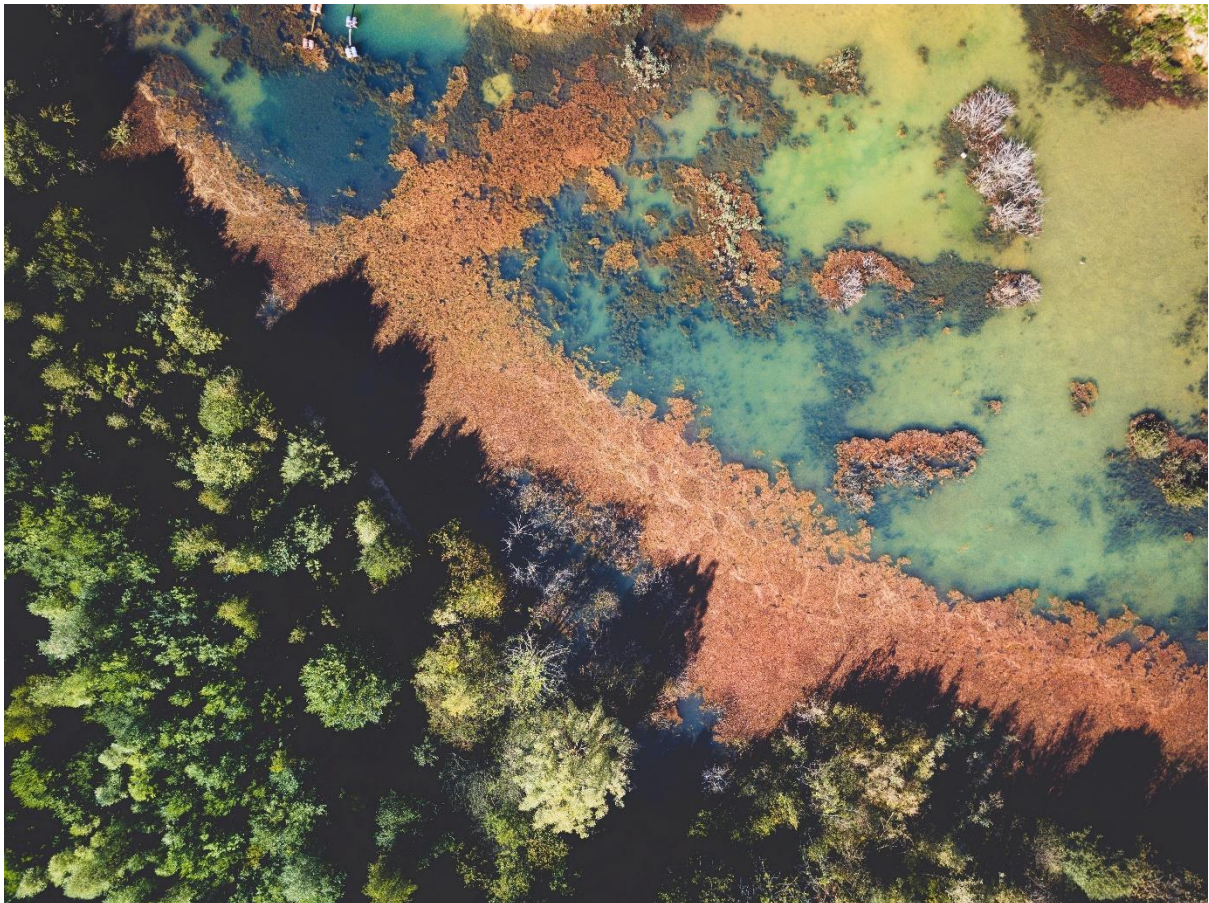


# Defining and measuring health in ecological ecosystems vs. entrepreneurial ecosystems

What can we learn from nature to make entrepreneurial ecosystems more resilient?



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## Abstract

Natural ecosystems are complex systems and scholars have been actively trying to understand them in the last years. One of the reasons there is such a high interest in understanding them is that they provide a variety of ecosystem services to humans. Because of this, it is important to monitor the health of entrepreneurial ecosystems to assure they can continuously provide those services. Also, entrepreneurial ecosystems are complex systems, that provide the human population social and economic value through the amplification of innovations, job creation, and other economic impacts. Entrepreneurial ecosystems became of great importance over the last years and have increasingly attracted the attention of policymakers, business practitioners, and academics. However, it is still largely unknown what makes some entrepreneurial networks so successful. Even though natural and entrepreneurial ecosystems are both complex systems, they also have many differences. This review looks at how health is defined and measured in both natural and entrepreneurial ecosystems. Even though both systems are fundamentally different, there are still things to be learned from nature through biomimicry. First of all, it is advisable to focus more on balance instead of growth when assessing the health of an entrepreneurial ecosystem. Furthermore, more metrics should be developed to measure the diversity and resistance of an entrepreneurial ecosystem. Interconnectedness and knowledge & resource exchange within an ecosystem and with other ecosystems should be also fostered more and also incorporated into the assessment.

