrate different areas of intuitive knowledge that, for example, educators can tap into. This could lead to insights that may have not been raised through the currently more dominant metaphors such as the machine metaphor, competitive metaphors and the journey metaphor. The purpose of these insights is to increase pluralism in educational settings where a circular economy is being addressed and allow for a reflection on the current, mainstream discourse.

Future research should focus on testing the practical application of these insights in business and educational settings as well as expand the list of insights that can be derived from nature. In this process, the inclusion of diverse perspectives and understandings of nature should play a central role – especially of those with a radically different relationships to nature compared to Industrial cultures.

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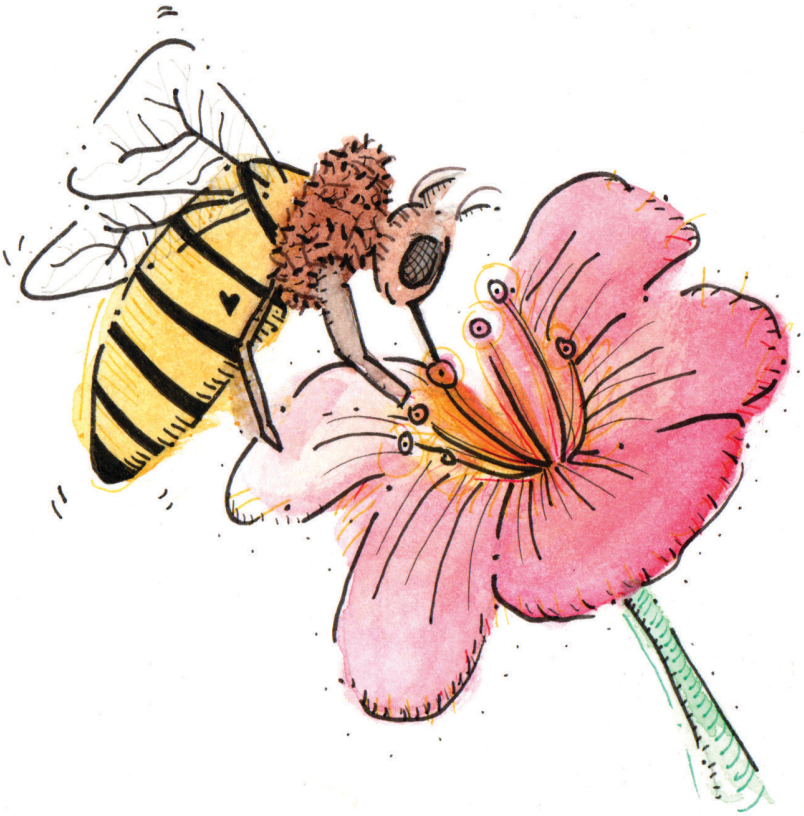
PART 4

Validation



The validation and evaluation
of the impact of the learning tool.

Chapter 6

Ecological design thinking for a circular economy – the impact of the forest metaphor for circular business

This chapter is accepted for publication as:
Fromberg, E. H. E., Bakker, C. A., & Peck, D. (2025). Ecological design thinking for a circular economy – the impact of the forest metaphor for circular business. *Circular Economy*

SUMMARY

This paper presents an evaluation of the educational tool *Ecological Design Thinking for a Circular Economy*, which uses the metaphor of a forest to support new ways of thinking about circular business models. The study responds to concerns that circular economy (CE) discourse continues to be shaped by mechanistic and linear metaphors, which may limit how change is understood and implemented in practice.

The forest metaphor emphasises interconnection, non-linearity, and ongoing transformation. The tool was designed as an origami-style pamphlet with structured prompts to guide participants in relating forest dynamics to circular economy principles. An exploratory comparative case study was conducted to assess the tool's impact. One workshop in 2023 engaged participants with the forest metaphor without the tool, while a second workshop in 2025 used the tool to support the same process. In both cases, pre- and post-programme surveys were used to explore conceptual change and perceived value.

The results show that the tool supported participants in generating more concrete insights and applying ecological ideas to circular economy contexts. It also brought attention to the contrast between some ecological principles and the realities of existing businesses and organisations.

This study contributes to circular economy education by showing how metaphor-based tools can support conceptual development. It indicates that working with ecological metaphors can help participants question dominant assumptions and consider alternative models for circular practice.

6.1. INTRODUCTION

The idea of a circular economy (CE) was introduced to minimise waste and pollution, keep products and materials in use for longer and regenerate natural systems (Ellen MacArthur Foundation, 2013). It was intended as a proposal for a radically different economic system (Webster, 2021) and gained substantial traction in both business sustainability discourse as well as academia (Alnajem et al., 2020). Despite ambitions for radical systemic change from a linear to a CE, current CE discourse is mostly shaped by metaphors rooted in linear economic thinking (Fromberg et al., 2023a; Webster, 2021). These dominant metaphors include the machine metaphor, which emphasises efficiency and control; metaphors such as sports and war, emphasising competitive elements between businesses; and the journey metaphor, which frames a CE as a step-by-step transition (Fromberg et al., 2023a).

Metaphors are pervasive because they shape most abstract thought (Lakoff & Johnson, 1982), and therefore, they influence how problems and solutions are thought of. They determine what is prioritised, what remains overlooked and how solutions are conceptualised. The current dominant metaphors seem mechanistic and tend to reinforce direct causation patterns (Lakoff, 2010), suggesting that one event or action produces another without intermediary factors. If a CE continues to be informed by the same metaphors that influence a linear economy, it risks perpetuating the same cognitive patterns instead of prompting transformative change and radically different outcomes (Fromberg et al., 2023b). To address this, one can engage in different ways of thinking that could potentially lead to new lines of enquiry (Lockton et al., 2019).

An alternative metaphor with the potential to lead to different insights for a CE is the forest metaphor (Fromberg et al., 2025). This metaphor can be considered part of a broader category of ecological metaphors for a CE, which is considered an enabler for a more resilient CE (Zisopoulos et al., 2025). Given the complexity and the dynamic properties of ecological systems, this cluster of metaphors holds potential for effectively incorporating systemic causation (Lakoff, 2010), which conceptualises outcomes as emerging from the interactions of multiple factors within systems, thereby aligning with principles of systems thinking. Previous studies suggest that engaging with the forest metaphor for a CE can help highlight the holism of the economic system, the importance of relationships between different entities and conceptualise the diversity of change processes that can happen concurrently (Fromberg et al., 2025). Figure 6.1 shows a comparison of the current dominant CE discourse as per (Fromberg et al., 2023) with the insights that could lead from the forest metaphor for a CE (Fromberg et al., 2025).

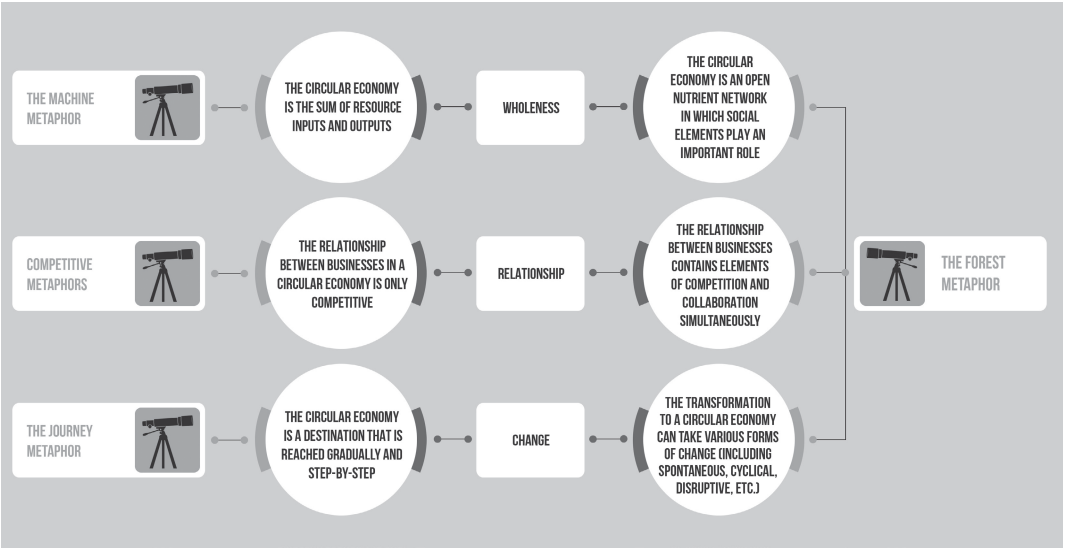


Figure 6.1 Current dominant CE discourse versus the insights of the forest metaphor for a CE

To engage with this different, more systemic, conceptualisation of a CE, the authors developed a pedagogical intervention in the form of a learning tool (Appendix F) that applies Ecological Design Thinking for a Circular Economy in a concrete and tangible way. The tool offers a structured engagement, resulting in ideas and solutions in line with this conceptualisation. It presents 18 subdomains of the forest metaphor, which emerged from prior empirical research (Fromberg et al., 2025) that explored which aspects of a forest ecosystem were perceived as intuitive by business professionals. These intuitively resonant elements were subsequently projected onto CE discourse. It serves as a pragmatic entry point, purposely limited to those subdomains that facilitate engagement with business professionals. The objective of this engagement is for participants to reflect on their current conceptualisations as well as come up with novel ideas for a CE that are radically different from ideas resulting from current dominant metaphors.

This study investigates the research question: To what extent does the tool for ecological design thinking for a circular economy support participants in obtaining new insights and discoveries? To address this research question, an exploratory comparative case study was conducted. One case study explored participant engagement with the forest metaphor for a CE without the tool (as per Chapter 3), and the other case explored this engagement with the tool. This case study evaluates (1) participants' overall workshop experience, (2) the conceptual impact of engaging with the metaphor by using the tool,

(3) whether engaging with the tool led to new insights and discoveries, and (4) the design and the content of the tool.

By exploring how the engagement with ecological metaphors, such as a forest, can influence conceptual thinking, this study contributes to both theoretical discussions on CE discourse as well as practical approaches for CE education and pedagogy.

6.2. BACKGROUND

6.2.1. Conceptual Metaphor Theory

Metaphors are often seen as the decoration of a language, but they are much more than that: they are fundamental to human cognition (Lakoff & Johnson, 1980). Kövecses (2016, p.13) explains that metaphors function as a "conceptual tool for structuring, restructuring, and even creating reality". They not only affect communication but are also deeply integrated into cognitive processes that influence how we think, reason, and form our worldview (Lakoff & Johnson, 1980).

The cognitive basis of metaphor was established by Lakoff and Johnson (1980) in their book *Metaphors We Live By*. In their work on Conceptual Metaphor Theory (CMT), they argue that metaphor is a cognitive phenomenon which influences how humans make sense of abstract ideas by mapping familiar experiences or domains onto more complex or unfamiliar ones. Through a mapping process, CMT shows how people can understand the unfamiliar or more complex domain (the target domain) in terms of another, more familiar one (the source domain) (Lakoff & Johnson, 1980). Conceptual metaphors are typically written in the form TARGET DOMAIN IS/AS SOURCE DOMAIN and are capitalised. Examples of conceptual metaphors are LIFE IS A JOURNEY, ANGER IS FIRE, and THEORIES ARE BUILDINGS (Kövecses, 2016).

One of the main features of conceptual metaphors is their systematicity. For example, in the commonly cited metaphor ARGUMENT IS WAR, elements such as attack, defence and strategy are mapped from war onto the act of having an argument, which shapes how people conceptualise debates (Dancygier, 2016), as shown in Figure 6.2. Even though conceptual metaphors are systematic, they do remain figurative, and only some of the aspects from the source domain are mapped onto the target domain, not all (Gibbs Jr, 2011).

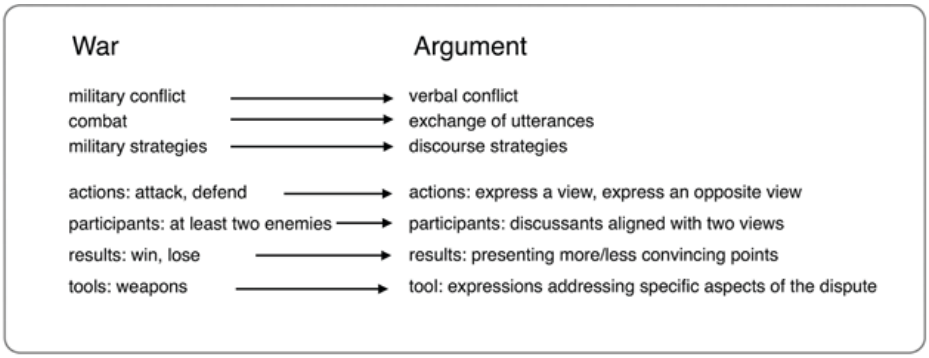


Figure 6.2. The conceptual metaphor ARGUMENT IS WAR (Dancygier, 2016).

Plato claimed metaphors to be dangerous rhetorical devices for deceiving (Gerhard & Russel, 1984), and Lakoff (2014) has also elaborated on this in the context of American politics and how metaphor is used to deceive and manipulate. However, when used thoughtfully and transparently, metaphors have the potential to be helpful in an educational setting because of their cognitive properties, allowing new concepts to be associated with familiar ones. Aristotle recognised metaphors' pedagogical potential, describing them as valuable tools for discovery and understanding (Kirby, 1997). More recently, metaphors have also been proven to help improve the understanding of abstract concepts in science education (Mayer et al., 1995).

However, in a study from Low et al. (2008), it was found that lectures which actively use metaphors to explore abstract phenomena often do not explain the role of the metaphor itself. This can cause issues for participants who are not taking part in their first language (Littlemore et al., 2011). It is, therefore, important for teachers and educators to explain explicitly the role of metaphor and the meaning of the metaphors that are used in the learning setting. Even though it requires additional explanation and sufficient linguistic skills from participants who engage outside of their first language, teaching about conceptual metaphors has been proven to promote critical thinking among both native and non-native speakers (Littlemore & Sheldon, 2004).

Besides using metaphors in a reflexive way or to prompt critical thinking, metaphors can also be used to arrive at new ideas and solutions. When that is the case, they are used in a generative way (Schön, 1993). When used generatively, metaphors can support innovation, enabling individuals to see problems and solutions in new ways and explore new lines of enquiry (Lockton et al., 2019). This study evaluates a pedagogical tool for a CE that uses metaphor in both a reflexive and generative way.

6.2.2. Pedagogical Tools for CE

In recent years, a growing number of educational tools have been developed to support learning about CE, particularly in business and design contexts. The Ellen MacArthur Foundation, a UK-based charity, provides a wide range of online learning resources, including the *Circular Design Guide*, which offers methods and tools aimed at helping professionals integrate CE principles into business practices (Ellen MacArthur Foundation, 2025).

There are also learning tools developed by academics. Santa-Maria et al. (2022) developed the *Circular Design Sprint*, a design thinking tool for CE education and innovation contexts. As part of the EU-funded Circular X project, Konietzko et al. (2020) introduced *The Circularity Deck*, a card-based tool that helps professionals analyse and develop the circularity potential of their business ecosystems.

More playful and interactive tools have also been introduced. *In the Loop,* one of the earliest CE-focused serious games, is a simulation centred around resource flows and supply chain disruption and resilience (Whalen et al., 2018). *Risk & RACE* is a similar tool, which also includes financial trade-offs in circular strategies from a business perspective (Manshove & Gillabel, 2021). The game *NEXTGEN* focuses on CE in the context of the urban water cycle (Khoury et al., 2023).

While many of these tools focus on business model innovation, resource flows and efficiency, or stakeholder dynamics, none explicitly explore how metaphors shape how a CE is conceptualised. This study builds on CMT and explores the implications of these metaphors as part of a pedagogical tool. Specifically, it examines how the forest metaphor can shape new understandings about a CE.

6.3. METHODOLOGY

Through an exploratory comparative case study, this research compared the results of a 2023 case study (Fromberg et al., 2023b) to the results of the workshop in 2025. The methodology used is an exploratory comparative case study and took a qualitative approach to understand the implications of the forest metaphor and tool in depth (Mill et al., 2009).

