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Article

Transforming Circular Economy Thinking Using the Forest as a Metaphor

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Abstract: 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.



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Keywords: circular economy; conceptual metaphor theory; forest metaphor; sustainability education

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 emphasize reductionism, competition and incrementalism, which have been criticised by some academics [3–5]. 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 and Beinbocker [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 system 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 a nature-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 nature-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 1.

Table 1. Comparison of roles between natural networks and the business ecosystem [11].

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 work demonstrates a clear potential for using the forest metaphor through the variety of insights that Tate et al. [11] were able to demonstrate—from supply chain insights to post-consumer insights.

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; and (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 nature-inspired 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 focuses 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.

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 and Brandon [17]: (1) dealing with wholeness, (2) the importance of relationship and (3) 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” that 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 ecosystemic 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.

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 1.

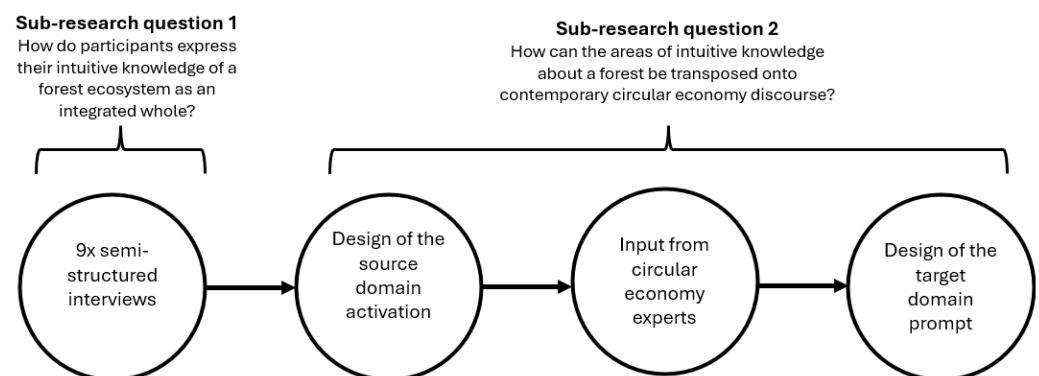


Figure 1. Research design.

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 2 and the interview guide can be found in Appendix A.1. 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 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 will be pseudonymised from the point of transcription and anonymised after all data have 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 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 1-h, semi-structured interview 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 were 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 were analysed according to the three themes (wholeness, relationship and change) and these were used as structuring elements. The final clusters are displayed in column 1 of the Results Section.

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.

3.3. Expert Input

The results from column 3 were presented to 7 circular economy experts. 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. An overview of the participants can be found in Table 3.

Table 3. Overview of the circular economy expert participants.

Participant	Gender	Geographical Location	Occupation
1	Female	Sweden	Entrepreneur
2	Female	Russia	Business professional
3	Female	Norway	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 h. 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.

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.

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” and “reactive change to disruption”.

These were transposed onto circular economy discourse in Tables 4–6. The Results Section consists of three different tables, corresponding to the areas set out by Du Plessis and 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 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 4. Dealing with wholeness.

Column 1 Interview Clusters	Column 2 Source Domain Activation Proposal (by the Authors)	Column 3 Target Domain Themes Raised by Circular Economy Experts	Column 4 Prompt for Transposition onto the Target Domain (by the Authors)
Redundancy	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.	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 ecosystem. Think of:
(Bio)diversity	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.	Increase the number of elements that can fulfil a variety of purposes to ensure flexibility.	<ul style="list-style-type: none"> 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)?
Fragility	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.	Allow people to build a diversity of skills and capabilities to enhance creativity.	<ul style="list-style-type: none"> Are the people in your ecosystem building diverse sets of skills and capabilities?
Resilience		Ensure spare capacity in case of disruption.	<ul style="list-style-type: none"> Is there spare capacity available in case of disruption (for example disruption in the supply chain)?
Lack of boundaries	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, which enhances their ability to survive.	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 ensures that these leaves are useful in an open system. Think of:
Concentrations of life	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.	Enhance the interoperability of products, components and materials.	<ul style="list-style-type: none"> Offering transparency of information such as details on material contents or open-sourcing product blueprints to enable user repairs.
Cyclical		Allow learning and knowledge sharing to happen between different players in the system.	<ul style="list-style-type: none"> 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.