## Layman's Summary

Natural ecosystems provide us with a variety of services and if we want to continuously profit from them we need to make sure that they stay healthy. For this, there needs to be a way to define and measure health in natural ecosystems. Also, businesses are connected with other key players in a complex system, the entrepreneurial ecosystem. The generation of new businesses is important to create new jobs and bring forward innovations and other economic impacts. Even though they are so important there is a lack of understanding of what makes some of those ecosystems so successful. Like in natural ecosystems there needs to be a way to define and measure health. Since entrepreneurial ecosystems are also complex systems it could be interesting to take natural ecosystems as inspiration to improve the output of entrepreneurial ecosystems. Even though natural and entrepreneurial ecosystems are both complex systems, there are also many differences. This review looks at how health is defined is measured in both natural and entrepreneurial ecosystems. Even though both systems are fundamentally different, there might be still things to be learned from nature. First of all, it could be advisable in focusing more on balance instead of growth when analyzing business environments. Furthermore, it is advisable to better foster diversity and also measure this aspect in all elements of an entrepreneurial ecosystem. Also, it should be aimed to create more connections to exchange knowledge and resources within an ecosystem and between ecosystems.

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## Introduction

In nature, an ecosystem is a community of living and non-living components that are characterized by general rules and relationships (Chapin et al., 2002). Also in entrepreneurship, it is increasingly being acknowledged that firms do not exist on their own but as part of a network, which is referred to as the entrepreneurial “ecosystem” (Colombo et al., 2019). In both cases, the output of the systems extends beyond the outputs of the individual parts of the system (Adner, 2017).

Natural ecosystems provide many services that give the human population social and economic value (Logan et al., 2020). The economic importance of ecosystem services is for example shown by a study where it was found that the modeled monetary value generated by ecosystem services in Limburg was estimated to be around €112 million in 2010, with results in an average value of €508 per hectare (Remme et al., 2015). However, those services can only be provided by a healthy well-conditioned ecosystem (Lu et al., 2015). If an ecosystem is in an unhealthy state, for example through loss of biodiversity, the capacity of available ecosystem services will be impaired (Lu et al., 2015).

Entrepreneurship can be considered a significant driver of competitiveness, and social and economic development (Xu & Maas, 2019). Entrepreneurship is important to amplify innovations, create jobs, satisfy customer demand, and other economic impacts (Xu & Maas, 2019). Having a strong entrepreneurial ecosystem can improve a region's resilience against shocks for example the closure of large local firms (Schrijvers et al., 2022). There is a positive relationship between the quality of an entrepreneurial ecosystem and its output (Schrijvers et al., 2022). Entrepreneurial ecosystems became of great importance over the last years and have increasingly attracted the attention of policymakers, business practitioners, and academics (Ianioglo, 2022). Entrepreneurial ecosystems are like natural ecosystems complex systems. However, the biological interpretation of the concept “ecosystem” is so far not taken too literally in the context of entrepreneurial ecosystems (Stam, 2015).

A ‘rainforest’ where many species grow randomly without a planned pattern was previously mentioned as a metaphor for an entrepreneurial ecosystem (Hwang & Horowitz, 2012). The rainforest will flourish the more resources are available, for which the inhabitants compete (Hwang & Horowitz, 2012). Also in entrepreneurial ecosystems, there is a fine balance between collaboration and competition (Hwang & Horowitz, 2012). Since entrepreneurial and natural ecosystems have similarities, it could be interesting to take the ecosystem metaphor more seriously and take aspects that make natural ecosystems thrive as inspiration to increase the health of entrepreneurial ecosystems.

Although looking to nature for inspiration is an ancient practice, the term, definition, principles, and processes are relatively new (Fernhaber & Stark, 2019). The term “biomimicry” was first coined in the 1990s by Janine Benyus (1997) in her book *Biomimicry: Innovation Inspired by Nature* and since then, biomimicry has received interest from scientists and businesses (Fernhaber & Stark, 2019). There are multiple key motivations leading to our fascination with nature (Fernhaber & Stark, 2019). First, we are part of nature ourselves (Fernhaber & Stark, 2019). Furthermore, nature has been designed and redesigned for approximately 4 billion years, often with great success (Fernhaber & Stark, 2019). Despite rising popularity, there are still several gaps in the implementation of biomimicry across multiple fields; specifically, much of the focus on biomimicry is product-based (Fernhaber & Stark, 2019). However, there is less attention and utilization of biomimetic concepts at the process and system-level scales (Fernhaber & Stark, 2019).



## Method

This review is about summarizing definitions of health and its measurement in natural ecosystems vs. entrepreneurial ecosystems. Overall, the following research questions were aimed to be answered:

- a. How is health defined and measured in natural ecosystems vs. entrepreneurial ecosystems?
- b. What can we learn from nature to make entrepreneurial ecosystems more resilient?

Those questions were answered through a state-of-the-art literature review. When collecting articles for the review the following search term was used in different combinations: “entrepreneur”, “ecosystem”, “health”, “measure”, “nature”, and “resilient”. Based on the output of this search and a first selection based on recency and reading the abstract interesting articles were identified, which were used for the review. A summary of the findings was reported and then compared in the “results” section and learnings were discussed in the “discussion & conclusion” section.