A textual analysis by Fromberg et al. (2023a) showed that there is a pattern of dominant metaphors in current CE discourse. However, within this broader pattern, Kitchherr et al. (2023) also found 221 distinct definitions for a CE. Therefore, it is expected that within the

patterns of dominant CE metaphors, the concept of a CE can be understood differently by various stakeholders. Therefore, this research adopts an interpretivist epistemology to acknowledge the subjective and culturally embedded nature of knowledge. It views a CE as conceptually plural, shaped elements, such as by conceptual metaphors (McVittie, 2009). An interpretivist epistemology gives space for the researcher to view the world through the lens of the participant and to acknowledge how their perceptions and experiences influence their view (Thanh & Thanh, 2015).

To do so, this study used surveys, which showed the implications of the learning tool and how this changed the participants' perception and their view of a CE (Bartlett & Vavrus, 2017). These surveys were employed for two case studies, each a two-day workshop on systems thinking, organised by the University of Cambridge Institute for Sustainability Leadership. The first case study took place on 27-28 February 2023, and the second on 10-11 March 2025. The workshop design, facilitators and workshop facilities were the same across both case studies. The cohort size was 36 in 2023 and 21 in 2025.

The first morning of the course provided lectures on systems thinking, CE and how metaphors influence patterns of thought. The first afternoon was centred around a 2.5-hour workshop on Ecological Design Thinking for a Circular Economy – this session is the scope of this research. The purpose of the inclusion of this session in these workshops was to support the change from thinking through direct causality towards systemic causality. The second day of the workshop was centred around dimensions that are considered out of scope for this research.

6.3.1. Participant recruitment

Before the workshop, all potential participants received the opportunity to sign up for the study voluntarily and complete their pre-programme survey. They were presented with a consent form before completing the pre-programme survey (see Appendix G). All participants who completed the consent form, the pre-programme survey and the workshop were sent the post-programme survey (Appendix H).

This study also includes the perspective of the facilitator through a post-programme survey after the 2025 workshop. The facilitators delivered both the 2023 and the 2025 workshops, and the authors of this study were excluded from the facilitator survey. This resulted in the inclusion of three facilitators.

6.3.2. Overview of participants

In the first workshop in 2023, there were 36 participants enrolled in the workshop. 19 of them signed up for the study, completed the pre-programme survey, the workshop and the post-programme survey. An overview of the participants is presented in Table 6.1.

Table 6.1. Overview of participants of the 2023 workshop

Number	***Age***	***Sector***	***Self-reported familiarity with CE and CE competencies***
23.1	50s	Business	Competent
23.2	40s	Business	Beginner
23.3	30s	Business	Moderate
23.4	30s	Business	Moderate
23.5	40s	Business	Competent
23.6	40s	Policy making	Beginner
23.7	20s	Business	Moderate
23.8	40s	Business	Moderate
23.9	30s	Policy making	Moderate
23.10	50s	Finance	Moderate
23.11	20s	Education	Moderate
23.12	40s	Business	Competent
23.13	40s	Business	Moderate
23.14	50s	Consultancy	Expert
23.15	20s	Academia and Research	Competent
23.16	40s	Consultancy	Moderate
23.17	30s	Academia and Research	Competent
23.18	50s	Business	Moderate
23.19	50s	Business	Competent

The second workshop, in 2025, had 21 participants enrolled, of whom 16 participants signed up for the study, completed the pre-programme survey, the workshop and the post-programme survey. An overview of these participants can be found in Table 6.2.

Table 6.2. Overview of participants of the 2025 workshop

Number	***Age***	***Sector***	***Self-reported familiarity with CE and CE competencies***
25.1	20s	Business	Moderate
25.2	20s	Coaching	Competent
25.3	40s	Education	Expert
25.4	50s	Academia and Research	Moderate
25.5	40s	Business	Competent
25.6	60s	Education	Moderate
25.7	50s	Business	Moderate
25.8	50s	Academia and Research	Competent
25.9	50s	Business	Moderate
25.10	50s	Business	Moderate
25.11	50s	Business	Competent
25.12	40s	Business	Competent
25.13	40s	Business	Moderate
25.14	40s	Academia and Research	Competent
25.15	40s	Business	Competent
25.16	40s	NGO	Beginner

Even though two different cohorts of participants engaged in the workshop across the two years, most of the participants stated that they were in their 30s, 40s, and 50s and work mostly in business. Also, the level of familiarity and competencies related to CE is similar across the two cohorts.

As part of the 2025 sample, facilitators (Table 6.3.) were asked to complete a post-programme survey and share their insights. The facilitators were involved in both the 2023 workshop and the 2025 workshop.

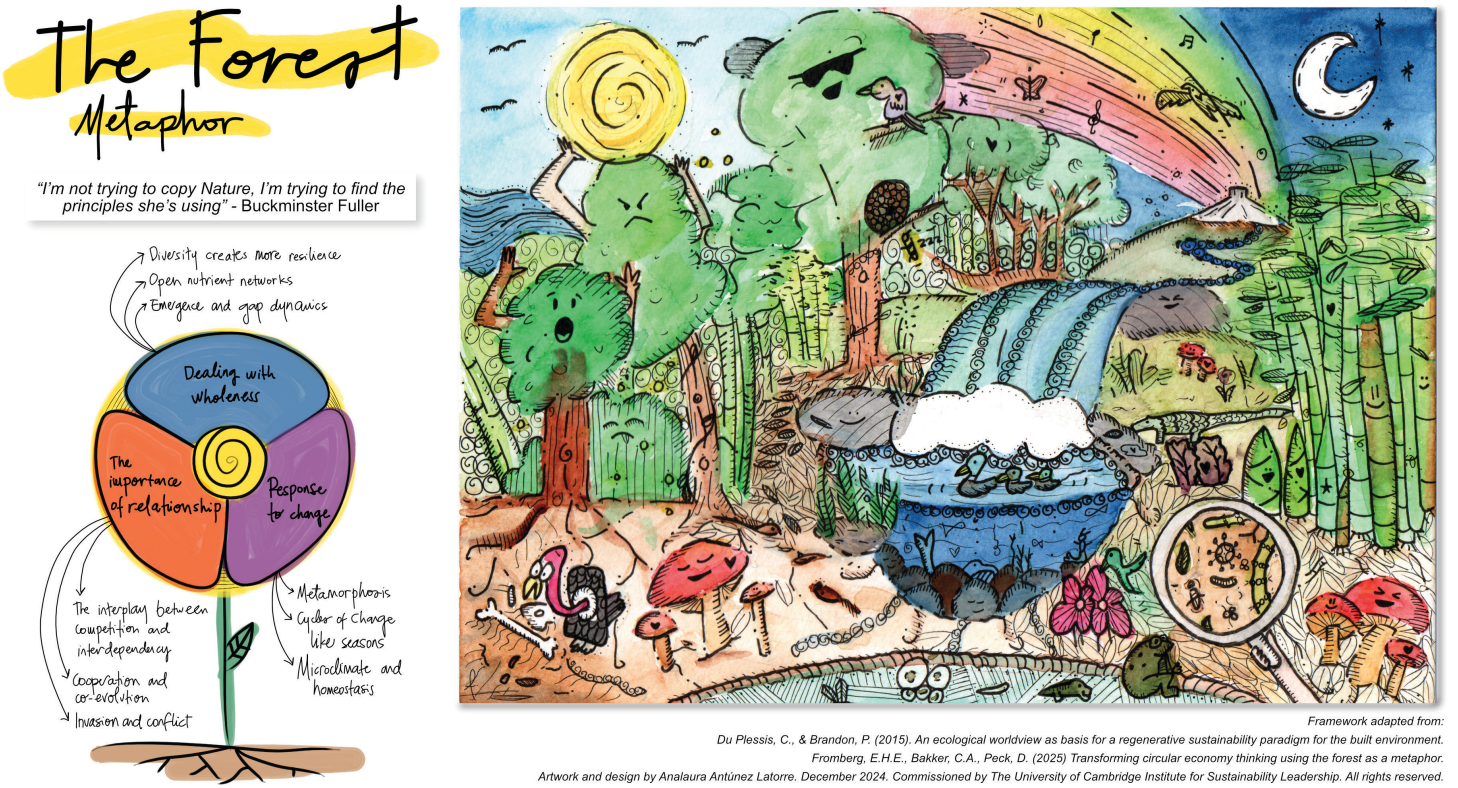
Table 6.3. Overview of the facilitators

Number	***Sector***	***Self-reported familiarity with CE and CE competencies***
F1	Academia	Expert
F2	Education	Expert
F3	Business	Expert

6.3.3. Workshop design

A pre-workshop activity or “homework” before a workshop or lecture has proven to have a positive effect on overall learning (Yumusak, 2020). Therefore, the workshop required the participants to complete a pre-workshop activity called “Wide Angle Vision”, where they were asked to visit a forest, woodland, or other local natural ecosystem and observe its wholeness. At the beginning of the workshop, the participants were invited outside, in a woodland area, again, to make additional observations prior to the engagement with the tool. This allowed the participants and faculty members to activate any latent knowledge that they had about a forest.

After the completion of the Wide Angle Vision exercise, they were invited back to the plenary room, where they were placed in breakout groups, each with a facilitator. Upon arrival, they were asked to complete a worksheet, as per Figure 6.3., and present back to their breakout group how they believe (part of) a forest works. This exercise revealed to the facilitator what potential source domains this group finds particularly intuitive.



Framework adapted from:
Du Plessis, C., & Brandon, P. (2015). An ecological worldview as basis for a regenerative sustainability paradigm for the built environment.
Fromberg, E.H.E., Bakker, C.A., Peck, D. (2025) Transforming circular economy thinking using the forest as a metaphor.
Artwork and design by Analaura Antúnez Latorre. December 2024. Commissioned by The University of Cambridge Institute for Sustainability Leadership. All rights reserved.

Figure 6.3. The worksheet used after Wide Angle Vision by Antúnez Latorre (2025). The participants were instructed to make notes on "how they believe (part of) a forest works."

After the engagement with the worksheet, the participants were directed to the 18 cards that each of them had in front of them. All groups engaged in the same first card: Open Nutrient Networks. This card was used to explain the design of the tool. The complete tool can be found in Appendix F.

The first part of each card is dedicated to a reflection completed individually and in silence, as shown in Figure 6.4. The purpose of this part is to activate the source domain of the metaphor. This part shows a written prompt with information about a forest that was considered intuitive by sustainable business professionals in Fromberg et al. (2025).

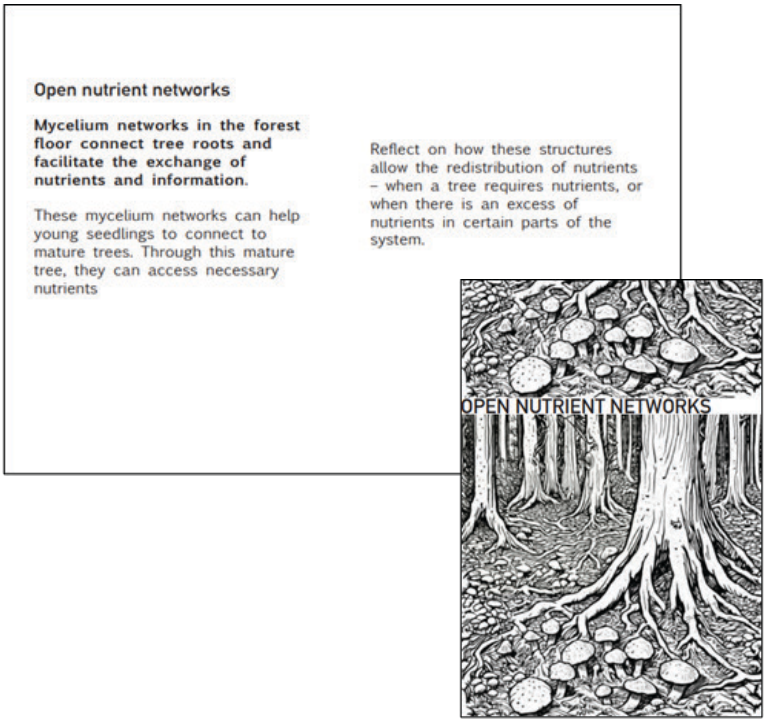


Figure 6.4. Open Nutrient Networks Card, the front of the card and stage one: metaphor activation.

The second stage presents a prompting question that asks the participants how they can relate the insights from the source domain to circular business discourse – the target domain, as shown in Figure 6.5. To allow for more inspiration, suggestions are given, including a real-world example.

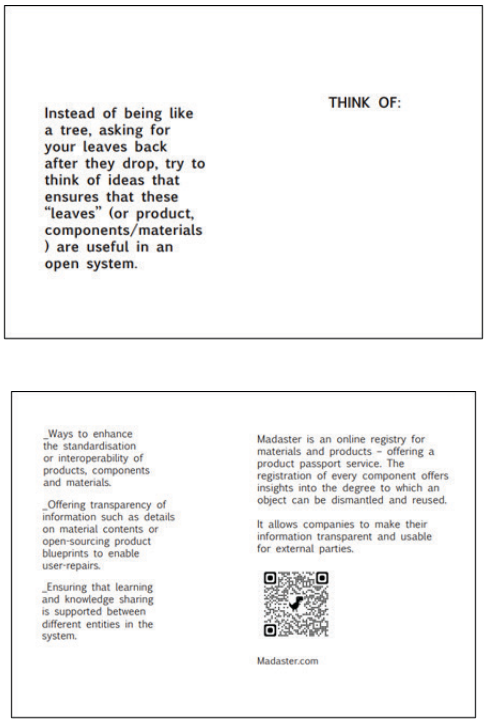


Figure 6.5. Open Nutrient Networks Card, the second stage, where the source domain is related to the target domain.

Finally, at the back of the card, as per Figure 6.6., a broader question is presented that allows for dialogue between the different participants.

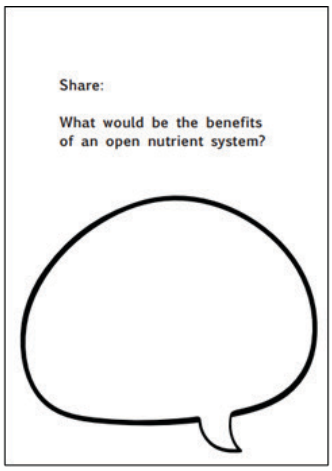


Figure 6.6. Open Nutrient Networks Card, the final stage, including a prompt for a group dialogue.

After the completion of the first card, the facilitator directed the group to the next card. This same process was repeated with the other cards. This process continued for approximately 1 hour and 45 minutes. Finally, the workshop was brought back into the plenary and wrapped up by the main facilitator. This part consisted of a facilitated dialogue about the three components of the forest metaphor: dealing with wholeness, the importance of relationship, and the response to change (Du Plessis & Brandon, 2015; Fromberg et al., 2025)

The total workshop lasted 2.5 hours (including the activation exercise and the wrap-up). After the workshop, participants and facilitators were asked to complete the post-programme survey.

6.3.4. Data collection and analysis

In total, two surveys were conducted as part of the 2023 workshop: a participant pre-workshop and post-workshop survey. As part of the 2025 workshop, three surveys were conducted: a participant pre-workshop and post-workshop survey, as well as a facilitator survey (Appendix I) conducted after the workshop. All surveys included both closed- and open-ended questions.

The surveys were presented through Qualtrics and Google Forms, and participants were given a participant number to collect pseudonymised data from the start. The insights were analysed manually using Microsoft Excel.

Frequencies and percentages were used to analyse the closed responses. For the open-ended questions, a qualitative analysis was conducted to identify recurring patterns. All answers to open questions were coded and clustered around themes. The patterns and quotes provided illustrative insights, offering a descriptive understanding of how participants experienced the tool.

Four dimensions were measured across the surveys: (1) participants' overall workshop experience, (2) the conceptual impact of engaging with the metaphor by using the tool, (3) whether engaging with the tool led to new insights and discoveries, and (4) the design and the content of the tool. A summary of constructs and measures can be found in Table 6.4..