Table 4. Cont.

Column 1 Interview Clusters	Column 2 Source Domain Activation Proposal (by the Authors)	Column 3 Target Domain Themes Raised by Circular Economy Experts	Column 4 Prompt for Transposition onto the Target Domain (by the Authors)
Growth	Ecological niche Many factors determine the right size of a single entity in nature. One factor that influences this is the individual 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	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: <ul style="list-style-type: none"> 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	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).	Find the right scale for business operations to respond most effectively to the needs of the system.	
Niche	Reflect on how micro-, meso-, and macro-systems in a forest are deeply integrated.	Consider both the positive and negative impacts of the business on all levels in the system, on a micro, meso and macro level.	
Experimental	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.	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: <ul style="list-style-type: none"> 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?
Conditions for life	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.	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.	
Fuzzy boundaries	Communities in enmeshed layers When leaves fall on the forest floor they can create a rich layer of organic matter.	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: <ul style="list-style-type: none"> Leveraging decentralised supply chains and place-based innovation. Celebrate the skills and expertise that are present in communities. Enhancing distributed ownership and participation. Supporting the Commons and publicly owned assets and infrastructure.
Layers beneath layers	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.	Celebrate the skills and expertise that are present in communities.	
Different levels of life	Reflect on how social activity has the potential to enhance nutrient flows. What would happen in an ecosystem if there was not this social activity?	Enhance distributed ownership and participation.	
Decomposers		Support the “Commons” and publicly owned assets and infrastructure.	
Desire lines	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.	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: <ul style="list-style-type: none"> Opportunities where the current linear economy is failing to deliver.
Pioneering species	Reflect on how this sudden event creates a knock-on effect that is noticeable at many levels in the ecosystem.		
Canopy			
Dynamic circumstances			

Table 4. Cont.

Column 1 Interview Clusters	Column 2 Source Domain Activation Proposal (by the Authors)	Column 3 Target Domain Themes Raised by Circular Economy Experts	Column 4 Prompt for Transposition onto the Target Domain (by the Authors)
Emergence	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.	Nurture local value networks.	How does your business engage in the self-organisation of the wider system? Think of: <ul style="list-style-type: none"> Local value networks that attune to each other. Pre-competitive collaboration. Industry-wide initiatives.
Ant colonies	Reflect on how this form of self-organisation is influenced by communication and environmental cues that allow the colony to stay in tune with contemporary conditions.	Drive change through pre-competitive collaboration and industry-wide initiatives.	
Self-organisation			

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

Table 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. The importance of relationship.

Column 1 Interview Clusters	Column 2 Source Domain Activation Proposal (by the Authors)	Column 3 Target Domain Themes Raised by Circular Economy Experts	Column 4 Prompt for Transposition onto the Target Domain (by the Authors)
Opportunism	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 ultimately settling in a new ecosystem.	Seek to increase the utility of existing resources through sharing. Enhance the interoperability of products, components and materials.	How can you do more with what is available to you? Or enable others to do so with what you put out in the system. Think of: <ul style="list-style-type: none"> Seek opportunities for sharing of existing resources. Ensure the interoperability of what you put out in the system. Allow information sharing to happen generously.
Purposeful relationships	Reflect on other opportunistic relationships that you could find in natural systems.	Enhance the interoperability of products, components and materials.	
Symbiotic relationships	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.	Identify ways to create symbiotic collaborations with external entities in the value chain.	How can you create mutual benefits and reciprocal relationships within the entire value chain? Think of: <ul style="list-style-type: none"> Activity outside of the transactional nature of the supply/customer relationship. How you can create reciprocal partnerships with entities that the business depends on.
Reciprocity	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.	Allow for activity outside of the transactional nature of the supplier/customer relationship.	
(Inter) dependency	Reflect on the interdependence that exists in natural ecosystems.	Work on stable, reciprocal and effective partnerships with entities that the business relies upon.	