## Natural ecosystems as an inspiration

The word ecosystem was originally made up due to the recognition that organisms cannot be analyzed separately from their environment (Tansley, 1935). By the biological definition, natural ecosystems are systems without a sense of purpose or direction (Fernhaber & Stark, 2019). They are not static and change over time following a “mutual adjustment of their components” that directs towards the “perfect dynamic equilibrium that can be attained in a system developed under given conditions and with the available components” (Tansley, 1935; Thomas & Autio, 2020). Ecological balance can be defined as “a state of dynamic equilibrium within a community of organisms in which genetic, species, and ecosystem diversity remain relatively stable, subject to gradual changes through natural succession” (Perttu, 1995).

Natural ecosystems are self-sustaining, self-sufficient, and self-organizing and can survive with only natural inputs like water and sunlight (Marten, 2010). Most of the inputs and outputs of a natural ecosystem exchange with adjacent ecosystems however only in small amounts since ecosystems have evolved multiple strategies for holding onto materials (Marten, 2010). For agricultural ecosystems, this is a bit different since they are a combination of design by humans and design by nature (Marten, 2010). Those ecosystems use domesticated plants or animals to produce different goods for human consumption (Marten, 2010). They are not self-sustaining, since they require human input to shape them in a way that they generate maximal output (Marten, 2010). Modern agricultural ecosystems need the most inputs since they differ most from natural ecosystems, whereas traditional agricultural ecosystems are more similar to natural ecosystems by taking advantage of natural processes instead of fighting nature (Marten, 2010). Due to this mix of controlled and self-running characteristics, agricultural ecosystems could be also an interesting model to look at when finding bio-inspired ideas to improve entrepreneurial ecosystems.

## How is health in a natural ecosystem defined?

To assure we can continuously profit from welfare-improving ecosystem services, it is crucial to manage and understand those complex systems (Lu et al., 2015). There needs to be a way to assess the overall performance of the system, which can also be described as ‘health’ (Costanza & Mageau, 1999). This is crucial to formulate appropriate policies and practices (Lu et al., 2015). In the dictionary, the following definition of health can be found: “1. the condition of being sound in mind, body, and spirit; and 2. flourishing condition or well-being” (Costanza & Mageau, 1999). These definitions are quite vague and to manage the environment efficiently a more leading definition is needed, one that can be used for all complex systems at different levels (including organisms,

ecosystems, and economic systems). Schaeffer et al. (1988) simply defined ecosystem health as the absence of disease. Disease is in this case defined as the failure of the ecosystem to function within acceptable limits, which leads to a weak ability to repair itself (Schaeffer et al., 1988). Rapport (1989) later on defined ecosystem health based on three aspects: 1. vital signs and system integrity, 2. counteractive capacity, and 3. threats from stress on the environment that are influenced by social and cultural values. Costanza (1992) proposed the close link between ecosystem health and the idea of sustainability. Sustainability in this case is defined as a comprehensive, multi-scale, dynamic measure of system resilience, organization, and vigor (Costanza, 1992). Also, Mageau et al. (1995) suggested that a healthy ecosystem is sustainable and therefore can maintain its structure and function over time if it's exposed to external stress.

In those early definitions, ecosystems were often described as structurally and functionally like organisms. Ehrenfeld (1992) and Suter (1993) remarked that ecosystems are simply not organisms and therefore do not have the same properties. It is also questionable if ecosystem health is an objective scientific concept since the definition of good or bad health of an ecosystem is influenced by value judgment within society (Lu et al., 2015). Those values change throughout time, since our understanding of nature changes (Lu et al., 2015). It is therefore questionable if health as an assessment tool gives an appropriate scientific basis for managing the environment (Lancaster, 2000). Even though the standard of health is not entirely objective it can still be a useful concept in environmental management to imply specific societal goals (Lu et al., 2015).

After a couple of years of discussion, the concept of ecosystem health is now more and more accepted and applied (Lu et al., 2015). Lu et al. (2015) defines ecosystem health as “the status and potential of an ecosystem to maintain its organizational structure, its vigor of function and resilience under stress, and to continuously provide quality ecosystem services for present and future generations in perpetuity”. Based on this definition some indicators can be defined to assess the overall health of an ecosystem.

### How health is measured in natural ecosystems

Natural ecosystems are complex systems and all complex systems consist of several interacting parts of a different type, structure, and function within the system (Capra & Luisi, 2014). The behavior of a system cannot simply be summarized by adding up the behavior of the individual parts which makes it difficult to measure them (Costanza & Mageau, 1999). According to Lu et al. (2015), three important issues must be considered when assessing ecosystem health: “What are the major drivers of change in ecosystem conditions and how do they interact? How can ecosystem sustainability be achieved for the continuous supply of ecosystem services? What resilience strategies should be put in place to allow ecosystems to respond to external stresses?”.

Natural ecosystems are complex and dynamic and it is not possible to measure them directly (Logan et al., 2020). Different aspects of ecosystem health must be assessed via performance indicators (Logan et al., 2020). Most likely each indicator represents a different characteristic of an ecosystem, which means that the specifics of each indicator vary according to the scientific, economic, and management objectives (Harwell et al., 1999). However, it is still desirable to have an overall index that assimilates all the different perspectives (Logan et al., 2020). It is a big challenge to select the appropriate indicators (Logan et al., 2020). A good indicator should be “representative, easily interpreted, broadly comparable, sensitive to change and have a reference or guideline value” and for it to be useful it should be “approved by international consensus, be well-grounded and documented, have a reasonable cost/benefit ratio and ideally have adequate historical and on-going spatial-temporal coverage” (Logan et al., 2020). Jørgensen et al. (2011) proposed five criteria to

select suitable indicators to assess ecosystem health: “simple to apply and easily understood by laymen, relevant in the context, scientifically justifiable, quantitative and acceptable in terms of costs when assessing ecosystem health from a practical environmental management point of view.”