Table 6.4. Summary of constructs and measures

Dimension	***Item Type***	***Example Question***	***Theoretical Foundation***
Workshop experience	Likert scale and open questions	How would you rate the overall learning experience of the workshop: • Very negative • Somewhat negative • Neutral • Somewhat positive • Very positive	Developed by the author.
Conceptual impact	Multiple choice questions with experimental sentences and open questions	How did the workshop affect your understanding of a circular economy? • It deepened my understanding of a circular economy. • It changed my understanding of a circular economy. • It did not affect my understanding of a circular economy. • Other: [ ]	Posner et al. (1982) Piloted experimental sentences by the authors.
Fruitfulness of the new conceptualisation	Likert scale questions, multiple choice questions and open questions	Please rate the statement below: "I will be able to implement some of the insights from the forest metaphor in my profession, business or organisation."	Posner et al. (1982)
Tool design and content	Likert scale questions and open questions	Please evaluate the following statements: Disagree Neutral Agree The visual design of the cards was clear and supportive in the activity. The time given for each activity was sufficient. The cards sparked inspiration and new ideas.	Tahir & Wang (2020)

6.4. RESULTS

The surveys revealed a variety of insights related to the workshop experience, the effects on the understanding of a CE, the conceptual accommodation and the tool design.

6.4.1. Workshop experience

The comparative elements of this case study are visualised in percentages, in which the number of participants included in the 2023 study is 19 and in the 2025 study is 16.

As shown in Figure 6.7., the overall workshop experience in 2025 was more positive compared to the one in 2023.

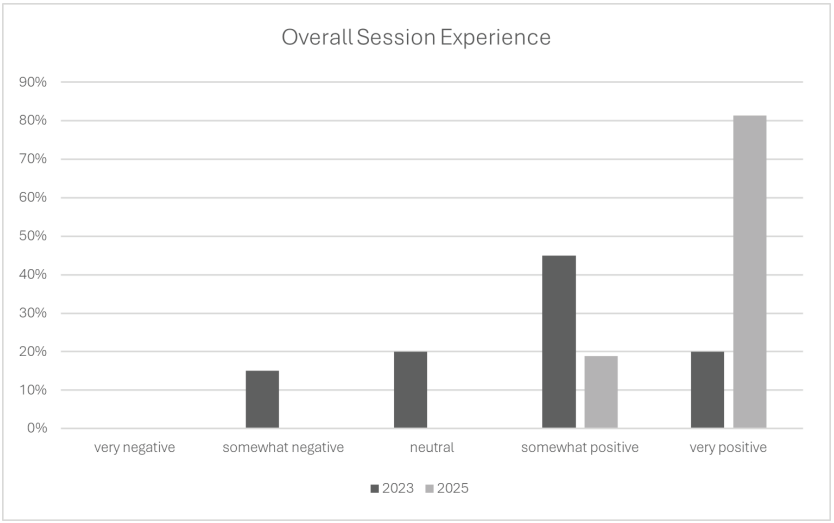


Figure 6.7. The overall session experience.

Most participants rated their experience as either “somewhat positive” or “very positive”, indicating a generally positive reception of the workshop. In an optional open question, participants were asked to elaborate on this. A participant of the 2025 workshop reflected: “I think this was a very powerful learning experience, and the cards are a highly innovative artefact.”

The facilitators rated the overall experience of delivering the workshop as very positive (by 2) and somewhat positive (by 1). They were asked to provide their reflections on the content and the design of the cards through an open question. One facilitator elaborated: “The setup creates a clear connection through metaphor from the forest

to the CE, which allowed for relational thinking to become the foreground and enabler of circular thinking."

6.4.2. Effects on the understanding of a CE

In both pre-programme surveys, the participants were asked to select a so-called experimental sentence to express what kind of conceptualisation resonated most with them. There were multiple sentences proposed, containing competitive metaphors and ecological metaphors. The outcomes are visualised in Figure 6.8. and show a similar composition across both cohorts, each with 3 participants selecting a competitive metaphor and 16 (2023) and 13 (2025) selecting an ecological metaphor.

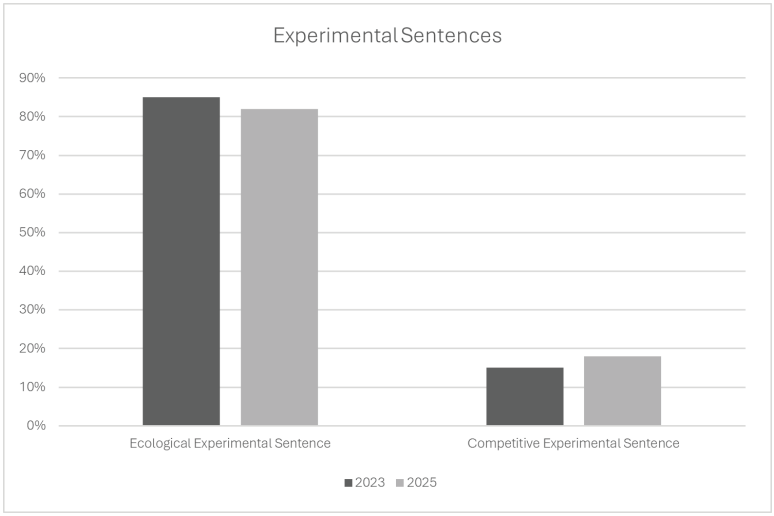


Figure 6.8. A comparison of the selection of experimental sentences across the two workshops

The most often selected experimental sentence was: "By implementing a circular economy, businesses can create a flourishing ecosystem to thrive in." This indicates that most of the participants across both workshops found an ecological conceptualisation of a CE somewhat natural before engaging with the tool.

When asked how the workshop affected their understanding of a CE, the participants replied similarly across both workshops, as shown 5in Figure 6.9.

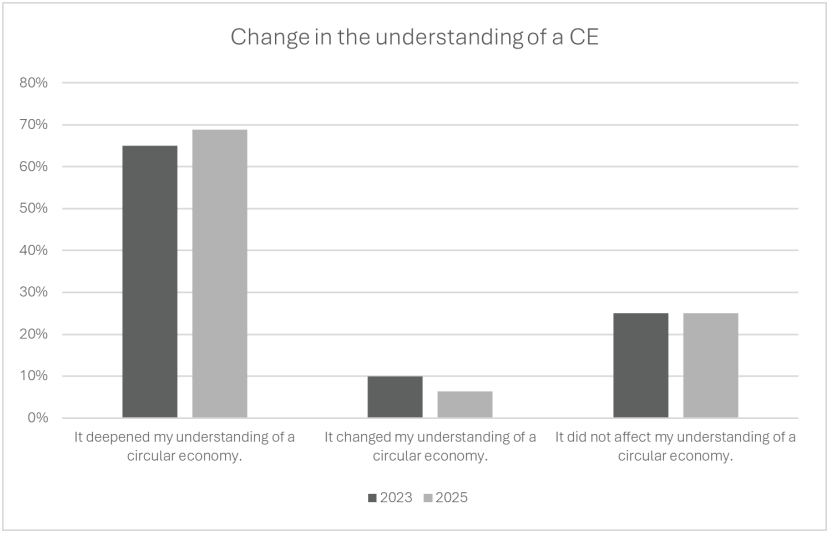


Figure 6.9. Change in the understanding of a CE.

Most of the participants experienced a deepening of their understanding of a CE: 65% (13) of the participants in 2023 selected this, compared to 68.8% (11) of the participants in 2025.

6.4.3. Conceptual accommodation

This study evaluates the success of engagement with the metaphor and the tool specifically through four conditions for conceptual accommodation by Posner et al. (1982), which include:

1. Intelligibility – whether the new concept is understandable.
2. Initial plausibility – whether the new concept seems reasonable.
3. Dissatisfaction with the old concept – whether the participants recognise the limitations in their existing concepts.
4. Fruitfulness – whether the new concept leads to meaningful new insights and discoveries.

It was concluded that the first three conditions were met after the 2023 workshop, however, the fruitfulness condition at that time was insufficiently met (Fromberg et al., 2023b). At that stage, without the tool, participants were only able to generate more

abstract solutions that were perceived as incompatible with the competitive nature of businesses (Fromberg et al., 2023b).

This part of the study assesses whether participants were more able to come up with new insights and discoveries through their use of the tool. This would mean that they would consider the conceptualisation more fruitful.

First, the participants were asked to express whether they felt a tension between the insights from the forest metaphor and the reality of businesses and organisations. The result is shown in Figure 6.10., which compares the results from the 2023 workshop to the 2025 workshop.

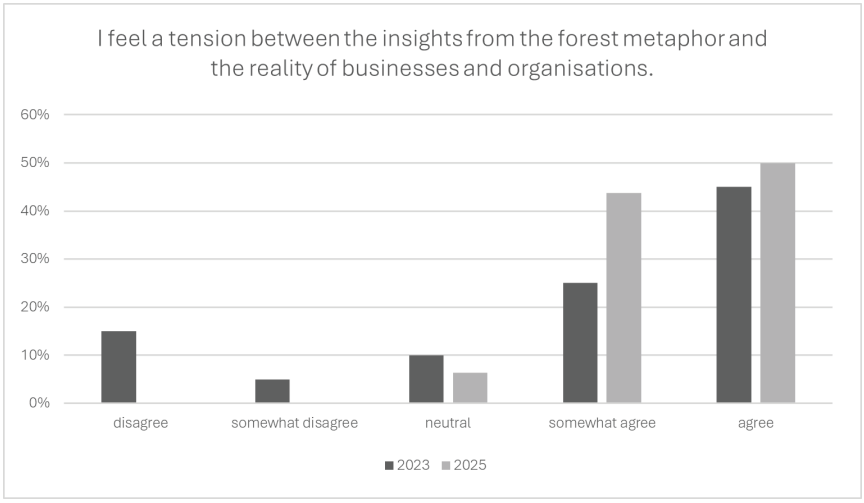


Figure 6.10. The use of the tool caused increased tension between the insights from the forest metaphor and the reality of businesses and organisations

This shows an increase in tension between the insights from the forest metaphor and the reality of businesses and organisations. Together with this increased tension, the participants also found the metaphor more enriching compared to the 2023 workshop, as shown in Figure 6.11.

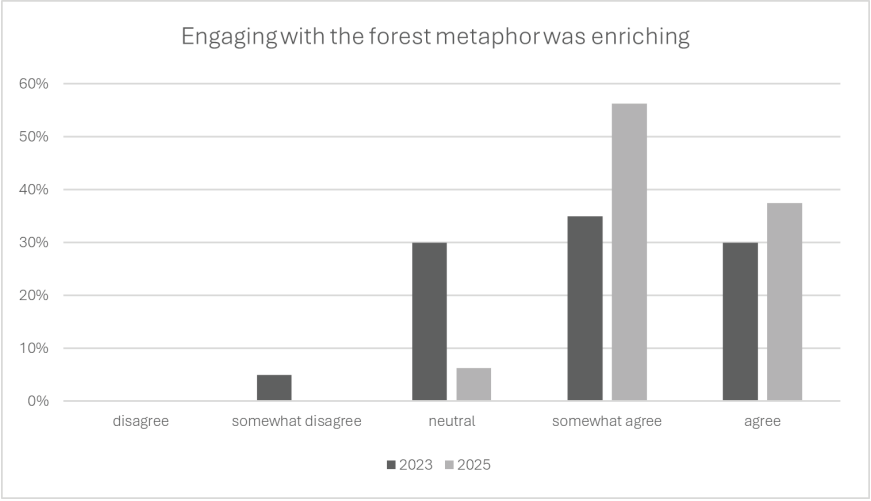


Figure 6.11. The use of the tool made the engagement with the forest metaphor more enriching

During the open questions, participants were asked about the type of ideas that were discussed during the workshop. They were also asked to elaborate on what they consider realistic ideas to implement in a business and what they consider unrealistic to implement. Therefore, the open questions offer anecdotal evidence on the engagement with the metaphor.

The first card that was used by all groups related to open nutrient networks, which prompted reflections related to increasing utilisation of materials, components and products, as well as more flexible ways of evolving or reutilising these. Through this card, intellectual property rights were considered one of the key barriers to more open nutrient networks in a CE.

There was also dialogue about the role of the financial industry, and a need was expressed by one of the groups to create a card that explicitly refers to the extractive nature of financial services industries. Participants suggested that the source domain of a parasite would be appropriate for this. This resonates with the work from Michael Hudson (2015). In his book, *Killing the Host,* he argues that the finance, insurance and real estate sectors have gained control of the "economy's brain" and are now favoured over the real economy of labour and production.

Other reflections were made on the current lack of "decomposers" in the system, referring to smaller-scale, more opportunistic entities that use what is available. These

entities are also described as “gap exploiters” by Bakker et al. (2014). There was also an emphasis on infrastructure and assets that could be considered the commons, such as community-owned material banks.

The facilitators were also asked about what, in their opinion, the most interesting idea was that surfaced during the engagement with the tool:

- Facilitator 1: “[...] revealing additional possibilities through repair networks and skill shares that interwove pro-circular behaviours across communities”
- Facilitator 2: “The idea [...] that we were going to be a components company which allows local people to assemble and repair.”
- Facilitator 3: “The shift to an open-source company.”

Overall, the insights suggest that the participants were able to arrive at more concrete insights and discoveries with the use of the tool.

6.4.4. Tool design

In the 2025 workshop post-programme survey, both the participants and facilitators were asked to rate the design and the content of the cards specifically. For the assessment of the tool design, the data of the participants and the facilitators were merged, resulting in 19 respondents for these questions. The result is presented in Figure 6.12. and shows that overall, the design and the content of the cards were experienced very positively.

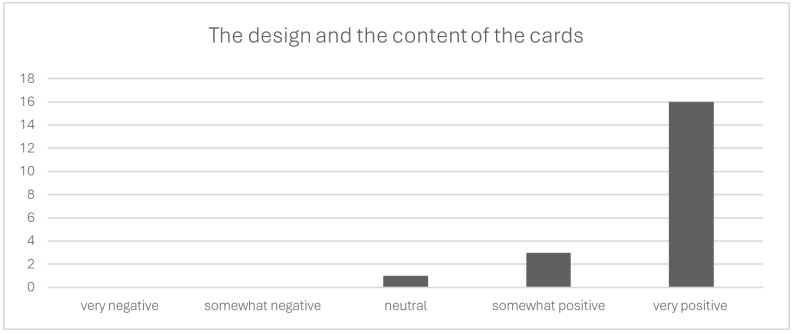


Figure 6.12. The rating of the design and content of the cards by the participants and facilitators.

The effectiveness of the tool has been evaluated according to adapted criteria for learning design by Tahir & Wang (2020) in which (1) Enjoyment, (2) Satisfaction, (3) Understandability, and (4) Usefulness is evaluated. For each criterion, both the

participants and facilitators rated three sentences. The results are presented below in Figure 6.13.

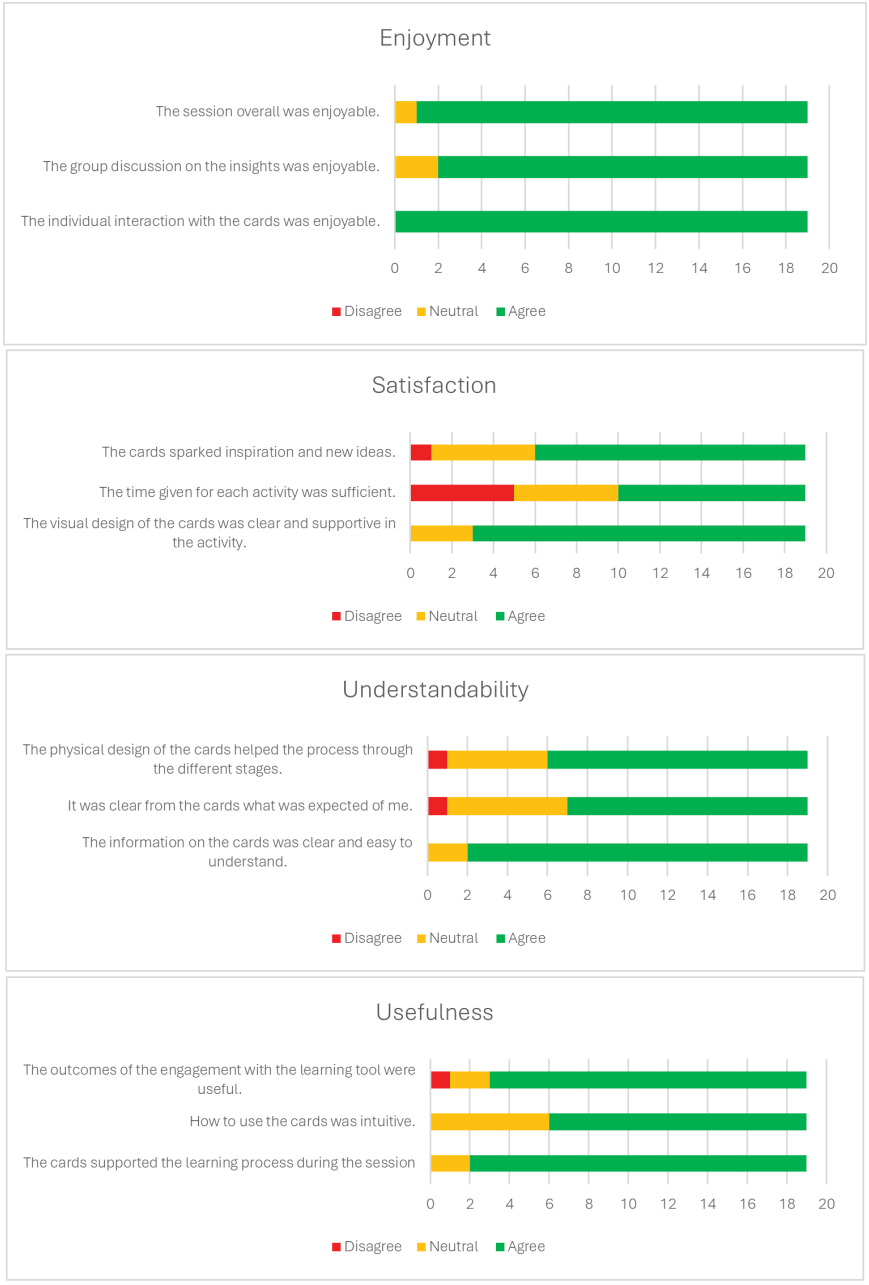


Figure 6.13. The effectiveness of the learning design according to criteria adapted from Tahir & Wang (2020)

Overall, the learning design scored positively across all criteria. The criterion "Enjoyment" scored most positively, whereas "Satisfaction" was rated lowest, mostly due to insufficient time given for the activity.

