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Live or let die?

Incorporating resilience thinking into biodiversity impact measurement

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RSM - a force for positive change

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Executive summary

Global biodiversity is approaching a breaking point. Currently, 25% of global biodiversity is threatened and if trends continue, up to 1 million species can face extinction in the decades to come (Díaz et al., 2019). Not only is biodiversity essential for the functioning of our planet's ecosystems, but it also provides crucial services which our society depends on. Consequently, biodiversity loss and ecosystem collapse represent one of the gravest dangers threatening our society today (Franco, 2020).

Sadly, organizations have played an important role in global ecosystem deterioration and biodiversity loss. However, as public awareness grows, organizations are increasingly being called upon to measure and reduce their ecological footprint (Smith et al., 2019). Unfortunately, as highlighted by Addison et al. (2019), only few organizations are currently doing so. Instead, the financial sector is taking the lead. Coming to terms with the material risk posed by biodiversity loss, financial institutions are developing methodologies that allow them to measure the biodiversity footprint of their portfolios. By gaining an insight into their own indirect biodiversity footprint, financial institutions can commence engagement efforts with organizations that have a large biodiversity footprint. As a result, in the absence of biodiversity reporting legislation, financial institutions can take it upon themselves to regulate and monitor biodiversity impact across the different sectors of the economy (Mulder & Koellner, 2011).

Importantly, there has been no organizational literature investigating the presence of resilience thinking in these corporate biodiversity impact methodologies. By analyzing a socio-ecological system from a resilience lens, biodiversity qualities can be identified which can help safeguard ecosystem stability in the face of change and disturbances. Consequently, any biodiversity impact methodology, may it be managerial or scholarly, lacking a resilience theory lens is thereby overlooking important information regarding the value and function of biodiversity. In the light of this research gap, a qualitative study was conducted which focused on how organizations can incorporate resilience thinking into their biodiversity impact measurement.

In order to answer the research question, a holistic single case study of ASN Bank's 'Biodiversity Footprint for Financial Institutions' (BFFI) methodology was conducted. By taking an abductive reasoning form and approaching the question from a Naturalist perspective, this study was interested in finding if and how resilience thinking occurred in the BFFI methodology. Data was collected through in-depth semi-structured interviews and a documentary analysis. In total, ten interviews were conducted with five experts, who were interviewed twice. The interviewees represented the different organizations which were involved in the development of the BFFI methodology. Two interviewees worked at ASN Bank, one at CREM, one at PRé Sustainability and one at the Radboud University Nijmegen. Data was analyzed using a thematic analysis, as described by Braun & Clarke (2006), after which a final theoretical process model was constructed by the researcher. Finally, two validation interviews were conducted in which the findings were shared with the interviewees.

The result of this thesis suggest that aspects of resilience thinking can be incorporated in a corporate biodiversity impact methodology. Before a methodology can start to consider resilience mechanisms, a balance first needs to be struck between the forces of desirability, suitability and feasibility. The interplay between these forces decides the complexity, scope and ultimately the data constraints of the methodology. The decisions made in this stage will have a fundamental influence on the resilience thinking capacity of the methodology. Once a balance has been struck, the process model provides organizations with two examples of strategies which allow for resilience insights. Firstly, through the use of proxies, an organization can consider organismal abundance and panarchy. By measuring total ecosystem biodiversity and the health of lower trophic levels, an organization can roughly analyze ecosystem quality and resilience. The second strategy is complementary to the first, as it helps to improve the impact score quality. By considering an ecosystem's geographic sensitivity, actively eliminating biodiversity drivers through investments policies and making steps to measure their avoided impacts, an organization can improve the accuracy and reliability of the proxy insights. Taken together, these strategies can provide an insight, although limited, into the impact of an investment on ecosystem resilience.