In literature different possible indicators can be found. Ecosystem health can for example be assessed by looking at three groups of indicators: vigor, organization, and resilience (Rapport, 1992). Vigor could be represented by for example productivity or metabolism, organization by for example biodiversity indices and parameters from network analysis, and resilience by for example growth range and recovery time after damage (Rapport, 1992).

Another indicator can be the level of degradation of an ecosystem (Rapport, 1992). An ecosystem in an unhealthy condition can be described by different indicators for example decline in nutrient pools, primary productivity, size distribution, and species diversity (Rapport, 1992). Kay and Schneider (1992) reflect the function and structure of an ecosystem by using the term “ecosystem integrity” to refer to the ability of an ecosystem to maintain its organization through functional and structural attributes. Rapport (1995) and Fairweather (1999) suggested that ecosystem health evaluation indicators should not only include ecological indicators at multiple levels to capture the complexity of an ecosystem, but also biophysical indicators and social-economic indicators to represent the quality and sustainability of ecosystem services provided for human society.

The resilience of an ecosystem is one of the main indicators proposed for assessing ecosystem health and refers to its ability to maintain its structure and function under stress (Costanza, 1992). An ecosystem can be considered resilient when it persists during changes in the environment and continuously provides ecosystem services to the species within (Willis, 1997). Ecosystems need to be robust, meaning capable of absorbing external shocks and maintaining the potential for innovation (Iansiti & Levien, 2004). Resilience can be measured by the capacity to rebound structurally and functionally from disturbance (Lu et al., 2015). Natural and human disturbances can lead to disrupted nutrient cycling, reduce productivity, cause the loss of biodiversity, and lead to other symptoms of ecosystem dysfunctions (Rapport et al., 1985). While resilience can be described as the capacity of an ecosystem to recover after the function got impaired, resistance means the capacity of maintaining the function of the ecosystem under stress (Whitford et al., 1999). Resistance could be measured by the survival of selected species, primary productivity, nutrient cycling, biodiversity, and symbiosis persistence while resilience could focus on the recovery rate and degree of those variables measured to evaluate resistance (Whitford et al., 1999). These aspects are also important for entrepreneurial ecosystems and it will be assessed in the next section if there are already such indicators in use for this occasion.

If the health of a natural ecosystem could not be maintained, there are three methods to recover its health: restoration, rehabilitation, and remediation (Lu et al., 2015). Restoration means returning an ecosystem to high ecological integrity for which rehabilitation is used (Lu et al., 2015). If there are fundamental changes to ecosystem conditions, the original ecosystem cannot be restored and a new ecosystem will need to be created by remediation (Catchment, 2004). In the presence of certain stressors, ecosystems undergo dramatic changes that can alter the ecosystem irreversibly which makes ecological restoration hard to be achieved (Lu et al., 2015).

There are multiple indicators to assess ecosystem health and even though natural ecosystems are far too complex to understand completely, measuring different indicator parameters can give an estimation of the health of an ecosystem which can guide stakeholders to take action if needed.

## Entrepreneurial ecosystems as they are now

Entrepreneurial ecosystems are like natural ecosystems complex systems. Heterogeneous but still complementary organizations, which together create outputs on the systems level, are part of this network (Seppelt et al., 2011). Those outputs can be seen as an analogy to 'ecosystem' services delivered by natural ecosystems (Thomas & Autio, 2020). Like natural ecosystems, entrepreneurial ecosystems 'co-evolve' through a process where the continuously changing environment & participants mutually influence and adapt to each other (Basole, 2009; Lewin & Volberda, 1999). In contrast to natural ecosystems, entrepreneurial ecosystems do have a direction and purpose, since they are used to enable "forward-moving, purpose-driven entrepreneurial productivity" (Fernhaber & Stark, 2019). Because of this difference, there has been criticism that the term ecosystem is used incorrectly as a metaphor in business (Fernhaber & Stark, 2019). On the other hand, most practitioners remark that an entrepreneurial ecosystem can never be entirely planned or directed and will grow organically which means that the development of an ecosystem is not a linear and obvious process (Meier et al., 2021).

Despite the entrepreneurial ecosystem approach becoming popular over the last years, there is a lack of accurate, credible, and comparable metrics to measure them (Leendertse et al., 2021). Entrepreneurial ecosystems are not just defined by a cluster of isolated parts, but by the connections between individuals, groups, organizations, and institutions, and because of this a holistic view is needed, one that considers the performance of individual parts as a function of the overall performance of the ecosystem (Iansiti & Levien, 2004).