Although the tool was used and presented in a formal learning setting, the different cards were designed to be printed off a regular printer, therefore reducing costs and making it more viable to allow learners to take them with them after the workshop. A participant of the 2025 workshop reflected on this: "Following the workshop, I had a chance to further review the cards. There is a lot of rich content and I'm looking forward to seeing how we can apply this to specific challenges linked to our business.". Together with the consensus that 2.5 hours was too little time for this activity, this shows the value of a post-workshop individual engagement with the tool.

6.5. DISCUSSION

After the 2023 workshop, it was determined that all conditions for conceptual accommodation were met except for one: the fruitfulness of the conceptualisation of a circular economy as a forest. This refers to whether the new concept leads to meaningful new insights and discoveries (Posner et al., 1982). The tool was designed after the 2023 workshop and aimed to resolve the tension between the forest metaphor's insights and the reality of businesses and organisations. It was expected that, through the tool, breaking up the heuristic of the forest metaphor into more digestible subdomains would reduce the tension by allowing participants to come up with more concrete and tangible ideas, leading towards meeting the final condition for conceptual accommodation (Fromberg et al., 2023b). The workshops were, in general, positively received by both participants and facilitators.

The participants were able to come up with more detailed and concrete ideas when engaging with the tool. The workshop was considered more enriching with the tool, compared to without the tool. However, rather than reducing it, engagement with the tool amplified the tension between the insights of the forest metaphor and the reality of businesses and organisations. While this increased tension could have led to resistance or disengagement, participants received it positively, suggesting that it was seen as thought-provoking. This finding could have important implications for CE teaching and learning. It suggests that this discomfort and tension could play a constructive role in learning and critical thinking rather than being perceived as an obstacle. This tension allowed the participants to reflect on current economic structures and re-evaluate their assumptions critically.

This challenges the notion that learning should be centred around learner comfort. Kavedzija (2019) describes this experience as learning discomfort and states that the role of the facilitator or teacher should be to find the optimal level of challenge. Vygotsky (1978) refers to this same phenomenon as the zone of proximal development. Conceptually, this aligns with the Goldilocks principle, which is commonly invoked across disciplines to describe the optimal conditions that are neither excessive nor insufficient. This type of approach also challenges the idea of seeing a learner as a customer to be satisfied (Kavedzija, 2019). McLay et al. (2023) explain that, especially for 21st-century challenges, teachers need to actively create room for such discomfort in the learning process. Ness & Riese (2015) elaborate that meaning, knowledge, and creativity emerge in the tension of different perspectives. In this case, that would be the contrast between the insights of the forest metaphor and the reality of the current linear economy.

Since, within this tension, the tool enabled the participants to generate clearer insights and more concrete discoveries, it appears to have made the forest metaphor more fruitful compared to engagement with the metaphor without the tool, meeting all four conditions for conceptual accommodation by Posner et al. (1982).

The main source of dissatisfaction with the tool among some participants and facilitators was the limited time available for the engagement. The 2.5-hour session did not allow enough time for satisfactory engagement, and several participants expressed that continuing to engage with the tool after the formal workshop session was beneficial to them. This suggests that incorporating a post-workshop individual reflexive exercise into future sessions could extend the learning process flexibly.

This study considers conceptual change a precursor to a CE that works in a radically different way compared to the current linear economy. From a pedagogical perspective, the goal is not to prescribe action, but to support participants in rethinking the dominant assumption that may influence the solutions that they can come up with. In some cases, it may empower individuals to better advocate for regenerative ideas or recognise where their thinking aligns with ecological metaphors. However, the decision to act on these insights remains with the learner, always.

There are several limitations to consider when interpreting these findings. First, all participants who signed up for the study indicated a prior openness to an ecological conceptualisation of a CE. This suggests they may have been predisposed to engage with the forest metaphor more positively. Additionally, all participants met the main researcher during the workshop and were aware that they had designed the tool, which

may have influenced their responses. However, as this was also the case for both the 2023 and the 2025 workshop, any potential bias would likely be present in both data sets, allowing for a comparable analysis. The language levels of the participants were not considered fully in this research. Also, during the 2025 workshop, the facilitators were more experienced with running an interactive session of this nature, which could have also impacted the more positive rating for this workshop.

This study explores the implications of the engagement with a relatively novel metaphor for CE discourse: an ecological metaphor. To understand its implications, the forest metaphor is employed as a figurative construct, intended as a pedagogical tool. It does not attempt to provide an exhaustive account of forest ecology. Its purpose is to serve as a heuristic that facilitates potentially novel understandings.

However, like any metaphor, the cluster of ecological metaphors can also bring a series of limitations (Lakoff, 2014). The absence of a singular, governing agent within a forest reflects its inherent wilderness. It is a notable limitation when deploying this metaphor onto CE discourse, since the role of the government is not conceptualised. Liu and Hanauer (2011) suggest the garden metaphor to cover this specific subdomain. Hodgson (1993) also identifies a significant limitation of employing "natural metaphors": framing something as "natural" can render it unquestionable or inevitable, which could allow it to hide an ideological agenda.

6.6. CONCLUSION

This research aimed to address the research question: To what extent does the tool for ecological design thinking for a circular economy support participants in obtaining new insights and discoveries? The study conducts an exploratory comparative case study that analyses participant responses from two workshops held in 2023 (without the tool) and 2025 (with the tool).

This research found that the participants' overall engagement with the forest metaphor was more positive with the tool. The engagement in 2023, without the tool, met three out of four conditions for conceptual change: (1) intelligibility, (2) initial plausibility and (3) dissatisfaction with the old concept. However, the fourth condition, "fruitfulness", was insufficiently met and refers to whether the new concept leads to meaningful new insights and discoveries. The engagement with the tool led to more specific and concrete solutions. In addition, the participants reported a more enriching experience compared to the 2023 workshop and an increased tension between the insights from the

forest metaphor and the reality of their businesses and organisations. This suggests that their engagement with the tool contributed to a more fruitful conceptualisation of the forest metaphor for a CE, meaning that it led to meaningful new insights and discoveries.

Beyond the impact on CE education, this study emphasises the potential of ecological metaphors in shaping CE discourse. While ecological metaphors have been used in mainstream CE discourse to understand certain themes of a CE, this study shows that the forest metaphor could challenge certain aspects of the broader mainstream understanding of a CE. It especially prompted critical reflection on the competitive nature of business and intellectual property rights, opening conversations about collaborative and open approaches in business. In a generative way, the metaphor allowed participants to focus on more community-led and place-based approaches to innovation, which allows businesses to tune in more to the context surrounding their supply chain and business model and consider both social and environmental dimensions simultaneously.

There is significant potential to further develop and refine the tool. First, there is a clear need for expanding the tool, considering elements of the forest metaphor that would allow participants to make sense of financial systems. In addition, future research could also draw insights from other ecosystems beyond a forest, such as rivers, meadows and the tundra. Also, this tool has the potential to be used on an individual level as well as in a group setting. Therefore, further development to make this tool more available for individual participants would increase its impact.

Ultimately, this research reinforces that metaphors are not merely the decoration of language but can also be a powerful learning tool. This can be used in a reflexive way, by challenging previously unquestioned assumptions, or in a generative way, by allowing new ways of thinking and developing novel solutions.

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Chapter 7

Discussion and Conclusion

The concept of a circular economy (CE) aims to create radically different outcomes compared to the current linear economy; therefore, approaches and thinking should also be radically different. This thesis explores the implications of an ecology-inspired metaphor.

The main research question is:

How can ecology-inspired metaphors enrich circular economy discourse?

To address this, the thesis consisted of four different parts:

- Part 1 Identification: to identify current dominant conceptual metaphors in CE discourse.
- Part 2 Exploration: to explore the implications of the use of the forest metaphor for a CE.
- Part 3 Synthesis: to create a tool that allows learners to apply the forest metaphor to a CE.
- Part 4 Validation: to validate and evaluate the impact of the learning tool.

The research questions that were addressed in these parts were:

Identification:

1. Through what conceptual metaphors does current academic discourse conceptualise the idea of a circular economy? (Chapter 2)

Exploration:

2. To what extent does the forest metaphor allow students to rethink the relationship between businesses in a circular economy? (Chapter 3)
3. What are the implications of the forest metaphor for a technosphere as a subdomain of a circular economy? (Chapter 4)

Synthesis:

4. What new lines of enquiry can be explored for a circular economy through the forest metaphor? (Chapter 5)

Validation:

5. To what extent does the tool for ecological design thinking for a circular economy support participants in obtaining new insights and discoveries? (Chapter 6)

The answers to the research questions contribute to a potentially alternative way of making sense of a CE compared to what is currently considered mainstream. In this chapter, I will summarise the findings of the different studies that form part of this

thesis. Then, I elaborate on what this means for CE discourse and what the pedagogical implications are. This is followed by a reflection on the contributions to science, practice and society as well as the limitations of the thesis and the implications for future research.

7.1. SUMMARY OF FINDINGS

The first part of this study aimed to identify current dominant conceptual metaphors in CE discourse. It found the machine metaphor as the most pervasive metaphor in academic CE discourse, which mostly emphasises material flows and resource inputs and outputs. The second most pervasive metaphor was the cluster of competitive metaphors, such as sports and war. This metaphor was mostly used to conceptualise the relationships between businesses in the economy as competitive. Finally, change towards a CE was conceptualised through the journey metaphor, making sense of change as a step-by-step process.

These three most often used conceptual metaphors are the same as in current conventional economic discourse, potentially perpetuating similar understandings and outcomes. For example, the machine metaphor in conventional economic thinking is critiqued for not taking into account social dimensions or seeing those merely as an externality (Mutari, 2018). Current CE discourse has received similar critique (Corvellec et al., 2021). A common thread between these conceptual metaphors in CE discourse is that they neglect complexity and dynamic, nonlinear behaviour and activities. A metaphor that did grasp some of these elements was the cluster of ecological metaphors, mostly observed in a single paper that was part of the textual analysis. This cluster of metaphors was the fourth most used one, and because it did display elements of complexity and nonlinearity, it demonstrated the potential for this metaphor to address the limitations of the earlier-mentioned metaphors.

The second part of the study explored the implications of the use of such an ecological metaphor for a CE: the forest metaphor. First, a case study was conducted where business professionals engaged with this metaphor to get an understanding of where this metaphor would be most useful. Then, a specific subdomain of this metaphor was explored in an in-depth and structured way.

The case study showed that the engagement with the forest metaphor in the context of circular business was considered enriching by the business professionals. However, they also expressed a tension between the insights of the forest metaphor and the reality

of their business or organisation. When asked about areas where they would be able to implement insights from the forest metaphor, many were unable to identify concrete areas. To understand its specific implications for business in a CE, the second part of the exploration consisted of a more structured enquiry of a subdomain of this metaphor: the technosphere of a CE as fruit from a tree. Unlike the machine metaphor, which conceptualises this domain as a closed pipework of controlled inputs and outputs, this metaphor would consider it as an open flow of not just products, components and materials, but also of information. Therefore, this study showed a profoundly different line of enquiry for this subdomain in a CE, focused on setting the right conditions for these products, materials and components. By seeing this domain as an open nutrient network, it challenged topics like intellectual property rights, which prevent external entities from using these "nutrients" freely.

To get to this similar level of depth across other areas of the metaphor CIRCULAR ECONOMY AS A FOREST, the third part of the study set out the foundations for a learning tool. This was specifically aimed at business professionals, and the intention was that it would allow for a more structured engagement with the forest metaphor. It concluded in 18 forest subdomains that were considered intuitive by business professionals and projected these onto areas within CE discourse.

Many of these subdomains provided more nuance compared to the current dominant CE metaphors. For example, through its current competitive metaphors, relationships between businesses are often conceptualised as merely competitive. However, through the forest metaphor, there is more of an interplay between elements of competition and collaboration. The same was visible for how change is conceptualised. For example, in addition to more step-by-step or evolutionary, gradual change, there were also many other forms of change, such as seasonal as well as more sudden change, such as in metamorphosis. A noticeable area of contrast was how material flows are conceptualised through the forest metaphor in comparison to the currently used machine metaphor. Through the metaphor of a machine, material flows are conceptualised as if they were operating in a closed pipe work. Through the forest metaphor, this is seen as a much more open system with many social elements playing a more important and integrated role. The 18 domains that were presented in this study were turned into a learning tool called "Ecological Design Thinking for a Circular Economy".

The fourth and final part of this study evaluated this learning tool and compared it to the case study of part two. The study found that the participants' overall engagement with the forest metaphor was more positive with the tool. The engagement with the tool led to more specific and concrete solutions. While ecological metaphors have

been used in mainstream CE discourse to understand certain themes of a CE, this study shows that the forest metaphor could challenge certain aspects of the broader mainstream understanding of a CE. It especially prompted critical reflection on the competitive nature of business and IPR, opening conversations about collaborative and open approaches in business. In a generative way, the metaphor allowed participants to focus on more community-led and place-based approaches to innovation, which allows businesses to tune in more to the context surrounding their supply chain and business model and consider both social and environmental dimensions simultaneously.

7.2. IMPLICATIONS FOR CIRCULAR ECONOMY DISCOURSE

The main research question of this thesis asks how ecology-inspired metaphors, such as a forest, can enrich circular economy discourse. This study organised the insights of the forest metaphor for CE around three areas: (1) dealing with wholeness, (2) the importance of relationship, and (3) response to change (Du Plessis & Brandon, 2015).

Through the area "dealing with wholeness", the forest metaphor makes sense of a CE in a different way than the current mechanistic discourse, influenced by the machine metaphor. The machine metaphor focuses on measurable flows (materials, emissions, etc), mostly in a quantitative way and disconnected from society. In contrast, the forest metaphor focuses more on place, which allows for themes around environmental sustainability (including material flows) and social sustainability to be integrated and seen as one, within the context of its place. Whereas the machine metaphor aims for efficiency through standardised, homogenous inputs, the forest metaphor emphasises the importance of diversity and redundancy for the resilience of the wider ecosystem. This could be the diversity of scale of businesses to different material inputs, as well as what types of economic activities that take place. Also, through the machine metaphor, the economy is seen as something to be controlled through "pulling levers" and "pressing buttons", which is in contrast with the participatory and experimental nature of the forest metaphor.