Importantly, this study contributes to the current literature in a number of ways. First, by approaching organizations with a resilience lens, this study has attempted to include a much needed natural science perspective into the organizational sciences. Furthermore, this thesis gives a first insight into how a methodology can take into account resilience thinking and how it can be operationalized in practice. This should signal to the organizational literature that a 'bridge' between the academic domains can be built and that cooperation between the research domains can be further developed. Furthermore, the results also have profound managerial implications. Notably, the final process model encourages management to educate stakeholders and clients about the importance of resilience thinking. By combining this with a more equally distributed cost and effort structure, an impact methodology can start increasing in complexity and thereby improve its ability for resilience thinking. Secondly, by providing insight into the two different strategies, management can potentially start incorporating these steps into their own methodologies. In the case that certain sections of the methodology are outsourced, the two strategies provide initial criteria which management can use to select and evaluate the tools available to them. All in all, the result of this thesis help management consider crucial ecosystem qualities which can help safeguard global biodiversity for generations to come.

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1 Abstract

The level of diversity around the world has rapidly deteriorated in recent years. Numerous species have already gone extinct and many more are set to go extinct if the current trends persist. With businesses playing a large role in this deterioration, organisations increasingly face pressure to measure and reduce their ecological footprint. Nonetheless, there are few studies that focus on resilience thinking as a pillar of biodiversity impact measurement. This study aims to close this research gap.

The results of this study imply that it is possible to incorporate certain aspects of resilience thinking in biodiversity impact measurement. In order to create a solid methodology, researchers have to find a balance between the forces of desirability, suitability and feasibility. When researchers find the appropriate balance, the process model provides proxies and strategies that improve the accuracy and reliability of impact scores. These two outcomes of the model can provide insights into the impact of an investment on ecosystem resilience.

2 Terms & concept definitions

Ecosystem: the dynamic process in which organisms interact as a functional unit, together with the non – living environment. (OECD, 2019)

Biodiversity: "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (United Nations, 1992, pg 3).

Ecosystem services: the goods and services produced by biodiversity (UNEP FI, 2008) . These services including regulating (e.g soil fertility by microorganisms), production (e.g cultivation of food) and creating a positive impact through its cultural value (e.g recreational purposes) (de Knegt et al., 2014; UNEP FI, 2008).

Functional Biodiversity: a group of organisms that play a critical role in the provision of ecosystem services (Deutsch et al., 2003).

Responsive Biodiversity: the biodiversity within a functional group that contribute to the provision of the same ecosystem service (Folke et al., 2004).

Functional Redundancy: the ability of an ecosystem to compensate for species extinction within a functional group, thereby maintaining the provision of ecosystem services (Walker, 1992).

Keystone Species: a species that has a proportionally large influence on ecosystem functioning, relative to its abundance (Dodds & Whiles, 2019)

Spatial variability: the distribution of a species population across a landscape (Biggs et al., 2012)

Adaptive Cycles: an adaptive cycle describes the phases of growth and decay in a system and attempts to capture the complexity and dynamics of its structures (Garmestani & Benson, 2013)

Panarchy: the concept of adaptive cycles being nested together and influencing across different spatial and time scales (Allen et al., 2014).

3 Topic and relevance

"Global warming may dominate headlines today. Ecosystem degradation will do so tomorrow."
(Hanson et al., 2012, pg 2)

Our planet has developed ecosystems in every imaginable type of environment, from the scorching Saharan deserts to the lush rainforests of the Amazon. For an extended period of time, organizations have been exploiting ecosystems as a source for nutrition and materials, seemingly with the idea that these resources could be harvested without limit. However, as we are currently living in an age of resource shortages and climate change, humankind has discovered that we might be pushing our ecosystems to a global threshold, with far reaching socio-economic effects as a consequence (Newbold et al., 2016; World Economic Forum, 2020). The resilience of our ecosystems to change is highly reliant on the diversity of organisms, known as the biodiversity, that live and interact within them (Díaz et al., 2019).