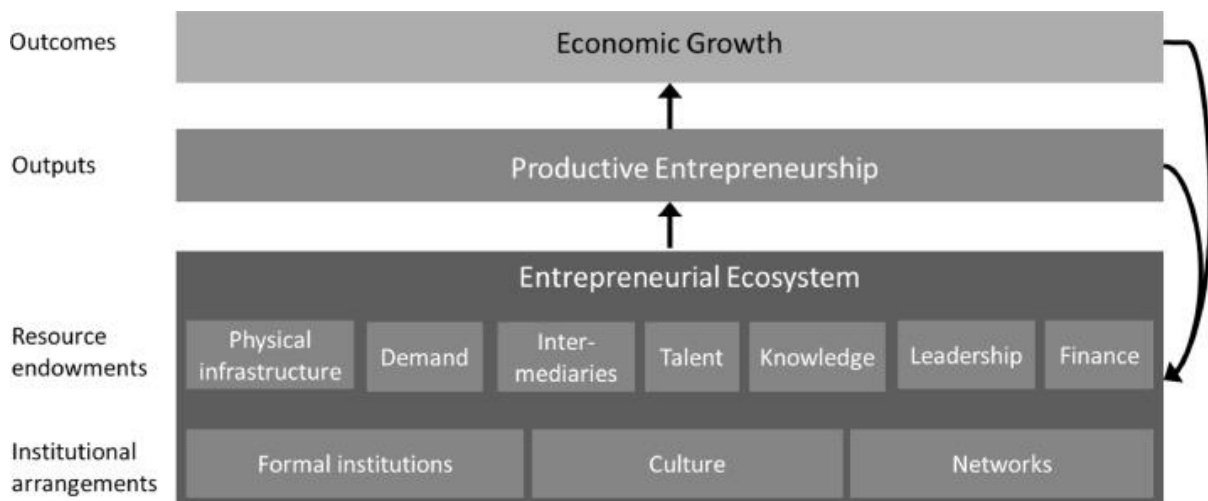


Figure 1 "Key elements, outputs and outcomes of the entrepreneurial ecosystem"(Stam, 2015)

### How is health defined in entrepreneurial ecosystems?

A healthy entrepreneurial ecosystem is said to have productive entrepreneurship as an output that results ultimately in the aggregation of value, in this case, defined as economic growth, as an outcome (Stam, 2018) (Figure 1). Productive entrepreneurship can be defined as "any entrepreneurial activity that contributes directly or indirectly to the net output of the economy or to the capacity to produce additional output" (Baumol, 1994). Productive entrepreneurship can be proxied by the prevalence of high-growth firms (Stam & Bosma, 2015), the number of registered



new firms founded less than five years ago (Leendertse et al., 2021), or the degree of internationalization of firms and innovators (Stam, 2018).

### How to measure health in entrepreneurial ecosystems

Entrepreneurial ecosystems have posed to be a useful metaphor to bridge the gap between the public and private sectors (Stam, 2018). To map the 'health' or 'quality' of an entrepreneurial ecosystem, an index can be constructed which includes ten elements (Stam, 2018): Formal institutions, culture, networks, infrastructure, finance, leadership, talent, knowledge, demand and intermediate services. The ten elements can be quantified and given a comparable value from which the index can be calculated (Stam, 2018).

For both the outcome and output of an entrepreneurial ecosystem, there are no perfect measures (Stam, 2015). A challenge in this context is that many metrics are focused on input-output systems and they then cannot tell us what is going on within the actual ecosystem (Meier et al., 2021). To optimize the entrepreneurial ecosystem, it is necessary to identify metrics that help to understand what is going on within an ecosystem (Meier et al., 2021).

The ecosystem framework shown in Figure 1 describes ten key elements of an entrepreneurial ecosystem. Based on previous literature (Stam, 2015; Stam & Van de Ven, 2021; Wurth et al., 2021) these ten elements should have the ability to capture the most essential conditions for entrepreneurship to be productive (Leendertse et al., 2021).

#### **Formal institutions:**

Formal and also informal institutions reflect the general standards within society (North, 1990). For businesses, it matters what quality and efficiency these institutions have (Stam, 2018). This can for example be assessed by analyzing surveys focused on corruption, rule of law, government effectiveness, and voice and accountability (Charron et al., 2012). In those surveys, questions focus on both experiences and perceptions of institutions within a certain region (Charron et al., 2019). Another useful indicator can be the Ease of Doing Business Index from the World Bank which includes seven elements related to business regulations at the national level (Leendertse et al., 2021). In nature there are no such things as formal institutions, therefore for this element, it does not make so much to take inspiration from nature.

#### **Culture:**

Entrepreneurship culture can give a reflection on how much entrepreneurship is valued in society (Fritsch & Wyrwich, 2014) which influences how likely people become entrepreneurs (Wyrwich et al., 2016). Empirical indicators to measure culture should be able to capture the regional entrepreneurial culture, including entrepreneurial motivation, cultural and social norms, the importance to be innovative, and trust in others (Leendertse et al., 2021).