Through the area "the importance of relationships", the forest metaphor makes sense of relationships between businesses in an economy in a different way than the current competitive metaphors do. Through war and sports metaphors, current CE discourse mostly emphasises competitive elements of the relationship between businesses. This does not mean that collaboration and cooperation are not addressed in CE discourse; it merely means that the metaphors that are used to make sense of the relationship between businesses do not emphasise these features. The forest metaphor offers a perspective that

is in line with an ecosystemic way of being, where businesses view themselves as part of a wider network of economic activity in a participatory way. It does not mean that there is no competition in such networks, but this competition is in interplay with collaboration and cooperation due to the interdependent nature of the relationships.

Through the area "response to change", the forest metaphor makes sense of change towards a CE in a way where many different types of change can happen consecutively and in parallel. It is a nonlinear view of seeing this change versus the more managed step-by-step approach, through the journey metaphor, which is the currently dominant metaphor. The forest metaphor especially challenges the focus on CE roadmaps, which many (regional) governments and businesses have tuned into. Many uses of the journey metaphor suggest a clear destination, with logical steps that lead towards this. The forest metaphor is not deterministic since many different types of change create an unpredictable landscape. Therefore, listening to feedback plays an important role and leads to a more experimental approach for businesses.

The forest metaphor offers a different line of enquiry compared to the currently used CE metaphors. For many participants who engaged with this metaphor, this led to novel ideas for them. Mentions in this thesis of "novel ideas", "new ways of thinking", and "discoveries" denote shifts in sense-making, rather than claims of new-to-the-world solutions.

However, with every metaphor, there are domains that are emphasised and elaborated on as well as areas that are less explained or overlooked. The forest metaphor for a CE is no exception. In *Economics and Evolution*, Hodgson (1993) points out a key limitation of the "natural metaphor": labelling something as "natural" can make it appear unquestionable and inevitable, which in turn may conceal an underlying ideological agenda.

In an ecosystem, such as a forest, that is assumed to have elements of wilderness, there is no entity with substantial agency, such as a gardener in the garden metaphor. These wilder natural metaphors may suggest that the economy is a self-sustaining system that does not need a governing entity, which contributes to the societal narrative around small government. However, at the same time, there is a reliance on public and common infrastructure required to set the right systems conditions for more distributed and local initiatives to emerge. Even though these could be established and maintained by communities and private entities, this could also be prompted by governments. The stewardship for these assets and infrastructures is not clearly conceptualised through the forest metaphor, and this would be an area where, for example, the garden metaphor could play a role.

Finally, the adoption of a forest metaphor does not inherently ensure sustainability or circularity. Instead, it should be regarded as an exploratory tool that could generate novel insights and solutions. These insights will have the potential to be profoundly unsustainable. The forest metaphor does not offer a moral direction for business practice. Therefore, the interpretation of these findings remains subject to human judgment.

7.3. PEDAGOGICAL IMPLICATIONS

Aristotle observed that metaphors could be considered a learning tool, allowing the learner to reflect on their existing patterns of thought and explore new lines of enquiry (Saffer, 2005). Metaphors can help create awareness of current patterns of thought and allow learners to explore whether this is authentic to them (Lakoff & Johnson, 1980). When a learner decides to "change their mind", it means that they are accommodating a new conceptualisation. To reach this point, the following conditions are to be met (Strike & Posner, 1982):

- There must be dissatisfaction with existing conceptions.
- A new conception must be intelligible.
- A new conception must appear initially plausible.
- A new conception should be fruitful.

This thesis proposes the conceptualisation of a circular economy through the forest metaphor as an alternative line of enquiry. During the teaching case studies in Chapter three and six, learners engaged with the metaphor, but accommodation is up to the individual learner. The study used these four conditions from Strike & Posner (1982) to evaluate whether learners could accommodate this conceptualisation, if they wished to do so.

When there is a dissatisfaction with the existing conceptualisation (condition 1), and a new conceptualisation is presented that is intelligible, initially plausible and could be fruitful, the conditions for conceptual accommodation are met (Strike & Posner, 1982). However, this finding may suggest that ideas could be deconstructed and substituted with new understandings and perspectives. Meyer (1991; p.12) emphasises the importance of the worldview of an individual in creating consistency and unity between ideas that are held: *"The human mind is not like some public plaza where all may come and go as they please. On the contrary, it is a unity, it has an exigence for unity, and it imposes unity on its contents [...] Every grasp of data involves a certain selection, every selection affects an initial structuring, and every structuring anticipates future judgments."*

Gregory Bateson sees the mind as an ecology of conceptualisations, and there is an ongoing interplay between ideas (Bateson, 1975). There is a unity, a worldview, that needs to be taken into consideration. Kearney (1984; p.1) defines worldview as: *"a culturally organised macro through: dynamically interrelated basic assumptions of people that determine much of the behaviour and decision making"*. The term worldview can be traced back to Kant's (1790) work on *Weltanshauung*. Colbern (1996) visualised the introduction of different ideas to the wider worldview of individuals as shown in Figure 7.1.

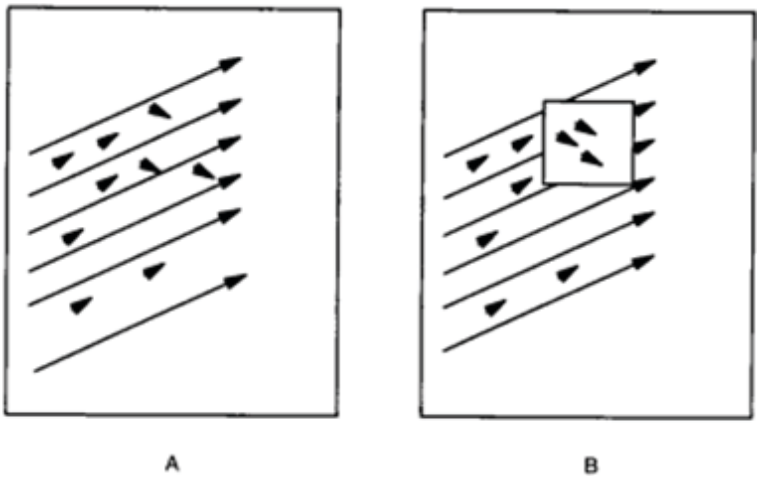

Figure 7.1. the orientating effect of worldview (Cobern, 1996)

The long parallel arrows show the orientation of the worldview, in which concepts, visualised as small arrows, are integrated. Some of the concepts go against the existing orientation of the individual's worldview, as seen in both A and B by the arrows pointing down. It is often understood that the sheer force of the weight of the new concepts will shift the orientation of the worldview. If all large arrows change direction, this may suggest a Kuhnian type of worldview change (Cobern, 1996). At risk, however, as visualised in B, is that individuals wall off novel concepts that do not fit their worldview. Eventually, these novel concepts will deteriorate over time if not maintained.

When teaching new conceptualisations that may be better supported by an alternate worldview, the educator needs to situate the concepts within a bigger picture (the wider conceptual ecology). Through a more holistic view, the learner may start to appreciate the unity between the presented concepts. In addition to that, as per Cobern (1996) the curriculum in which the new conceptualisation is present must include reflections on the assumptions about:

- The non-self (the spiritual, natural, the social);
- The relationship of the individual self to the non-self; and
- The different forms of causality (e.g. systemic, direct)

Loving (1995) reiterated the importance of a Socratic exchange in order to achieve this, where the educator continues to ask questions till contradictions arise and to surface intimate insights such as beliefs and values within the learner. Facilitating the process of surfacing these insights and situating complex concepts, such as a CE, in a coherent landscape of ideas, are examples of critical skills that are required from educators who wish to engage in this topic. It also reinforces the argument that online training programmes that aim to upskill the workforce to implement CE ideas are likely to miss crucial aspects of conceptual development and situating this in a wider worldview. Therefore, more immersive, longer-term programmes that include smaller group learning and individual supervisions are better suited to such transformational learning experiences.

Currently, in design education, metaphors are mostly used in a generative way for ideation, to lead to new perceptions and solutions (Schön, 1979; Cila, 2013). However, the metaphors often used for these generative purposes tend to lack the systematic features that conceptual metaphors have. The work of Logler, et al. (2018) shows that these metaphors are often used in larger quantities to prompt new ideas. Using conceptual metaphor in design education could go beyond ideations and has the potential to lead to an enquiry by the designer into their current conceptual ecology and their worldview.

7.4. CONTRIBUTIONS

7.4.1. Contributions to Science

This thesis contributes to the scientific understanding of a CE by offering a critical evaluation of the dominant metaphors that underpin its current discourse. While a CE is often positioned as a transformative alternative to the linear economy, many of the metaphors that are used to describe it remain closely aligned with reductive and mechanistic thinking. This thesis shows how current metaphors influence discourse and shape the solutions that are valued. By increasing awareness of the metaphors that form part of this discourse, it also invites reflection on whether these are serving their purpose.

As a response to these dominant metaphors, this research builds on the work of Tate et al. (2019), who introduced the forest as a metaphor for a CE. Their work mapped components of forest ecosystems onto economic entities, such as comparing decomposers to recyclers. While useful as a conceptual prompt, their analysis remained largely illustrative and was not grounded in empirical research. This study builds on and extends their work by offering a more detailed investigation, supported by empirical insights. This research demonstrates how the forest metaphor can support the exploration of new lines of enquiry. This contribution lies not only in deepening the metaphor for a circular economy but also in demonstrating its potential as a tool for ideation and reflection.

This thesis also advances the work of Du Plessis & Brandon (2015) by extending the three dimensions that they associate with an ecological worldview (wholeness, relationship and change) within the context of CE discourse. Their work offers a valuable theoretical foundation for thinking about regenerative systems. This thesis contributes to this by making these themes more tangible through the integration into the forest metaphor. By doing so, this research provides a more applied interpretation of regenerative principles and contributes to bridging the gap between ecological theory and CE discourse.

7.4.2. Contributions to Practice

This thesis offers several contributions to practice by introducing new ways of thinking about a CE that can inform business models, design and educational approaches.

For business practitioners, the research contributes to a reframing of value creation within a CE. Rather than prioritising efficiency and throughput, the forest metaphor encourages a focus on overall resilience, mutual benefits, and local context. This perspective supports the development of business ideas that are grounded in collaboration and place-based opportunities. It provides a narrative for approaches such as repair cafés, community kitchens, and localised production networks, helping these to legitimise themselves as meaningful contributions to a circular economy rather than peripheral experiments.

In the field of design, this research proposes a shift away from product-centred innovation towards a broader understanding of design in the wider context of the economy. The forest metaphor encourages designers to consider how interventions interact with social and ecological dimensions over time. This not only looks at how materials circulate, but also at how relationships are formed and evolve and how the wider system changes.

This work also holds implications for educators. By making abstract principles from ecology more applicable in the context of a CE it provides pedagogical value. Besides this, this research offers an alternative narrative that can help learners to engage more critically and creatively with ideas relating to a CE. By shifting the language used to describe a CE, it becomes possible to open up space for different kinds of thinking, including those that are often overlooked.

7.4.3. Contributions to Society

This thesis contributes to society by proposing an alternative metaphor as a tool to support more inclusive, community-centred approaches to a CE. It weaves together environmental and social dimensions of a CE uses this to strengthen the role of local communities.

By framing a CE through the forest metaphor, it emphasises forms of productivity that are often overlooked in conventional economics, such as repair, care, reuse and community support. In doing so, it challenges the extractive logic of profit-driven corporations. This research seeks to recognise these currently overlooked forms of productivity as vital contributors to economic life.

The work also makes a more practical contribution to society through the development of a learning tool that has been published as part of the EU-funded CoCoon projects (www.cocoon.bio). This open-access resource is designed to be printed on a standard A4 printer and can be used in both group and individual settings, making it as accessible as possible. It is intended to support reflection, discussion and ideation, particularly within the context of business in a CE.

7.5. LIMITATIONS AND IMPLICATIONS FOR FUTURE RESEARCH

7.5.1. The conceptualisation of nature

Nature is considered an inspiration for many who seek metaphors that could counterbalance “mechanistic” patterns of thought (Urlica et al, 2020; Webster, 2021). Even though the 18 source domains identified in Chapter five were intelligible and well-accepted by the participants of the case study in Chapter six, there remain many different ways of conceptualising nature. Urlica et al. (2020; p.135) elaborate: *“While some metaphors construct Nature as an integrated whole, others conceptualise it as an assemblage of parts or as a resource.”*

Chapter five intentionally scoped the study around an understanding of nature as an integrated whole. However, there may be alternative ways to conceptualise nature that could again lead to different lines of enquiry as well as potential misconceptions and blind spots. Whilst engaging with the forest metaphor, it is important to appreciate that the conceptualisation of a forest is not homogenous, especially from a didactic point of view. Further research is necessary to understand what these different types of conceptualisations could mean for CE discourse.

7.5.2. Ecological design thinking for a circular economy as an innovation tool

The tool on Ecological Design Thinking for a Circular Economy has been tested with business professionals in a postgraduate education setting. The group that engaged with the tool was diverse in a variety of ways, for example, learners were from different industries, cultural backgrounds and levels of seniority and work experience. This allowed the groups to come up with various creative and bold ideas. When a tool is tested in an organisation, and more specifically with a specific team within this organisation, it will make for a different environment. The tool has proven to be an effective learning tool; however, further research is necessary to determine whether the tool would make for an effective innovation tool as well.

7.5.3. Expanding the tool

As stated in Chapter five, the 18 proposed source domains were not an exhaustive list and only focused on insights from the forest metaphor specifically. Through further research, the tool can be expanded to encompass other ecological source domains, such as meadow, coastal area, tundra or desert.

The validation chapter identified a gap in the subdomain that the tool covers: the financial economy. Participants of the study suggested that parasites would be an appropriate source domain for the extractive practices of the financial economy in modern capitalistic societies. This resonates with the work from Michael Hudson (2015). In his book, *Killing the Host* he argues that the finance, insurance and real estate sectors have gained control of the "economy's brain" and are now favoured over the real economy of labour and production.

This card has been added to the tool after the validation stage and is based on insights from the validation stage only. Therefore, validation of this specific card should be considered in future research.

Due to the elements of wilderness in a forest, there is a lack of a single entity with agency, such as a government. This is considered an important limitation of the forest metaphor, and

Nick Hanauer and Eric Liu (2011) suggest that the garden metaphor is used to conceptualise governments in relationship with the economy. Instead of being in control of the economy like a driver of a machine, gardeners tend to the garden and set the right system conditions for the desired activity to thrive. This stewardship requires a humble yet active attitude (Mixon, 1995).

7.5.4. Increasing the uptake

The use of a metaphor-based approach in CE education is still young. While there is interest in alternative narratives within academic circles and beyond, metaphors are rarely explicitly used and explained in conventional teaching or professional contexts. CE is therefore often presented as a fixed concept that can be taught and understood straightforwardly. As a result, it is more convenient to teach with a focus on explaining, rather than creating a space to explore assumptions, beliefs and worldviews. It requires time, trust and willingness to deal with uncertainty, which not all educators may feel comfortable with. This is where learning tools could be useful: not only for students, but also for educators. The resource developed through this research can be used in both group and individual settings and can also be part of teacher training initiatives.

Business professionals may also face challenges in engaging with ecology-inspired metaphors for a CE from the perspective of their role. Many people working in business have limited time and are under pressure to meet reporting requirements, KPIs or other short-term performance measures. These working conditions are not designed to support deep, reflexive work and questioning. Within this context, using ecological metaphors may not seem relevant or useful. It may also be difficult to justify, especially when it is not immediately tied to measurable outcomes. However, the role of metaphor-based work can be to prepare business professionals for more long-term economic changes and help them identify novel ways of creating value as a business.

Further research is needed to identify the type of support required to increase the uptake of metaphor-based work among educators and business professionals.

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EPILOGUE

As I continued to embrace the indeterminism of my research, I also kept craving the comfort of control and precision.

There is an elegance in allowing events to unfold, but there is also a relief in knowing what comes next.

Stitch by stitch,
I have come to realise that my circle of control is about as wide as my palm.

Just the right size.

In the quiet moments with my needlepoint,
I indulge in a pattern that tells me where the thread should twist and turn,
fuelling me to face the unavoidable nonlinearity of my research.

Through this, I have learned that I am as contradictory as the systems I seek to study;

structured and fluid,
intuitive and exacting,
tangled and clear.

The insights from my research did not only come from stillness, from reflection, or from tending to the threads that refused to be pinned down.

They also came from technique, from structure and discipline;

and, most importantly, from the wisdom of knowing
when each approach was needed.

Appendix

APPENDIX A

This is the signup and consent form for the study in Chapter 3.