Table 5. Cont.

Column 1 Interview Clusters	Column 2 Source Domain Activation Proposal (by the Authors)	Column 3 Target Domain Themes Raised by Circular Economy Experts	Column 4 Prompt for Transposition onto the Target Domain (by the Authors)
Co-creation	Cooperation and co-evolution Pollinators such as bees, butterflies and some 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.	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? Think of:
Cooperation	Therefore, flowering plants and pollinators have co-evolved over many years with adaptations that enhance this cooperation. Reflect on how deeply the survival of both pollinators, as well as flowering plants, relies on this 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.	<ul style="list-style-type: none"> • Allow your supply chains to utilise a diversity of different inputs. • Anticipate and evolve to receive inputs that may be considered by-products or “waste” by others. • Build relationships in the wider supply chain to drive change 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 more heavily on surface water and puddles.	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:
Dominance	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.	Seek to compete with unsustainable products and services. Support emerging entities to compete fairly with established entities.	<ul style="list-style-type: none"> • Seek to compete with unsustainable products and services. • Support emerging entities to compete fairly with established entities. Avoid using similar scarce inputs that other businesses rely upon (for example, ensure the production of biomaterials is not food competitive).
Community	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.	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 be part of a movement that empowers local communities to be an active part of the value chain? Think of:
Communication	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.	Ensure that materials stay local whilst information is shared widely and in an accessible way.	<ul style="list-style-type: none"> • 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.
Sharing	Reflect on the wealth of information that flows through root networks.	Open up and redesign intellectual property to allow for collaboration for the good of society.	<ul style="list-style-type: none"> • Open up information that is considered intellectual property to serve the good of society.
Relationships in the forest floor			
Conflict	Invasion and conflict An invasive species is a non-native organism that is introduced to a new environment and causes 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.	Use performance or access business models to sell or lease high-quality products in an accessible way.	How can you disrupt an unsustainable system through your business activities? Think of:
Fall out	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 native plant communities.	Allow thriving second-hand markets to disrupt first-hand markets.	<ul style="list-style-type: none"> • How you can use different business models such as selling performance or access to offer high-quality products in an accessible way. • Allow thriving second-hand markets to disrupt first-hand markets.
Parasitical relationships	Reflect on how quickly an invasive species can lead to a cascading effect in the wider ecosystem.	Encourage a more long-term view from investors to allow businesses to focus on ambitious ideas instead of generating immediate income.	Encouraging a more long-term view from investors to allow the business to focus on an ambitious idea.
Hostile environments			

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 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.

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”.

Table 6. Response to change.

Column 1 Interview Clusters	Column 2 Source Domain Activation Proposal (by the authors)	Column 3 Target Domain Themes Raised by Circular Economy Experts	Column 4 Prompt for Transposition onto the Target Domain (by the Authors)
Managing with a light touch	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.	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:
Feedback loops	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 what kind of feedback is available and how this could allow the business to evolve.	<ul style="list-style-type: none"> How do contexts such as the local community or the wider supply chain network affect how the business operates? Reflect on what kind of feedback is available and how this could allow the business to evolve. What kind of information is currently guiding the business?
Evolving	In addition to the examples mentioned previously, reflect on what other types of feedback or lessons would be beneficial for a tree’s evolution.	Tune into unforeseen challenges and disruptions that require businesses to respond in creative ways.	<ul style="list-style-type: none"> Tune into unforeseen challenges and disruptions that require businesses to respond in creative ways.
Sudden change	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.	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 change of the economy? Think of:
Metamorphosis	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.	Take part in a wider movement of activity to contribute towards reaching a “tipping point”. Engage with governments to set the right conditions to make a circular economy the new status quo.	<ul style="list-style-type: none"> 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 circular economy the new status quo.
Canopy	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.	Seek inviting contexts where experimentation and learning can happen.	What would you consider a progressive “microclimate” for your business to exist in? Think of:
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.	Engage with policymakers and government on how they can allow new varieties of value creation to emerge.	<ul style="list-style-type: none"> What kind of contexts would be safe for experimentation and learning to happen? How can policymakers and government support the environment where new varieties of value can emerge?
Microclimate	Reflect on how you experience the microclimate of a forest when you enter and leave the forest during a hot day.	Encourage the development of community-maintained infrastructure that can support a wide set of creative endeavours.	<ul style="list-style-type: none"> What type of community-maintained infrastructure would support creative endeavours locally?