Organizations are heavily reliant on the stability of ecosystems and their biodiversity. Through interactions within their ecosystem, organisms produce what are known as ecosystem services, which humans can then consume or utilize. Examples of ecosystem services include pollination by bees and soil fertility regulation by micro-organisms (de Knegt et al., 2014). Strikingly, the World Economic Forum calculated in their latest report that more than half of the world's GDP, $44 trillion in economic value, is dependent on ecosystems and the services they provide (World Economic Forum, 2020). This is compounded by Reale et al. (2019) who found that approximately 40% of all the goods traded in the economy today originate from biodiversity. Especially sectors such as construction, agriculture and food & beverages require ecosystem services such as clean water and healthy soils (World Economic Forum, 2020). It becomes clear that the welfare of organizations and the economy are therefore closely interlinked with the state of ecosystems and their biodiversity.

Unfortunately, according to the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES), the world's leading biodiversity monitor, global ecosystems are reaching a breaking point (Díaz et al., 2019). Earth's major terrestrial biomes have seen a decline of 20% in the number of their native species (Díaz et al., 2019). Furthermore, 25% of global species of animals and plants are threatened and up to 1 million species can face extinction in decades if urgent action is not undertaken (Díaz et al., 2019). According to the World Economic Forum, in its latest Global Risk Report, biodiversity loss and ecosystem collapse is even within the top three global risks based on impact and likelihood of occurring, thereby presenting a greater threat then both interstate conflict and water crises (Franco, 2020)

Sadly, organizations have played an important role in global ecosystem deterioration and biodiversity loss. Reade et al. (2015) states that any decision an organization makes has an impact on the environment, whether they know it or not. Through their direct consumption and indirect impacts, such as pollution and invasive species, organizations have helped push global biodiversity to the edge (Díaz et al., 2019; OECD, 2019; Reade et al., 2015; World Economic Forum, 2020). However, as awareness grows, organizations are increasingly being called upon to measure and reduce their ecological footprint (Smith et al., 2019). A study by Addison et al. (2019) investigated the sustainability reports of the top 100 largest firms, by revenue, and found that roughly half of them mentioned biodiversity, however, only five firms had a clear strategy for improving biodiversity which was both time bound and measurable. Reade et al. (2014) notes that biodiversity is still difficult to grasp for organizations due to its unclear interlinkages and low visibility. In addition, there is currently limited knowledge amongst corporate leaders regarding the risks associated with biodiversity loss (Winn & Pogutz, 2013). This is highlighted by Reale et al. (2019) who found that Brazilian organizations most reliant on the stability of local ecosystems and their services, for example dams and electrical facilities, were not doing enough to restore or protect these biomes. Strikingly, it was found that all the actions conducted by the Brazilian organizations in question were not done on their own initiative, but instead to stay within the boundaries of the law (Reale et al., 2019). Both Addison et al. (2019) and Reale et al. (2019) highlight that biodiversity is increasingly being adopted in the corporate lexicon, however too little is currently being done to effectively measure and act on an organization's ecological footprint.

Increasingly, the financial sector, acknowledging that they can have a large indirect ecological footprint through their investments, is pioneering the development of biodiversity foot printing methods and tools (ASN, 2016; Bor et al., 2018; Mulder, 2007). Financial institutions are starting to realize that biodiversity loss can be a material issue and if not acted on can result in investment, reputational, legal and regulatory risks (Suttor-Sorel, 2019; van Tilburg & Achterberg, 2017). Therefore, in order to manage risks to their investments, financial institutions are developing comprehensive methods to calculate the biodiversity footprint of their portfolio. Following these insights, they can alter their lending policies and possibly persuade organizations to significantly improve their biodiversity impact (Mulder & Koellner, 2011). This means that even without the presence of a strict legislative system that stimulates biodiversity conservation by organizations, as highlighted by Reale et al. (2019), financial institutions can take it upon themselves to regulate the various sectors of the economy (Mulder & Koellner, 2011).