You are invited to participate in a research study about circular economy teaching and learning. This study is led by Emma Fromberg who is a researcher on a joint project between the University of Cambridge Institute for Sustainability Leadership and Delft University of Technology.

The purpose of this research study is to understand student engagement with new circular economy teaching methods. The study consists of two questionnaires and participation in the Sustainability Leadership Lab on 27-28 February 2023.

You are asked to complete one questionnaire before the Lab and one after. This study is intended to be published as an academic paper. As with any online activity, the risk of a breach is always possible. To the best of our ability, your answers in this study will remain confidential. We will minimise the risks by pseudonymisation of your participation. This means that your answers do not have your name attached to them, but your participation number only.

Your participation in this study is entirely voluntary and you can withdraw your consent at any time till 15.03.2023. Further information and contact details of the researcher are provided in the Participant Information Sheet. You are agreeing to this Opening Statement by submitting this survey.

We ask for your consent on the following statements:

- ☐ I have read and understood the study information. I have been able to ask questions about the study and my questions have been answered to my satisfaction.
- ☐ I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.
- ☐ I understand that taking part in the study involves the completion of two questionnaires.
- ☐ I understand that I will not be compensated for my participation.
- ☐ I understand that the study will end at 15.03.2023.
- ☐ I understand that taking part in the study also involves collecting potentially personally identifiable information (through open-ended questions in the questionnaire), with the potential risk of my identity being revealed.

- ☐ I understand that the following steps will be taken to minimize the threat of a data breach, and protect my identity in the event of a breach: pseudonymisation of collected data.
- ☐ I understand that personal information collected about me that can identify me will not be shared beyond the study team.
- ☐ I understand that the identifiable personal data I provide will be destroyed.
- ☐ I understand that after the research study, the de-identified information I provide will be used for an academic publication
- ☐ I agree that my responses, views or other input can be quoted anonymously in research outputs.

Name:

E-mail address:

APPENDIX B

This is the pre-programme survey for the study in Chapter 3.
Thank you for taking part in this research. Please be reminded that this is a voluntary activity, and refusing to take part in this will not have an effect on your completion of the Lab. You may withdraw your consent at any time before 15/03/2023. After that, your data will not be traceable anymore to you as an individual in the database and the researchers will therefore not be able to delete your contribution.

If you have any questions, please don't hesitate to contact the lead researcher.

Please enter your participant number (you find this in the welcome email:

Are you familiar with a circular economy?

- ○ Yes
- ○ Not sure
- ○ No

Please state your main role:

- ○ Business
- ○ NGO
- ○ Academia and Research
- ○ Education
- ○ Policy
- ○ Advisory
- ○ Other:

What is your age?

- ○ 20s
- ○ 30s
- ○ 40s
- ○ 50s
- ○ 60s
- ○ 70s
- ○ 80s

Is English your first language?

- ○ Yes
- ○ No, but I am proficient
- ○ No

How would you describe the level of your knowledge and competencies in relation to the topic “circular economy”?

- ○ Beginner
- ○ Moderate
- ○ Competent
- ○ Expert

Could you please explain in your own words what the idea of a circular economy means to you?

How does the idea of a circular economy relate to your business or organisation?

How collaborative with your external entities is your current organisation or business?

- ○ Not collaborative
- ○ Some basic collaborations
- ○ Mostly collaborative
- ○ High collaborative

Which sentence resonates most with you?

- ○ The circular economy is a way for businesses to stay ahead of the competition.
- ○ The circular economy is a way for businesses to build connections with other businesses.
- ○ By implementing circular economy, businesses can increase their performance.
- ○ By implementing circular economy, businesses can create a flourishing ecosystem to thrive in.

Please elaborate on why you selected this sentence in comparison to the others:

Do you think most individuals in your organisation would agree with you?

- ○ Yes
- ○ No
- ○ Not sure

If you selected “not” or “not sure” in the previous question, please elaborate on why you think this.

Would you like to make the researcher aware of any problems with the survey?

Thank you for participating in part 1 of the research. If you have any questions, please contact the lead researcher.

Next survey we ask you to submit your essential preparation worksheet (forest experience only). If preferred, you may also submit this hardcopy in person during the workshop or upload it already now in advance.

APPENDIX C

This is the post-programme survey for the study in Chapter 3.

Thank you for completing Survey 1 and the Sustainability Leadership Lab. Please note that your participation is fully voluntary, and you may withdraw at any time.

Please enter your participant number:

How would you rate the overall learning experience of the workshop:

- ○ Very negative
- ○ Somewhat negative
- ○ Neutral
- ○ Somewhat positive
- ○ Very positive

Please elaborate on your answer above:

Upon reflection, and after the workshop, how does the idea of a circular economy relate to your business or organisation?

How did the workshop affect your understanding of a circular economy?

- ○ It deepened my understanding of a circular economy.
- ○ It changed my understanding of a circular economy.
- ○ It did not affect my understanding of a circular economy.
- ○ Other:

Which sentence resonates most with you?

- ○ The circular economy is a way for businesses to stay ahead of the competition.
- ○ The circular economy is a way for businesses to build connections with other businesses.
- ○ By implementing circular economy, businesses can increase their performance.
- ○ By implementing circular economy, businesses can create a flourishing ecosystem to thrive in.

Please rate the statements below:

	Completely disagree	Somewhat disagree	Neutral	Somewhat agree	Completely agree
Engaging with the forest metaphor was enriching for my understanding of a circular economy.	○	○	○	○	○
The forest metaphor brought insights or made me look differently at what I currently know.	○	○	○	○	○
I feel a tension between the insights from the forest metaphor and the reality of businesses and organisations.	○	○	○	○	○

Please rate the statement below:

	Completely disagree	Somewhat disagree	Neutral	Somewhat agree	Completely agree
I will be able to implement some of the insights from the forest metaphor in my business or organisation.	○	○	○	○	○

What insights from the forest metaphor are realistic to implement in your organisation:

What insights from the forest metaphor are not realistic to implement in your organisation:

For which of the ten principles of regenerative economics can the forest metaphor be relevant?

	Completely irrelevant	Somewhat irrelevant	Neutral	Somewhat relevant	Completely relevant
p.1 Maintain robust, cross-scale circulation of critical flows including energy, information, resources, and money.	○	○	○	○	○
p.2 Regenerative re-investment.	○	○	○	○	○
p. 3/4. Maintain reliable inputs & healthy inputs.	○	○	○	○	○

	Completely irrelevant	Somewhat irrelevant	Neutral	Somewhat relevant	Completely relevant
p.5 Maintain a healthy balance and integration of small, medium, and large organisations.	○	○	○	○	○
p.6 Maintain a healthy balance of resilience and efficiency.	○	○	○	○	○
p.7 Maintain sufficient diversity.	○	○	○	○	○
p.8 Promote mutually-beneficial relationships and common-cause values.	○	○	○	○	○
p.9 Promote constructive activity and limit overly-extractive and speculative processes.	○	○	○	○	○
p.10 Promote effective, adaptive, collective learning.	○	○	○	○	○

How would you describe your affinity with the natural world?

How important is natural world inspiration in your work?

- ○ Very unimportant
- ○ Somewhat unimportant
- ○ Neutral
- ○ Somewhat important
- ○ Very important

Would you like to make the researcher aware of any problems with the survey?

Please note that after 15/03/2023 your individual contribution to the study will be fully pseudonymised and integrated into the study. It will not be possible to withdraw your consent after this date.

Please confirm that you understand that you cannot withdraw your consent after 15/03/2023.

- ☐ I confirm

APPENDIX D

This is the signup and consent form for the study in Chapter 5.

You are invited to participate in a research study on metaphors and circular economy. This study is led by Emma Fromberg who is a researcher on a joint project between the University of Cambridge Institute for Sustainability Leadership and Delft University of Technology.

The purpose of the part of the research that you are invited to is to map out the intuitive understanding that sustainability professionals have about forests. This part of the research consists of the completion of a worksheet that requires you to visit a natural ecosystem, which is followed by an online interview.

These activities will take place between the end of August 2023 and July 2024.

This study is intended to be published in an academic journal. As with any online activity, the risk of a breach is always possible. To the best of our ability, your answers in this study will remain confidential.

We will minimise the risks by pseudonymisation of your participation. This means that your answers do not have your name attached to them, but your participation number only. Your participation in this study is entirely voluntary and you can withdraw your consent at any time till 15.07.2024.

We ask for your consent on the following statements:

- ☐ I have read and understood the study information. I have been able to ask questions about the study and my questions have been answered to my satisfaction.
- ☐ I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions, and I can withdraw from the study at any time, without having to give a reason.
- ☐ I understand that taking part in the study involves the completion of two questionnaires.
- ☐ I understand that I will not be compensated for my participation.
- ☐ I understand that the study will end on 15.07.2024 and I will not be able to withdraw my consent for participation after this date.

- ☐ I understand that taking part in the study also involves collecting potentially personally identifiable information (through open-ended questions), with the potential risk of my identity being revealed.
- ☐ I understand that the following steps will be taken to minimize the threat of a data breach and protect my identity in the event of a breach: pseudonymisation of collected data.
- ☐ I understand that personal information collected about me that can identify me will not be shared beyond the study team.
- ☐ I understand that the identifiable personal data I provide will be destroyed.
- ☐ I understand that after the research study, the de-identified information I provide will be used for an academic publication
- ☐ I agree that my responses, views or other input can be quoted anonymously in research outputs.

Name:

Email address:

How deep is your understanding of natural systems?

- ○ Limited – through everyday interactions only
- ○ Moderate
- ○ This is my field of expertise

APPENDIX E

This is the interview guide for the study in Chapter 5.

Thank you for taking part in this interview. During this interview, we will explore how you make sense of a forest. This taps into your intuitive understanding of a forest and it does not matter within this interview if your answers are biologically incorrect. The correctness is not what is being tested.

Introduction

Could you please elaborate on your connection with natural systems and how deep this is?

Could you please start by elaborating on your experience in the forest?

Was this ecosystem easy or hard for you to reach? How did you get there?

Could you please elaborate on a feature of that ecosystem that stood out to you (such as a waterfall, stream, rock formation, dead tree, etc)?

Dealing with wholeness

[5min] Could you please take some time to make a mind map of all the entities and events in the ecosystem of a forest that you can think of? This may be through a drawing– feel free to use creative freedom.

Please elaborate on the entities and events that you defined.

What is the smallest entity and largest entity that you identified?

Please reflect on what characterises these entities and their scale.

Please describe when you left the forest and where you believe the forest begins and ends.

Reflect on the entities that you found around the edge of the forest. Why do you believe they live on the edge?

Did you find any other boundaries or edges in the ecosystem?

Did you notice any movements or dynamic features in the forest such as a stream of water, a bird in flight or a squirrel climbing up a tree?

The importance of relationship

Reflecting on the entities and events that you mapped out; did you witness any of these in relation to each other during your visit to the forest?

[5 min] Please take some time to review your mind map and reflect on the relationships between the defined entities.

How would you describe the nature of the relationships that you mapped out?

Which of these entities were living a more solitary life and which ones are more part (and dependent on) a wider community?

Can you think of moments where entities reacted to something that was happening in the forest? This could be over the short term (eg a bird flying away after a noise) or long term when a tree grows around another entity for example)

How would you describe the nature of these relationships in the ecosystem?

Response to change

What kind of season did you visit the forest? How was this visible?

How do you expect the forest to evolve over the seasons?

Would you consider the ecosystem that you visited young or old? Why?

How can you identify an old forest from a young forest?

Did you see any evidence of development/disruption and/or decay during your forest visit? What were the signs?

How did the forest react to these changes?

Are there any underlying sources that are important for the overall health of the forest that you can identify? What would be signs that a forest is healthy or thriving?

What would be signs that a forest is unhealthy or in decay?

Did you identify any signs of recovery after a disruption, such as a fallen tree after a storm? What did recovery look like?

Do you believe that the forest that you visited is in good or bad health?

Conclusion

We are now at the end of the interview. Thank you for participating in this research.

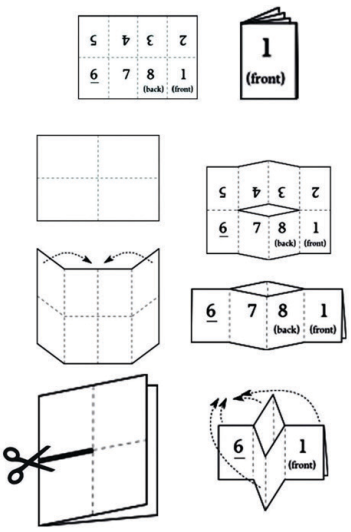
Do you have any observations that you feel we missed addressing during this research?

Please be reminded that you can revisit the information about this research in your Participant Information Sheet. It is possible to withdraw your consent to be included in this research till July 2024.

APPENDIX F

This Appendix shows the learning tool: Ecological Design Thinking for a Circular Economy. These pages are meant to be printed on A4 and folded as an origami pamphlet.

Folding instructions:



The final result

looks as follows:

2

Diversity and redundancy

Diversity can lead to functional redundancy where multiple entities fulfil the same role in the ecosystem – such as the many leaves on one tree. If some are lost due to a disruption, there may be enough left to maintain functions.

Another way how diversity contributes to the resilience of a forest is in a complementary way where entities are slightly different and therefore dependent on, for example, different resources.

3

Think of an example of diversity in a forest and reflect on how this contributes to the overall health and resilience of the wider economic ecosystem.

4

Reflect on how your business contributes to a diverse, resilient and healthy ecosystem.

5

THINK OF:

6

_Are you able to use a diversity of inputs?

_How flexible is your business model? Are there elements that have a variety of purposes that they fulfil (healthy redundancy)?

_Is there spare capacity available in case of disruption (for example disruption in the supply chain)?

_Are the people in your ecosystem building diverse sets of skills and capabilities?

7

Southwest England Fibreshed is part of a global movement of regional clothing producers.

Each "Fibreshed" creates its own local textiles system that relies on the strengths of the local community and the availability of infrastructure and resources. The Southwest England Fibreshed focuses a wool-economy.

All the different Fibresheds work together by sharing their learnings with the wider community and offering their advice and experience

8

Share:

What features could contribute to a diverse, resilient and healthy economic ecosystem?

Southwestenglandfibreshed.co.uk

2

Open nutrient networks

Mycelium networks in the forest floor connect tree roots and facilitate the exchange of nutrients and information.

These mycelium networks can help young seedlings to connect to mature trees. Through this mature tree, they can access necessary nutrients

Reflect on how these structures allow the redistribution of nutrients – when a tree requires nutrients, or when there is an excess of nutrients in certain parts of the system.

Instead of being like a tree, asking for your leaves back after they drop, try to think of ideas that ensures that these "leaves" (or product, components/materials) are useful in an open system.

THINK OF:

5

6

_Ways to enhance the standardisation or interoperability of products, components and materials.

_Offering transparency of information such as details on material contents or open-sourcing product blueprints to enable user-repairs.

_Ensuring that learning and knowledge sharing is supported between different entities in the system.

3

4

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8

Share:

What would be the benefits of an open nutrient system?

Madaster is an online registry for materials and products – offering a product passport service. The registration of every component offers insights into the degree to which an object can be dismantled and reused.

It allows companies to make their information transparent and usable for external parties.

Madaster.com

2

Ecological niche

Many factors determine the right size of a single entity in nature. One factor that influences this is the niche: different entities may occupy different roles and positions in a forest.

Imagine the largest or the smallest entity that you can think of in a forest.

Processes on a micro-level such as nutrient cycling can influence meso-level dynamics (think of plant growth and interactions between species) and even macro-level (such as the role that it plays in the global carbon cycle).

Reflect on how micro-, meso-, and macro-systems in a forest are deeply integrated.

As a business, how would you describe your "ecological niche"?

THINK OF:

5

6

_Whether your business is attuned to diverse local conditions or whether it prefers a "one-size-fits-all" approach.

_Reflecting on the business operations, what scale would allow the most effective response to the needs of the system (micro-, meso-, or macro-level)?

_How aware is the business and negative impacts of its core activities on a micro-, meso-, and macro-level?

4

7

RotterZwam collects the coffee grounds from local shops and uses these to cultivate mushrooms using the basement of an abandoned swimming pool.

There are functional limitations, such as the size of the basement where they can grow their mushrooms and supply restrictions such as limited coffee grounds that can be collected from the city's coffee shops.