Table 6. *Cont.*

Column 1 Interview Clusters	Column 2 Source Domain Activation Proposal (by the authors)	Column 3 Target Domain Themes Raised by Circular Economy Experts	Column 4 Prompt for Transposition onto the Target Domain (by the Authors)
Cyclical/cycles	<p>Adaptation and seasonal changes</p> <p>In the Northern Hemisphere, when the 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.</p> <p>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.</p> <p>Similar environmental cues signal to the tree when it is time to promote leaf growth in the spring.</p>	Consolidate or scale up business activities depending on the changes in legislation or supply and demand.	<p>How flexible and resilient is your business model when facing changing circumstances?</p> <p>Think of:</p> <ul style="list-style-type: none"> • 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.
Seasons	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.		
Growing			
Evolving			
Recovery	<p>Reactive change to disruption</p> <p>When a wildfire occurs, this can destroy trees, understory and other vegetation. Immediately after the event, the ecosystem appears barren and charred.</p> <p>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. However, some trees like certain pine species have seeds that require the heat of a fire to germinate.</p>	Minimise “monocultures” of businesses.	<p>What role could your business play in the recovery after a major disruption?</p> <p>Think of:</p> <ul style="list-style-type: none"> • How are you contributing to a diversity of business activity in the wider economy?
Reactive	Over time, the initial colonisers are replaced by other species and these allow more complex structures to emerge within the ecosystem.	Support and value “dormant” or niche business ideas that have possibilities to scale up or out when necessary.	
Decay	Reflect on different stages of recovery and the reaction to disruption.		

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 [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. 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 Column 3, have the potential to end up as a list and be used in a reductive manner. To mitigate this, Columns 2 and 4 are designed as a basis for interaction instead.

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 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, also 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.

However, 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.

7. Conclusions

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” and “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” and “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” and “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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Appendix A

Appendix A.1 Interview Guide

	Questions
Warming up	<u>Question 1.1</u> Could you please elaborate on your connection with natural systems and how deep this is?
	<u>Question 1.2</u> Could you please start by elaborating on your experience in the forest?
	<u>Question 1.3</u> Was this ecosystem easy or hard for you to reach? How did you get there?
	<u>Question 1.4</u> 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 (reintegrating humans with nature, dissolving boundaries, integrating the interior and exterior aspects of existence)	<u>Question 2.1</u> 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.
	<u>Question 2.2</u> What is the smallest entity and largest entity that you identified?
	<u>Question 2.3</u> Please reflect on what characterises these entities and their scale.
	<u>Question 2.4</u> Please describe when you left the forest and where you believe the forest begins and ends.

Questions

Dealing with wholeness (reintegrating humans with nature, dissolving boundaries, integrating the interior and exterior aspects of existence)

Question 2.5

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

Question 2.6

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

Question 2.7

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?

Question 3.1

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?

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

Question 3.2

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

The importance of relationship

Question 3.3

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

Question 3.4

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

Question 3.5

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

Question 4.1

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

Question 4.2

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

Question 4.3

Response to change

Would you consider the ecosystem that you visited young or old? Why?
How can you identify an old forest from a young forest?

Question 4.4

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

Question 4.5

How did the forest react to these changes?

Questions

Question 4.6

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?

Question 4.7

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

Response to changeQuestion 4.8

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

Question 4.9

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

Finish

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

Question 5.1

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

*Appendix A.2 Survey***Introduction**

The first part of this research was a qualitative enquiry which identified areas of intuitive knowledge about the forest. Shortly, you will be presented with a short explanation of each of these areas. These areas are referred to as "source domains".

We will ask you to think about where these insights can be applied to sustainability discourse. Please take liberty in how you wish to answer this question. Some examples are given to get you going, and you can always skip a question if you are not sure or you don't know.