Different frameworks and measurement systems, such as the LIFE certification, are available to financial institutions to measure the biodiversity footprint of an organization (Boiral, 2016; Mulder & Koellner, 2011; Reale et al., 2016). In addition, technological advances have allowed off-site assessment tools, such as LEFT and ENCORE, to become increasingly valuable as a local biodiversity assessment tool (Willis et al., 2015). However, in order to effectively screen their investment portfolios, potentially containing hundreds of different companies, financial institutions are developing their own, indirect, biodiversity impact methodologies (Berger et al., 2018). Importantly, to date, the organizational and management literature has paid little attention to the mechanics of direct and indirect methodologies and whether they analyze corporate biodiversity impact from a resilience theory lens.

The resilience of a socio-ecological system is defined as its ability to recover from a disturbance and reorganize while still remaining in the same dome of attraction (Beisner et al., 2003; Folke et al., 2004; Walker, Holling et al., 2004). By analyzing a socio-ecological system from a resilience lens, biodiversity qualities can be identified which can help safeguard ecosystem stability in the face of change and disturbances. Considering the intensifying anthropogenic pressures experienced by environments across the globe, ensuring for ecosystem resilience is becoming increasingly important. As a result, this thesis believes that any biodiversity impact methodology, may it be managerial or scholarly, lacking a resilience theory lens is overlooking important information regarding the value and function of biodiversity. This, in return, can result in a under representation of the true biodiversity impact inflicted by an organization and reduce the effectiveness of an organization's conservation efforts.

This thesis will seek to gain insight into how financial institutions measure their indirect biodiversity impacts. Specifically, the emphasis will lie on if and how financial institutions approach their indirect measurement using a resilience theory approach. For the case study, this research will be focusing on the Biodiversity Footprint Financial Institutions (BFFI) framework constructed by ASN; a Dutch bank with the ambition to have a net positive impact on biodiversity by 2030 (Berger et al., 2018). This framework is currently one of the most comprehensive in the world and is one of the few which concentrates on biodiversity foot printing on an investment portfolio scale (Berger et al., 2018). By concentrating on the BFFI framework, this thesis hopes to answer the following research question:

How can organizations incorporate resilience thinking into biodiversity impact measurement?

By taking an abductive angle and utilizing a revelatory single case study, this thesis aims to develop theory on how organizations can include resilience thinking into biodiversity impact measurements. The following report will be structured as followed. Section 4 will start off by providing a literature review on resilience thinking and identify how different ecosystem characteristics can promote or hinder ecological resilience. This is followed by an exploration of the interlinkages between biodiversity and organizations. Finally, the organizational literature on biodiversity impact measurement is reviewed and the subsequent research gap is identified. Section 5 provides an overview of the thesis methodology and is followed by Section 6 which outlines the basic structure of the BFFI. Finally, Section 7 provides a thick and detailed account of the research findings and Section 8 presents the final process model created by the researcher. This thesis will finish by providing recommendations on how resilience thinking can be further incorporated into biodiversity impact measurement.

4 Literature review

The following literature review is split into two topical sections; the natural sciences (4.1-4.7) and the organizational literature (4.8). The first section (4.1-4.7) introduces readers to the fundamentals of resilience thinking. This is then followed by a hierarchical overview of qualities and concepts, within the field of ecology, that influence the resilience of ecological systems. The aim of the first section is to provide an overview of the different ecosystem qualities which biodiversity foot printing methodologies can incorporate in order to foster resilience thinking. The natural sciences section consists of six sub chapters which focus on the following resilience principles: organismal abundance, functional and response biodiversity, functional redundancy, keystone species, spatial variability, connectivity, complex adaptive systems and panarchy.

The second section (4.8) approaches biodiversity from the organizational literature and highlights why biodiversity, and its subsequent loss, are material for business. Following a chapter that illustrates the urgency of biodiversity loss, a review is conducted which explores how biodiversity impact measurements has been studied in the organizational literature. In this section, the research gap is identified and, finally, the theoretical contribution of this thesis is showcased.