For example, entrepreneurship culture can be measured indirectly by counting the number of newly started firms, which indicates how usual it is to start up a new business in a certain region (Stam, 2018). Also, it can be measured by how much self-employment is seen as a viable career choice and how much successful entrepreneurs are valued, however, this measurement is often not available (Stam, 2018). The Global Entrepreneurship Monitor (GEM) measured at the country level can indicate entrepreneurial motivation and cultural and social norms (Bosma, 2013). The perceived

importance of being creative and innovative can be derived for example from the European Social Survey (Leendertse et al., 2021). Also trust as a more general indicator can be important to monitor because in societies where people trust each other it is easier to have economic interactions (Zak & Knack, 2001). Trust is also an important aspect to foster connectivity (Meier et al., 2021). If an entrepreneurial ecosystem is healthy, there are “soft rules” in place that prevent moral hazards (Meier et al., 2021). Those rules are needed to create a system where people openly share their ideas (Meier et al., 2021). A common way to measure this is to conduct surveys with founders and stakeholders in the ecosystem about their willingness to openly share ideas and connect and collaborate (Meier et al., 2021). A good metric of trust might be the level of investments, as they entail a higher level of risk and are made based on the hope that future benefits will be realized (Meier et al., 2021). In nature, it was shown that diverse ecosystems are most of the time healthier, therefore a biomimetic approach could be to measure the diversity of the newly started firms and the stakeholders involved.

### **Networks:**

Alliances and partnerships between ecosystem actors facilitate the exploration and exploitation of new technological knowledge (Meier et al., 2021). Also, networking and knowledge sharing make locations more attractive for investors and new talent (Meier et al., 2021).

Networks reflect how connected businesses are and can be measured by the percentage of businesses with at least 10 employees in a region that collaborate for innovation (Stam, 2018). Another metric that explores the individual's and firms' willingness to collaborate can be for example participants in tech meetups or the number of tech meetups itself per capita (Meier et al., 2021).

International connectivity is also an important aspect of entrepreneurial ecosystems (Meier et al., 2021). The scale of international connectivity of an entrepreneurial ecosystem can be measured by proxies such as the brand perception of a start-up hub (Meier et al., 2021). Alternatively, one could look at the number of international tech conference participants or second offices of top international start-ups as a function of the connectivity of a location (Meier et al., 2021).

The interconnectedness of an entrepreneurial ecosystem is also important from the nature perspective since it assures maximal knowledge and resource sharing.

### **Infrastructure:**

This part includes both transportation infrastructure and digital infrastructure (Leendertse et al., 2021). Physical infrastructure is important to foster interactions and therefore essential for entrepreneurship (Audretsch et al., 2015). Therefore it can be a useful composite measure (Stam, 2018). Examples of indicators are the accessibility of motorways and railways and the number of passenger flights (Annoni & Dijkstra, 2013).

Due to digitalization also digital infrastructures can enable interactions (Leendertse et al., 2021). It can for example be measured by the number of households with access to the internet (Leendertse et al., 2021). Infrastructure, like networks, also contributes to interconnectedness and therefore is also important from a nature perspective.

**Finance:**

For new and small firms to grow and survive, the accessibility and supply of finance are crucial (Stam, 2018). It can be measured by the amount of venture capital per capita and the percentage of SMEs that has financial constraints (Leendertse et al., 2021). Another measure can be the amount of SMEs that applied for bank finance and received it (Stam, 2018). It can also be assessed by looking at how easy it is to get loans (World Economic Forum), the prevalence of informal investors (Global Entrepreneurship Monitor), venture capital, and crowdfunding (Stam, 2018). Looking at this element from a nature perspective can be a bit controversial. In natural ecosystems with low resource availability, there can be often a high amount of diversity and innovativeness seen. This could be also beneficial for entrepreneurial ecosystems. However, it is of course also still important to support new ventures enough and therefore find a good balance.

**Leadership:**

To provide the actors in an entrepreneurial ecosystem with a certain direction or vision to work towards and make the ecosystem function more efficiently, good leadership is needed (Normann, 2013). This can either be provided by individuals or a collective to guide the system in a certain direction (Leendertse et al., 2021). Leadership is quite an intangible concept and therefore also difficult to measure (Leendertse et al., 2021). The number of innovation project leaders can for example be taken as a measure (Stam & Van de Ven, 2021). The concept of leadership clashes with the idea of a natural ecosystem since there, there is no leader. It could be interesting to compare entrepreneurial ecosystems with differently strong leadership.

**Talent:**

Human capital, or talent, was found to be linked to new firm formation and is therefore critical for entrepreneurship (Glaeser et al., 2010). It can for example be measured by the share of the population with a higher education degree (Stam, 2018). Also, the percentage of the working population who engages in lifelong learning can be an insightful measure (Leendertse et al., 2021). The quality of business and entrepreneurship education can also give insights into human capital (Leendertse et al., 2021). In the current digital society, it is also important to include a measure for digital skills (Leendertse et al., 2021). A diverse talent pool makes sure knowledge is recombined (Isaksen & Tripl, 2016; Menzel & Fornahl, 2010). Besides the diversity of the talent pool, density is also important since it can trigger network effects and increase the innovation potential of the environment (Meier et al., 2021). This can then further attract more talented individuals who are interested in starting their businesses (Meier et al., 2021). The density of knowledge and talent can be measured using different proxies that can give an idea about how much knowledge and talent is available within the ecosystem, for example, the number of developers per capita (Meier et al., 2021). It was found that in regions with a culturally diverse population, there is a higher chance that entrepreneurs pursue an innovative rather than a replicative business model (Prenzel et al., 2022). Again here, diversity is an important part that also fits the importance of diversity in natural ecosystems.