Diversity and redundancy

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

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.

Question 1

How would you apply these insights to the domain of business in a circular economy?

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

Open nutrient networks

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 could allow the redistribution of nutrients – when a tree requires nutrients, or when there is an excess of nutrients in certain parts of the system.

Question 2

How would you apply these insights to the domain of business in a circular economy?

Many factors determine the right size of a single entity in nature. One factor that influences this is the individual 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.

Ecological niche

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.

Question 3

How would you apply these insights to the domain of business in a circular economy?

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.

Experimentation and the right conditions for life

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.

Question 4

How would you apply these insights to the domain of business in a circular economy?

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.

Communities in enmeshed layers

Reflect on how social activity has the potential to enhance nutrient flows. What would happen in an ecosystem if there wasn't this social activity?

Question 5

How would you apply these insights to the domain of business in a circular economy?

Emergence and gap dynamics	<p>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.</p> <p>Reflect on how this sudden event creates a knock-on effect that is noticeable at many levels in the ecosystem.</p>
<p style="text-align: center;"><u>Question 6</u></p> <p>How would you apply these insights to the domain of business in a circular economy?</p>	
Self-organisation	<p>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.</p> <p>Reflect on how this form of self-organisation is influenced by communication and environmental cues that allow the colony to stay in tune with contemporary conditions.</p>
<p style="text-align: center;"><u>Question 7</u></p> <p>How would you apply these insights to the domain of business in a circular economy?</p>	
Opportunism and enhancing utilisation	<p>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 ultimately settling in a new ecosystem.</p> <p>Reflect on other opportunistic relationships that you could find in natural systems.</p>
<p style="text-align: center;"><u>Question 8</u></p> <p>How would you apply these insights to the domain of business in a circular economy?</p>	
Reciprocity and interdependency	<p>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.</p> <p>Reflect on the interdependence that exists in natural ecosystems.</p>
<p style="text-align: center;"><u>Question 9</u></p> <p>How would you apply these insights to the domain of business in a circular economy?</p>	

Cooperation and co-evolution	<p>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.</p> <p>This important process contributes to the genetic diversity of the plant species. Therefore, flowering plants and pollinators have co-evolved over many years with adaptations that enhance this cooperation.</p> <p>Reflect on how deeply the survival of both pollinators, as well as flowering plants, relies on this cooperation.</p>
<p><u>Question 10</u></p> <p>How would you apply these insights to the domain of business in a circular economy?</p>	
Competition	<p>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 more heavily on surface water and puddles.</p> <p>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.</p> <p>Reflect on how competition is everywhere in a forest where there are limited resources.</p>
<p><u>Question 11</u></p> <p>How would you apply these insights to the domain of business in a circular economy?</p>	
Community and information sharing	<p>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.</p> <p>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.</p> <p>Reflect on the wealth of information that flows through root networks.</p>
<p><u>Question 12</u></p> <p>How would you apply these insights to the domain of business in a circular economy?</p>	
Invasion and conflict	<p>An invasive species is a non-native organism that is introduced to a new environment and causes 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.</p> <p>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 native plant communities.</p> <p>Reflect on how quickly an invasive species can lead to a cascading effect in the wider ecosystem.</p>
<p><u>Question 13</u></p> <p>How would you apply these insights to the domain of business in a circular economy?</p>	

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.

Evolving through feedback

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

Besides the examples mentioned previously, reflect on what other types of feedback or lessons would be beneficial for a tree's evolution.

Question 14

How would you apply these insights to the domain of business in a circular economy?

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.

Metamorphosis

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.

Question 15

How would you apply these insights to the domain of business in a circular economy?

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.

Microclimate and 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.

Question 16

How would you apply these insights to the domain of business in a circular economy?

In the Northern Hemisphere, when the 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.

Adaptation and seasonal changes

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.

Question 17

How would you apply these insights to the domain of business in a circular economy?

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. However, some trees like certain pine species, have seeds that require the heat of a fire to germinate.

Reactive change to disruption

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

Reflect on different stages of recovery and the reaction to disruption.

Question 18

How would you apply these insights to the domain of business in a circular economy?

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