Therefore, economies of scale would not be a suitable model to increase impact. Instead, economies of scope could be; many similar (but separate) initiatives can pop up in other regions.

RotterZwam.nl

3

8

Share:

What ideas would contribute to economies of scope – and distributive systems? What ideas would be more appropriate for economies of scale – aimed towards efficiency?

2

Experimentation and the right conditions for life

When trees disperse their seeds, only a couple make it to an adult tree – if any. Many fall prey to birds, rodents, and insects or they could face environments that are not conducive to life. The dynamics of the forest floor act as a ground for experimentation.

Reflect on the nature of a successful succession, which requires the right conditions for life to come together. This may entail sufficient light, water, and nutrients, for example, as well as protection against external threats.

How does your business attune to the systems conditions and participate in shaping them?

THINK OF:

_How do you allow room for business ideas to fail as well as thrive?

_In what ways do you allow your core activities to be shaped by the context and availability of local resources, infrastructure and expertise?

_How do you take part in the creation of the right conditions for circular activities to arise?

3

4

Share:

What business-led systems conditions would support a circular economy?

5

Superblocks is a built environment project in Barcelona and was originally commissioned to reduce noise pollution.

However, the designers went to the root of the problem, and it ended up as an infrastructural project that allows for more sustainable ways of transportation, thriving local communities and enhanced green spaces.

These interventions resulted not only in reduced noise pollution, but also cleaner air, healthier residents and improved economic activity.

https://www.citiesforum.org/news/superblock-superilla-barcelona-a-city-redefined/

6

7

8

COMMUNITIES IN ENMESHED LAYERS

2

Communities in enmeshed layers

When leaves fall on the forest floor they can create a rich layer of organic matter. Decomposers break these down, releasing nutrients that can be taken up again by other entities.

Community is built around nutrient availability, and this makes social and material dimensions deeply intertwined.

Reflect on how social activity has the potential to enhance and direct nutrient flows. What would happen in an ecosystem if there was not this social activity?

Reflect on how you can support a thriving local community around your business activity:

THINK OF:

_Celebrate the skills and expertise that are present in communities.

_Making the opportunities to engage in decentralised supply chains and/or value chains accessible and inclusive.

_Utilising and supporting the Commons and publicly owned assets and infrastructure.

9

5

Fairphone manufactures sustainable mobile phones using ethical mining practices as well as sustainable design principles such as design for disassembly.

Through their repair community, users can support each other in maintaining and repairing their phones.

Fairphone supports this type of activity through its design and support model.

Fairphone.com

7

4

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3

Share:

How might you engage local communities and leverage social capital around product life extension or the re-utilisation of materials, components and products?

2

Emergence and gap dynamics

Imagine a tree falling in a forest. This event leads to a series of consequences also referred to as "gap dynamics". This is because a gap in the canopy appears which allows juvenile trees to race towards this light.

The temporary increase of light on the forest floor also allows for increased growth of the understory (plants that live closer to the forest floor) which typically receives less light. The decomposing tree releases nutrients into the forest floor which creates unique conditions for pioneering species and new growth to thrive.

Reflect on how this sudden event creates a knock-on effect that is noticeable at many levels in the ecosystem.

3

What kind of transformational events could create positive knock-on effects for circular businesses to thrive?

4

THINK OF:

5

_Ways to engage with policy makers to change the "rules of the game" and open up new circular business opportunities.

_Opportunities where the current linear economy is failing to deliver.

_Engagements with users and the wider public that could allow for a cultural shift to a different, circular model through awareness.

6

SoJo is a London-based startup that is focused on promoting sustainability in the fashion industry through connecting customers with local tailors. They also call themselves: "the Deliveroo of clothing repair" because they utilise a bicycle courier network to facilitate the transport.

Where previously users would dispose of their damaged clothes or clothes that did not fit them well anymore, SoJo's service allows them to keep these garments utilised for longer.

SoJo.uk

7

Share:

What kind of market gaps could be framed as opportunities for circular business models?

8

Self-organisation

Ant colonies have organised social structures that allow the group to work together to sustain the colony. The behaviour of each ant is influenced by local information and simple rules.

For example, ants lay down pheromones which create a pathway that other ants can follow (internal communication). There are also specialisations in different roles such as foragers and waste managers – led by environmental cues that allow the colony to adapt to changing conditions.

Reflect on how this form of self-organisation is influenced by communication and environmental cues that allow the colony to stay in tune with novel and changing conditions.

How does your business engage in the self-organisation of the wider system?

THINK OF:

2

3

4

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6

_The role of pre-competitive collaboration to create standards that allow a wider system to move towards circularity.

_Engagement with industry-wide initiatives to create a large-scale movement of change at once - and the ability to prepare for this.

_Collaboration and engagement with local residents and communities that could benefit from your business activity.

7

8

The Cody Dock Partnership is an enterprise formed to act as a vehicle for the community-led regeneration of a London industrial dock and its waterways.

It celebrates the industrial heritage, allows the community to enjoy the River Lea, and acts as an incubator for creative enterprise and supports cultural and educational programmes.

It is managed and maintained by local volunteers and regular community meetings ensure that the local residents can influence the development and management of the site.

Codydock.org.uk

Share:

What areas within a circular economy would lend itself well to the self-organisation of (business) communities and more spontaneous types of business activities?

OPPORTUNISM AND ENHANCING UTILISATION

2

Opportunism and enhancing utilisation

Some animals can support the transportation of seeds by, for example, eating fruit and defecating the seeds often far from the original location. Alternatively, seeds can attach themselves to certain animals' coats and hitch a lift to a completely new ecosystem.

Reflect on other opportunistic relationships that you could find in natural systems.

THINK OF:

How can you do more with what is available and already there? Or how can you enable others to utilise and repurpose what you put out in the system?

5

9

Share:

What type of design features would promote the increased utilisation of already-existing assets?

3

4

8

7

The app facilitates a connection between users who have items to lend and those who need them, increasing the utilisation of existing items.

Peerby promotes collaborative consumption and resource sharing through its peer-to-peer sharing platform.

www.peerby.com

_Seeking opportunities to use existing resources as input for your system.

_Ensuring interoperability and transparency of what you put out in the system.

_Designing your outputs in a way that allows others to use and reuse them in different ways.

Reciprocity and interdependency

There is a symbiotic association between the roots of a plant and the mycelium structures in the soil – these are two separate entities, but deeply and evolutionary entangled.

In this relationship, trees provide the fungi with carbohydrates (sugars) produced through photosynthesis. In return, the fungi enhance the trees' ability to absorb water and nutrients.

Reflect on the interdependence that exists in natural ecosystems.

How can you create mutual benefits and reciprocal relationships within your ecosystem of economic activity?

THINK OF:

_Creating benefits and value outside of the transactional nature of the supplier-customer relationship.

_The reciprocal partnerships with entities that the business depends on and how these can be deepened.

_Exploring the opportunities for more place-based partnerships which leverage what is already there.

Interface produces flooring and aims to reuse and recycle all its materials. They have worked together with an Italian company called Aquafil for over two decades. They specialise in producing nylon yarns from regenerated waste.

Through a durable partnership, they can both evolve their design and production to ensure enhanced benefits for both.

https://www.aquafil.com/magazine/secrets-for-circular-supply-chain-partnerships-from-interface-and-aquafil

Share:

Where, in a circular economy, do you believe creating partnerships and mutual benefits is most critical?

2 3 4 5 6 7 8 9

2

Cooperation and co-evolution

Pollinators such as bees, butterflies and birds visit flowers to obtain food by seeking nectar. Flowering plants benefit from this visit by transferring pollen from the male parts of one flower to the female parts of another.

This important process contributes to the genetic diversity of the plant species. Therefore, flowering plants and pollinators have co-evolved with adaptions that enhance this cooperation.

Reflect on how deeply the survival of both pollinators, as well as flowering plants, relies on this cooperation.

3

4

How can you tune into the needs of the wider business ecosystem around you and adapt to this?

THINK OF:

5

6

_How you can respectfully acknowledge dependencies and power dynamics that come with cooperation and co-evolution.

_Building spaces to openly engage in the evolution of the wider economic ecosystem and its change towards circularity.

_Anticipating and evolving to utilise inputs that may be considered by-products or "waste" by other entities.

7

8

The Forest Stewardship Council (FSC) and its certification system were established after recognising the need to address deforestation and regenerative forest management.

This initiative was led by diverse stakeholders such as NGOs, timber industry representatives, and Indigenous peoples' organisations and shaped the future of sustainable forest management.

https://fsc.org/en

Share:

What kind of opportunities could be unleashed when multiple entities within a supply chain decide to co-evolve towards a circular economy?

2

Competition

During dry seasons, plants compete for the limited available water resources. Some deep-rooted entities may be able to access groundwater, whilst other entities with more shallow roots could rely on surface water and puddles.

The process of competition could prompt plants to grow different root systems – with specialised relationships between plants and fungi to ensure reliable access to essential nutrients.

Reflect on how competition is everywhere in a forest where there are limited resources.

3

4

How can you ensure that competition is used for good?

5

THINK OF:

6

_Seeking to compete with unsustainable products and services and aim to replace these with solutions in line with a circular economy.

_Supporting emerging entities to compete fairly with established entities – such as renewable energy sources replacing heavily subsidised fossil fuel-based energy.

_Avoid using similar scarce inputs that other businesses rely upon (for example: ensure the production of biomaterials is not food competitive).

7

Tony's Chocolonely is a chocolate company that challenges the existing chocolate supply chain directly by addressing issues of exploitation, child labour, and unfair trade practices.

The company's mission is to make 100% slave-free chocolate the norm, not just for its own brand but for the entire chocolate industry.

tonyschocolonely.com

8

Share:

What markets within a linear economy would be challenging to compete with as a circular business? And which markets would be easier?

2

Community and information sharing

When trees are under attack, for example by an insect or parasite population, they can send distress signals to their neighbouring trees to warn them about this threat.

These trees can then start to produce enzymes to protect themselves against this threat, which could result in enhanced stability of the forest ecosystem – including the likelihood of survival for the signalling tree.

Reflect on this "invisible" sense of community, the wealth of information shared between trees and how, at first sight, trees seem to operate as individual entities.

How can you invite and empower external stakeholders into your ecosystem of economic activity?

THINK OF:

3

4

5

6

_Enable community spaces and repair cafes to allow citizens to repair their own projects as well as learn new skills or share their skills with community members.

_Ensure that materials, components and products stay local whilst information is shared widely and in an accessible way.

_Open up information that is considered intellectual property to serve the good of society.

7

8

Materiom is a start-up that provides open-access resources and data to foster innovation and development in the field of biomaterials.

Through their open-source material recipes, including step-by-step instructions and ingredient lists, they empower the general population to experiment with these biological materials.

All information is freely available and for anyone to use, modify and distribute, fostering a culture of open innovation and collaboration.

Materiom.org

Share:

What design principles and business models can businesses implement to empower their customers to repair and upgrade their products independently?

2

Invasion and conflict

Invasive species are non-native organisms that are introduced to a new environment and could cause harm to this ecosystem. Often, they grow rapidly due to the lack of natural predators, and this can displace or reduce native plants and animals.

Some invasive species can alter nutrient cycling processes. For example, invasive nitrogen-fixing plants like the black locust can increase nitrogen levels which further disrupt some native plant communities.

Reflect on how quickly an invasive species can lead to a cascading effect in the wider ecosystem.

3

How can you disrupt unsustainable systems through your business activities?

4

THINK OF:

5

_Positioning the business against an unsustainable industry and seeking direct alternatives for popular and unsustainable products.

_Exploring how you can use different business models such as selling performance or access allowing you to offer high-quality or more sustainable products in an accessible way.

_How you could allow thriving second-hand markets to disrupt first-hand markets and enable higher utilisation of already-existing assets.

6

Oatly is redefining the dairy industry by offering a plant-based, more sustainable alternative to traditional dairy. Through bold marketing and advocacy, they challenge the industry to reevaluate its environmental and ethical standards.

Oatly's success highlights rising consumer demand for sustainable choices, compelling the dairy sector to adapt or face the risk of losing market share.

www.oatly.com

7

Share:

Can you think of any more examples of "invasive" circularor sustainable solutions that disrupted unsustainable systems?

8

2

Evolving through feedback

Certain stressful events for trees can create a change in the DNA of the tree. Experiences such as droughts, diseases, and extreme temperatures have the potential to affect certain genes and therefore allow the tree to adapt to its unique circumstances and challenges. These changes in DNA are called epigenetic changes.

Reflect on of form of feedback allows the tree to learn lessons from the past and shape itself to fit better in the wider system.

Think of other examples of feedback within a forest ecosystem that shapes and changes the development of certain entities or relationships.

How can you make your business, product, idea or supply chain more context-specific?

THINK OF:

5

4

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3

Patagonia encourages their customers to return their items for repair and maintenance through their Worn Wear Programme. This provides the business with valuable information on how to improve the quality and durability of their products.

Share:

In what ways can you enhance the feedback that you receive - especially the more qualitative insights that are not easily expressed as numbers?

wornwear.patagonia.com

9

_How do contexts such as the local community or the wider supply chain affect how the business operates?

_What kind of feedback is available and how this could allow the business to evolve? What kind of information is currently guiding the business?

_Tuning into place-specific that require businesses to respond in creative ways.

Metamorphosis

Tadpoles undergo a process of metamorphosis to transform into adult frogs. Through the different stages of the metamorphosis, the tadpole undergoes profound changes orchestrated by hormonal signals.

This transformation enables the entity to thrive in different ecological circumstances throughout its life.

Reflect on the profoundness of the changes that suddenly happen, from a metabolic shift (from herbivorous to carnivorous) as well as the development of hind legs and lungs to function successfully above water.

How can the business contribute to abrupt and sudden changes in the economy?

THINK OF:

2

3

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Share:

What types of changes could prompt businesses to undergo a "metamorphosis" towards a circular business?

B Corp certification is designed to help businesses align their practices with sustainability through a structured framework. In many cases, B Corps are required to embed social and environmental considerations into their legal structures. This ensures that sustainability is deeply integrated into the company's core operations and decision-making processes.

www.bcorporation.net

_Take part in a wider movement of activity to contribute towards a "tipping point".

_How can business models and wider industry collaboration be in service of a changing economy?

_Engage with governments to set the right conditions to make a circular economy the new status quo.

2

Microclimate and homeostasis

A microclimate is a localised climate that differs from the surrounding regional climate. This can be due to the influence of factors such as vegetation and bodies of water. Microclimates play a crucial role in helping a forest to self-regulate and maintain homeostasis.

The canopy cover is a natural insulator, moderating temperatures by providing shade. This allows a forest to be cooler in the summer and warmer in the winter in comparison to areas that do not have this cover.

Reflect on how you experience the microclimate of a forest when you enter and leave the forest during a hot day.

What would you consider a progressive "microclimate" for your business to exist in?

THINK OF:

3

_What kind of contexts would be safe for experimentation and learning to happen?

4

_How can policymakers, (local) government, and municipalities support the environment where new varieties of value can emerge?

5

_What type of community-maintained infrastructure (the Commons) would support these creative endeavours?

7

Amsterdam Smart City is an urban development initiative that harnesses innovations for a more resilient and inclusive city. One of its components is the living lab – which allows the testing, piloting and refining of solutions in a real-life context.

8

https://amsterdamsmartcity.com/

9

Share:

If you had access to a progressive "microclimate", what would be a circular idea that you wish to test?

ADAPTATION AND SEASONAL CHANGES

2

Adaptation and seasonal changes

In the Northern Hemisphere, when fall approaches, deciduous trees begin the process of leaf abscission, where the leaves change colour, die and eventually fall off. This process is triggered by environmental cues such as decreasing daylight hours and cooler temperatures.

This allows the tree to conserve water and energy over the winter and avoids the risk of damage that could affect the overall health of the tree.

Similar environmental cues signal to the tree when it is time to promote leaf growth in the spring.

Reflect on the effect of climate change on these seasonal changes which may prompt trees to drop leaves too late or grow them again too early.

3

How flexible and resilient is your business model when facing changing circumstances?

4

THINK OF:

5

_Changes in supply such as supply disruptions or price volatility.

_Policy changes or requirements.

6

_Changes in demand such as trends, changing customer behaviours or purchasing power.