**Knowledge:**

Investment in knowledge can be an important source of entrepreneurial opportunities and prosperity (Stam, 2018). It can be helpful to look into investments in (public and private) research and development, which can be measured by the percentage of gross domestic product invested in R&D by public and private organizations (Stam, 2018). The more investment into R&D there is the more likely it is that new knowledge is produced which can lead to new business opportunities (Leendertse et al., 2021). Diversity of knowledge, competencies, and experiences helps entrepreneurial ecosystems with capturing new opportunities embedded in the system (Asheim et al., 2011).

Several studies found specialization and diversification to be important metrics to assess the innovation capacity of an entrepreneurial ecosystem (Meier et al., 2021). Strong industrial clusters have a higher capacity to absorb technological knowledge (Isaksen & Trippl, 2016). Also, diversification plays an important role, since it facilitates cross-fertilization between various knowledge areas (Meier et al., 2021). Proxies to measure can for example be investments based on stages & sectors or diversity of projects based on business models (Meier et al., 2021).

#### **Demand:**

Purchasing power and potential demand for goods and services are important to look at since it is only interesting for entrepreneurs to bring new products to the market if the potential customers have financial means (Leendertse et al., 2021). Demand can be measured by looking at disposable income per capita and measures of potential market demand (Stam, 2018). For natural ecosystems, in contrast, demand does not change the productivity of the system, therefore for this aspect inspiration from nature does not make sense.

#### **Intermediate services:**

A healthy entrepreneurial ecosystem needs a rich set of support infrastructures to increase connectivity within the community (Meier et al., 2021). The availability of intermediate business services can lower the barriers and increase the speed of new value creation (Stam, 2018). Measures can for example be the percentage of employees in knowledge-intensive market services and the number of incubators/accelerators per capita (Leendertse et al., 2021). Incubators and accelerators support people with innovative ideas to start their own companies by providing a wide variety of services like access to a network of experts and other entrepreneurs and training in different business skills (Cohen et al., 2019). Multiple studies have shown that those institutions can substantially contribute to the success of startups (Ayatse et al., 2017; Eveleens et al., 2017).

The measures of these elements can be used to calculate an index that is an approximation of the quality of an entrepreneurial ecosystem (Leendertse et al., 2021). This can help to better diagnose, understand and improve entrepreneurial ecosystems (Leendertse et al., 2021). The essence of an ecosystem is that the elements are interacting with each other which is not adequately taken into account when an index is calculated by the sum of its elements (Stam, 2018). For this, it's better to calculate a multiplicative index (Stam, 2018). However, this is still not adequately taking into account that entrepreneurial ecosystems are complex systems. The overall functioning of a complex system cannot simply be deduced from knowledge of the individual parts (Stam, 2018). The connectivity, nonlinearity, and openness can be taken into account more adequately in future studies (Stam,

2018). There is a significant correlation between the different elements of the entrepreneurial ecosystem which illustrates the interdependencies in the entrepreneurial ecosystem (Leendertse et al., 2021). (Leendertse et al., 2021) used a network methodology to show the interdependencies between the 10 elements and found that physical infrastructure, finance, formal institutions, and talent take a central position in the interdependence web, which gives the first indication that these elements are crucial for entrepreneurial ecosystems.

## Discussion & Conclusion

Even though natural and entrepreneurial ecosystems are both complex systems, they are quite different in many aspects. By the biological definition, an ecosystem is a system without a purpose or direction. This is already fundamentally different in entrepreneurial ecosystems since they do have a purpose, namely, to increase entrepreneurial productivity. This raises the question of how a natural ecosystem can and should be taken as inspiration. If the goal is to continue with business as usual and have the goal to generate as many new successful ventures as possible, the answer is probably no. However, when looking at the current state of the planet, with the climate crisis and depletion of resources, it is important to reassess the goal of entrepreneurial ecosystems in general.

The following section aims to give some advice on which aspects of a healthy natural ecosystem and which methods to measure them could be taken as inspiration to improve the health and measurement of entrepreneurial ecosystems:

### Advice: What can be taken as inspiration from nature

#### **Balance instead of growth focus**

So far, an entrepreneurial ecosystem is viewed as healthy if it has productive entrepreneurship as an output, meaning that it generates new ventures. However, if economies continue to constantly focus on growth this is not sustainable and therefore it is advisable to investigate other metrics that define the successfulness of entrepreneurial ecosystems.

Natural ecosystems exist more or less in balance. Aiming for balance instead of growth could be an interesting approach for entrepreneurship. This could be linked to the Doughnut Economic Model, which is a visual framework for sustainable development (Raworth, 2017). Its approach to measuring the performance of an economy is looking at the extent to which the needs of humanity are met without going over the border of what the earth is capable to handle (Raworth, 2017). In this model, an economy is viewed as thriving when all twelve social foundations (food security, health, education, income and work, peace and justice, political voice, social equity, gender equality, housing, networks, energy, and water) are met without overshooting any of the nine ecological boundaries (climate change, ocean acidification, chemical pollution, nitrogen and phosphorus loading, freshwater withdrawals, land conversion, biodiversity loss, air pollution, ozone layer depletion) (Raworth, 2017). In this case, human welfare, represented by the social foundations is in balance with the load on the environment. An entrepreneurial ecosystem could be defined as healthy if there is such a balance and it could be measured by comparing defined indicators for social foundations with indicators of ecological boundaries.



### **How much support is needed?**

In nature, ecosystems automatically direct themselves to a certain equilibrium. In agricultural ecosystems, this is different because they are shaped and controlled by humans to generate a certain desired output. Due to the complex system characteristics, it is often difficult to predict the output of a certain change in the system. Also for entrepreneurial ecosystems, it is questionable how much support through finance and support institutions is needed and how much should be left to the “natural” development of this business environment. If a natural ecosystem is the source of inspiration, it would be advisable to not influence the system too much. Neither is it advisable to provide too much support since then there might be too many businesses founded. In natural ecosystems that lack nutrients, it can be often seen that there is a high amount of diversity of species. This is because the organisms there have to find innovative ways how to adapt to difficult and highly competitive conditions. A healthy amount of competitiveness forces the ventures in an entrepreneurial ecosystem to be innovative.

### **Measuring diversity**

In a natural ecosystem, biodiversity is crucial when assessing health and specifically resistance. Also in entrepreneurial ecosystems, it was found to be a measure in the “talent’ and ‘knowledge’ part, but it could be also interesting to measure in the other parts, for example also in the output. Diversity within a community of entrepreneurs can be measured by different proxies, for example, the share of female founders or foreign-born founders (Meier et al., 2021). This could show the accessibility of entrepreneurship to all people and therefore also could be defined as some form of health. Also, it could be interesting to look at how many of the created ventures tackle one of the SDGs or incorporate practices on how to give back to the ecosystem.

### **Measuring resistance**

One of the newer definitions of natural ecosystem health is s “the status and potential of an ecosystem to maintain its organizational structure, its vigor of function and resilience under stress, and to continuously provide quality ecosystem services for present and future generations in perpetuity”. This could have been an interesting aspect of health to measure in entrepreneurial ecosystems. The Covid-19 pandemic had a massive impact on entrepreneurs and it can be insightful to measure how companies in different ecosystems managed to survive and then define the health of the respective entrepreneurial ecosystem based on the analysis. For example, the quick adaptation to the online work environment showed that companies who are better at innovating can better stay alive in more difficult conditions.

### **Increasing interconnectedness with other ecosystems**

In nature, many ecosystems are interconnected. Most of the inputs and outputs of a natural ecosystem exchange with adjacent ecosystems however only in small amounts since natural ecosystems have evolved multiple strategies for holding onto materials (Marten, 2010). This could be also an interesting strategy in entrepreneurial ecosystem management, to think of strategies about how to, first of all, keep materials and other resources cycling within the ecosystem to

maximally profit from it. When it is not possible internally it is advisable to investigate how inputs from other business ecosystems can be used and how outputs can be made available to others. Therefore health should not only be defined by a certain economic output but also by how much the ecosystems contribute to the environment and the people involved.

Also, an interesting approach could be to develop a model that interlinks entrepreneurial and natural ecosystems and analyze how entrepreneurial ecosystems integrate and interact with natural ecosystems. For long time management practices neglected the negative environmental effects of entrepreneurial activity. However, also consumer awareness changes and corporate sustainability can even offer a strategic competitive advantage (Braun et al., 2021).

Industrial ecology criticizes the over-exploitation behaviors of the current “take-make-waste” culture. Inspiration from nature is used to explore how systems can be more interconnected in a way that the waste of one part of the ecosystem can serve as input for another. A helpful tool to practice this approach is instead of encouraging founders to use the regular business model canvas to use the circular business model canvas. Circular business models aim to sustainably decouple economic growth from resource consumption and incorporate value creation across the boundaries of the company (Braun et al., 2021).

### **Restoration strategies**

In natural ecosystems, unhealthy conditions can be described by different indicators for example decline in nutrient pools or species diversity. It could be also interesting to define such indicators for entrepreneurial ecosystems to have some alarm threshold that stakeholders could act upon if they are passed under a certain value. For natural ecosystems, there are three methods to recover ecosystem health: restoration, rehabilitation, and remediation. For entrepreneurial ecosystems, it could also be interesting to develop strategies about how the system can be brought back to a healthy state after some disturbance, for example, the Covid-19 pandemic.

### **Challenges**

The problem with both entrepreneurial and natural ecosystems is that for many elements there are no measures available yet. So to fully understand and predict those systems it is needed to define and measure far more aspects of the system. Due to the interconnectedness, it is also needed to have a more systemic view of the health of an ecosystem in general.

It is known that both natural and entrepreneurial ecosystems are not static, they change over time. There has been criticism that the concept of entrepreneurial ecosystems is especially undertheorized concerning the evolution of the ecosystems (Cantner et al., 2021). The literature so far is lagging in the theoretical foundation of the development and change of entrepreneurial ecosystems over time (Cantner et al., 2021). It also does not consider the dynamics that lead to the creation, growth, maturity, decline, and re-emergence of entrepreneurial ecosystems (Cantner et al., 2021). Far more research on this area is needed.

Much of the focus on biomimicry so far is product-based and there is less attention and utilization of biomimetic concepts at the process and system-level scales. Therefore it is challenging to apply it to complex systems like entrepreneurial ecosystems. However, it is worth trying it out as we just cannot continue with business as usual.

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