7

Dock to Dish has a fishery model that connects local fishermen directly with restaurants. They operate on a "catch of the day" basis which allows them to work with whatever fish are sustainably caught, including bycatch.

These restaurants have the ability to adapt to the different species of fish that they were able to catch and adjust their menu to accommodate this.

docktodish.com

8

Share:

What types of products would lend themselves well to dealing with flexible, unpredictable and diverse inputs?

2

Reactive change to disruption

When a wildfire occurs, this can destroy trees, understory and other vegetation. Immediately after the event, the ecosystem appears barren and charred.

However, shortly after the fire, pioneer species – which are often well adapted to disturbed environments, begin their colonisation. These could be grasses or certain types of shrubs. Some trees like certain pine species, have seeds that require the heat of a fire to germinate.

Over time, the initial colonisers are replaced by other species that allow more complex structures to emerge within the ecosystem.

Reflect on different stages of recovery and the reaction to disruption

What role could your business play in the recovery after a major disruption?

THINK OF:

3

_How can you use your core competencies as a business to support the response to disruption such as disasters and population displacement?

4

_How are you contributing to a diversity of business activities in the wider economy to ensure resilience - and avoid fragility?

5

_Building in multi-purpose uses for your products, components and materials.

6

IKEA developed a flat-pack emergency shelter that can be used to respond to population migration. They are designed for transportation and rapid deployment and can be easily transformed and assembled. This adaptability ensures that displaced individuals can receive immediate, practical housing solutions.

https://ikeafoundation.org/stories/flat-pack-refugee-shelter-wins-design-of-the-year-2016/

7

Share:

Come up with ideas that could have a business case in times without disruption but could also support during a disaster response.

8

APPENDIX G

This is the student-facing pre-programme survey for the study in Chapter 6.
Thank you for taking part in this research.

Please be reminded that this is a voluntary activity. You may withdraw your consent at any time before 11/04/2025. After that, your data will not be traceable anymore to you as an individual in the database and the researchers will therefore not be able to delete your contribution. If you have any questions, please don't hesitate to contact the lead researcher.

We ask for your consent on the following statements:

- ☐ I have read and understood the study information. I have been able to ask questions about the study and my questions have been answered to my satisfaction.
- ☐ I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.
- ☐ I understand that taking part in the study involves the completion of two questionnaires.
- ☐ I understand that I will not be compensated for my participation.
- ☐ I understand that the study will end at 11.04.2025.
- ☐ I understand that taking part in the study also involves collecting potentially personally identifiable information (through open-ended questions in the questionnaire), with the potential risk of my identity being revealed.
- ☐ I understand that the following steps will be taken to minimize the threat of a data breach, and protect my identity in the event of a breach: pseudonymisation of collected data.
- ☐ I understand that personal information collected about me that can identify me will not be shared beyond the study team.
- ☐ I understand that the identifiable personal data I provide will be destroyed.
- ☐ I understand that after the research study, the de-identified information I provide will be used for an academic publication
- ☐ I agree that my responses, views or other input can be quoted anonymously in research outputs.

Please state your name, or participant number:

When are you due to participate in the workshop?

Please state the location of the workshop:

Please state your main role:

- ○ Business
- ○ NGO
- ○ Academia and Research
- ○ Education
- ○ Policy
- ○ Advisory
- ○ Other:

What is your age?

- ○ 20s
- ○ 30s
- ○ 40s
- ○ 50s
- ○ 60s
- ○ 70s
- ○ 80s

Is English your first language?

- ○ Yes
- ○ No, but I am proficient
- ○ No

Are you familiar with a circular economy?

- ○ Yes
- ○ Not sure
- ○ No

How would you describe the level of your knowledge and competencies in relation to the topic “circular economy”?

- ○ Beginner
- ○ Moderate
- ○ Competent
- ○ Expert

Could you please explain in your own words what the idea of a circular economy means to you?

How does the idea of a circular economy relate to your profession, business or organisation?

Which sentence resonates most with you?

- ○ The circular economy is a way for businesses to stay ahead of the competition.
- ○ The circular economy is a way for businesses to build connections with other businesses.
- ○ By implementing circular economy, businesses can increase their performance.
- ○ By implementing circular economy, businesses can create a flourishing ecosystem to thrive in.

Please elaborate on why you selected this sentence in comparison to the others:

Do you think most individuals in your organisation would agree with you?

- ○ Yes
- ○ No
- ○ Not sure

Please elaborate on why you think this:

Would you like to make the researcher aware of any problems with the survey?

Thank you for participating in part 1 of the research. If you have any questions, please contact the lead researcher.

APPENDIX H

This is the student-facing post-programme survey for the study in Chapter 6.

Thank you for taking part in this research. Please be reminded that this is a voluntary activity. You may withdraw your consent at any time before 11/04/2025. After that, your data will not be traceable anymore to you as an individual in the database and the researchers will therefore not be able to delete your contribution. If you have any questions, please don't hesitate to contact the lead researcher.

Have you completed Part 1 of the study?

- ○ Yes
- ○ No

Please state your name or participant number:

Please rate your overall experience of the workshop:

	Very negative	Somewhat negative	Neutral	Somewhat positive	Very positive
The overall experience.	○	○	○	○	○
The design and the content of the cards.	○	○	○	○	○
The quality of facilitation.	○	○	○	○	○

Please rate the statements below:

	Completely disagree	Somewhat disagree	Neutral	Somewhat agree	Completely agree
I am satisfied with the teaching methods that were being used.	○	○	○	○	○

	Completely disagree	Somewhat disagree	Neutral	Somewhat agree	Completely agree
I felt motivated throughout the session.	○	○	○	○	○
I learned during this session.	○	○	○	○	○
I felt comfortable during the session.					

Optional: please elaborate on your answers above:

Please rate the statements below:

	Completely disagree	Somewhat disagree	Neutral	Somewhat agree	Completely agree
Engaging with the forest metaphor was enriching for my understanding of a circular economy.	○	○	○	○	○
The forest metaphor brought insights or made me look differently at what I currently know.	○	○	○	○	○
I feel a tension between the insights from the forest metaphor and the reality of businesses and organisations.	○	○	○	○	○

How did the workshop affect your understanding of a circular economy?

- ○ It deepened my understanding of a circular economy.
- ○ It changed my understanding of a circular economy.

- ○ It did not affect my understanding of a circular economy.
- ○ Other:

Upon reflection, and after the workshop, how does the idea of a circular economy relate to your profession, business or organisation?

What was the most interesting or exciting idea that you came up with during the workshop?

Which sentence resonates most with you?

- ○ The circular economy is a way for businesses to stay ahead of the competition.
- ○ The circular economy is a way for businesses to build connections with other businesses.
- ○ By implementing circular economy, businesses can increase their performance.
- ○ By implementing circular economy, businesses can create a flourishing ecosystem to thrive in.

Please rate the statement below:

	Completely disagree	Somewhat disagree	Neutral	Somewhat agree	Completely agree
I will be able to implement some of the insights from the forest metaphor in my profession, business or organisation.	○	○	○	○	○

What insights from the forest metaphor are realistic to implement in your profession, business or organisation?

What insights from the forest metaphor are not realistic to implement in your profession, business or organisation?

Please answer the following questions:

	No	Not sure	Yes
Do you find the current mainstream conceptualisation of a circular economy limiting?	○	○	○
Do the insights of the forest metaphor resonate with you?	○	○	○
Do you think the ideas resulting from the forest metaphor are plausible?	○	○	○
Do you find the forest metaphor allows you to develop different ideas?	○	○	○

Please evaluate the following statements:

	Disagree	Neutral	Agree
The individual interaction with the cards was enjoyable.	○	○	○
The group discussion on the insights was enjoyable.	○	○	○
The session overall was enjoyable.	○	○	○

Please evaluate the following statements:

	Disagree	Neutral	Agree
The visual design of the cards was clear and supportive in the activity.	○	○	○
The time given for each activity was sufficient.	○	○	○
The cards sparked inspiration and new ideas.	○	○	○

Please evaluate the following statements:

	Disagree	Neutral	Agree
The information on the cards was clear and easy to understand.	○	○	○
It was clear from the cards what was expected of me.	○	○	○
The physical design of the cards helped the process through the different stages.	○	○	○

Please evaluate the following statements:

	Disagree	**Neutral**	**Agree**
The cards supported my learning process during the session.	○	○	○
How to use the cards was intuitive.	○	○	○
The outcomes of the engagement with the learning tool were useful.	○	○	○

Would you like to make the researcher aware of any problems with the survey?

Thank you for participating in the study. If you have any further questions, you can contact the lead researcher.

APPENDIX I

This is the facilitator-facing post-programme survey for the study in Chapter 6.

Thank you for taking part in this research. Please be reminded that this is a voluntary activity. You may withdraw your consent at any time before 11/04/2025. After that, your data will not be traceable anymore to you as an individual in the database and the researchers will therefore not be able to delete your contribution. If you have any questions, please do not hesitate to contact the lead researcher.

Please state your name:

When did you facilitate the workshop using the tool “Ecological Design Thinking for a Circular Economy”?

Have you facilitated this workshop (or a version of this workshop) before?

Is English your first language?

- ○ Yes
- ○ No, but I am proficient
- ○ No

Please rate your overall experience of the workshop:

	Very negative	Somewhat negative	Neutral	Somewhat positive	Very positive
The preparation and facilitation notes were clear and descriptive.	○	○	○	○	○

	Very negative	Somewhat negative	Neutral	Somewhat positive	Very positive
The overall experience delivering the workshop.	○	○	○	○	○
The design and the content of the cards.	○	○	○	○	○
Participant engagement	○	○	○	○	○

Please state any feedback on the preparation notes of the workshop:

Please state any feedback on the cards (content and design):

Please rate the statements below:

	Completely disagree	Somewhat disagree	Neutral	Somewhat agree	Completely agree
Engaging with the forest metaphor was enriching for their understanding of a circular economy.	○	○	○	○	○
The forest metaphor made them look differently at what they currently know.	○	○	○	○	○

	Completely disagree	Somewhat disagree	Neutral	Somewhat agree	Completely agree
They felt a tension between the insights of the forest metaphor and the reality of their profession, organisation or business.	○	○	○	○	○

Please state any feedback on the engagement with the content:

Did you observe any change within the learners (for example, how they thought of CE or engaged with some of the concepts)?

- ○ Yes
- ○ No
- ○ Not sure

What was the most interesting idea that was presented in your group?

If you had the chance, would you use this tool again in your teaching?

- ○ Yes
- ○ No
- ○ Not sure

Optional: please elaborate on why you would or would not use this tool again in your teaching:

Please evaluate the following statements:

	Disagree	Neutral	Agree
The individual interaction with the cards was enjoyable	○	○	○
The group discussion on the insights was enjoyable.	○	○	○
The session overall was enjoyable.	○	○	○

Please evaluate the following statements:

	Disagree	Neutral	Agree
The visual design of the cards was clear and supportive in the activity.	○	○	○
The time given for each activity was sufficient.	○	○	○
The cards sparked inspiration and new ideas.	○	○	○

Please evaluate the following statements:

	Disagree	Neutral	Agree
The information on the cards was clear and easy to understand.	○	○	○
It was clear from the cards what was expected of me.	○	○	○
The physical design of the cards helped the process through the different stages.	○	○	○

Please evaluate the following statements:

	Disagree	Neutral	Agree
The cards supported their learning process during the session.	○	○	○
How to use the cards was intuitive.	○	○	○
The outcomes of the engagement with the learning tool were useful.	○	○	○

Would you like to make the researcher aware of any problems with the survey?

Thank you for participating in the study. If you have any further questions, you can contact the lead researcher.

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My personal evolution is characterised by the creative and intellectual souvenirs that those close to me have generously gifted me. I am deeply grateful for being uplifted, supported, and cared for by wonderful human beings. I hope that my open mind has done justice to the brilliance that I am surrounded by.

***

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Conny, thank you for showing me what it looks like to be a bright, resilient and authentic woman in a male-dominated academic environment. You are the best role model I could have ever wished for.

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It was only months before I began my doctoral journey that I met George Elliman, in the middle of a pandemic. Since then, George has been my ever-loyal squire on this long academic quest, shouldering the burden of this scholarly crusade together with me, with grace, compassion and kindness.

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***

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***

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***

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***

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***

Finally, to Salami, my beloved cat and my dear companion through this journey.
You were with me for all the quiet little moments,
and I miss you more than words can say.

Rest peacefully, my young prince.

ABOUT THE AUTHOR

Emma Fromberg is a designer, researcher, and educator with extensive experience in circular economy and pedagogical innovation. Her work focuses on how business-led activities can contribute to system-level change and support the transition to a regenerative and inclusive circular economy.

She holds a BSc in Industrial Design Engineering and an MSc in Strategic Product Design from Delft University of Technology. After obtaining her teaching qualifications in secondary education physics, she managed the development and delivery of the first English-taught Circular Economy Massive Open Online Course, a collaboration between the Leiden-Delft-Erasmus Centre for Sustainability and the Ellen MacArthur Foundation.

In 2016, she moved to the Isle of Wight, United Kingdom, to join the Ellen MacArthur Foundation, where she led the annual Disruptive Innovation Festival: an online festival of ideas. This open-access platform provided a space for innovators and entrepreneurs to share circular economy ideas with a broad audience. Her later work at the foundation focused on material choices for a circular economy, in collaboration with the Cradle to Cradle Products Innovation Institute. This work resulted in the development of four Safe & Circular Material Choices methods for the Circular Design Guide.

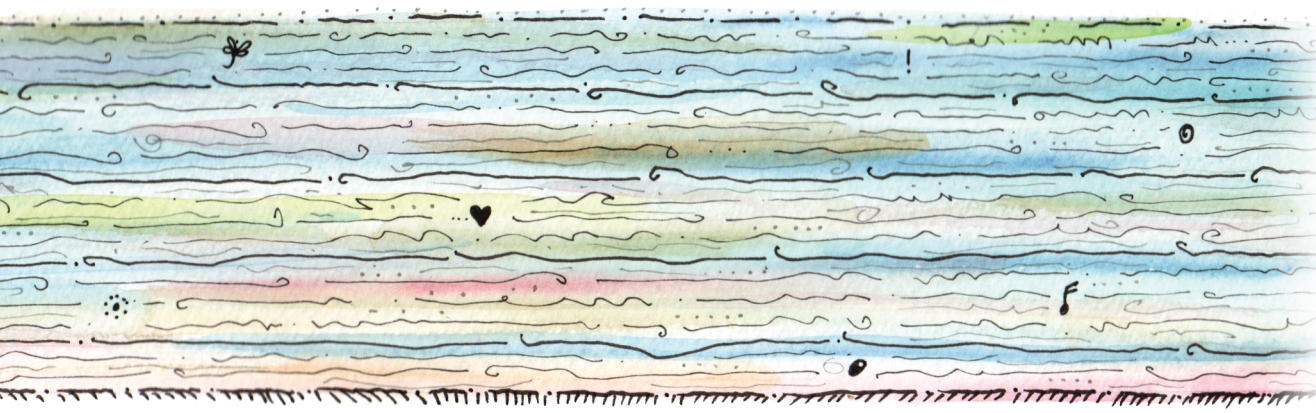
She returned to academia in 2019 as Course Director in Sustainable Business at the University of Cambridge Institute for Sustainability Leadership (CISL). In this role, she was responsible for the Postgraduate Certificate in Sustainable Business, a Master's-level programme designed for mid-to-senior level sustainability professionals, which contributes towards the Master of Studies in Sustainability Leadership. As part of this role, she obtained a Postgraduate Certificate in Higher Education Teaching and Learning, where she focused on the role of metaphors as a teaching method for systems thinking.

This research formed the foundation of her PhD at Delft University of Technology, which she pursued alongside her role at CISL from 2021 onwards. Her doctoral research draws inspiration from nature and living systems to challenge conventional mental models and to reimagine what it means to be a business in a circular economy. Emma is continuing her research as a Research Fellow at King's College London Centre for Sustainable Business.

Metaphors are not merely the decoration of language,
they shape how we understand abstract concepts
-such as a circular economy.

If we wish to use this concept as a transformative economic model,
we must evolve the metaphors we use to understand it.

This is an exploration of what happens when
metaphors from ecology are used to reimagine a circular economy.



What emerges is a perspective
that sees it unlike a machine
and more as a living system:

dynamic,
distributed,
and driven by relationships.

Emma H. E. Frowberg