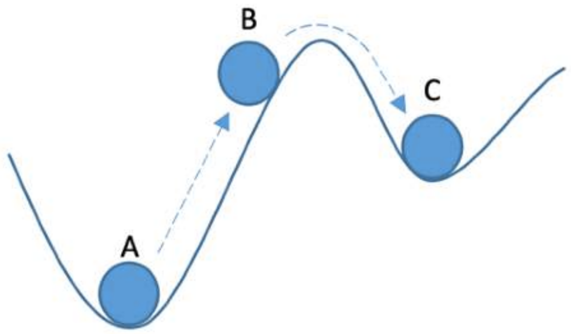
4.1 Resilience thinking

There are different ways of interpreting the term resilience in practice. According to Carpenter et al. (2001), definitions of resilience can include the capacity of a system to undergo change, while keeping its basic functionality or the ability of a system to resist change and return to its equilibrium position (Carpenter et al., 2001). Within this thesis, resilience is defined as the ability of a system to recover from a disturbance and reorganize while still remaining in the same dome of attraction (Beisner et al., 2003; Folke et al., 2004; Walker, Holling et al., 2004). A heuristic method of illustrating a systems resilience is through the position of a ball, representing the state of the system, on a landscape defined by the system parameters (Figure 1). When the ball is found in a stationary position at the bottom of the basin, then a stable state is reached in which ecosystem conditions remain constant.

Following a direct change to the system state or parameters, the ball can move up or down the landscape and potentially pass a threshold in which it rolls into a stable state. This process is known as a regime shift and can potentially lead to a new desirable or undesirable steady state (Beisner et al., 2003; Gunderson, 2000). A well-documented example of an undesirable regime shift is the eutrophication of Florida Bay in the early 1990's. Following the destruction of seagrasses in the bay, the once clear waters shifted to a turbid state dominated by algae blooms.

This was the result of changes to the system parameters, such as nutrient cycling and sea level change, and pressure to the system state through the removal of grazers (Groffman et al., 2006). Being able to predict thresholds is therefore crucial to ecosystem management. By acting with a precautionary principle in mind and avoid passing thresholds, the high-stake consequences of a regime shift can be avoided.

FIGURE 1: SYSTEM SHIFT



Note: The system is initially stable at point A, However, as system conditions change, the system state starts to move to point B. Once the threshold if exceeded, the system will roll to a new stable state at point C.
Source: Author, adapted from Beisner et al. (2003)

Importantly, the stable state of a system can exist in more than one dome of attraction within the limits of the parameters. As the values of a parameter change, the location and characteristics of the steady state conditions will move across the landscape. This concept is appropriately captured by Folke et al. (2016, pg 2) who states that "shifting pathways or basins of attractions do not take place in a vacuum". For example, following a disturbance, the steady state will not necessarily move in reverse along its original course, even if the parameter values go back to their initial condition. This is known as hysteresis and it is an important characteristic of alternate stable states (Beisner et al., 2003; Gunderson, 2000). The ability of a system to return to a stable state is dependent on the width of the basin and the steepness of the slope (Beisner et al., 2003), which are referred to as a system's latitude and resistance (Folke et al., 2004). Latitude, which is related to the width of the basin, refers to the maximum amount of change a system can endure without moving to a new basin of attraction. Resistance, on the other hand, is related to the steepness of the system slope and describes the ease or difficulty of moving the system up or down (Walker et al., 2004). The steeper the slope, the bigger the disturbance or change will have to be to move the system to a new basin. Together, the resistance and latitude of a system state influence the precariousness or proximity of the system to a critical threshold and possibly a new, undesirable, stable state (Beisner et al., 2003; Elmqvist et al., 2003; Winn & Pogutz, 2013).

Resilience theory is valuable to understanding ecological systems and managing them to handle disturbances. However, even with various methods available, as described by Brand (2009), determining the location of ecological thresholds in practice is difficult and can be uncertain (Beisner et al., 2003). This is further compounded through the presence of multiple stable states and the existence of nonlinear relationships.

4.2 Organismal abundance

There is general agreement in the scientific community that biodiversity plays a critical role in ensuring the resilience of an ecological system (Brand, 2009; Elmqvist et al., 2003; Folke et al., 2004). Importantly, different field experiments have shown that ecosystems with a high biodiversity can achieve a larger biomass and potentially be more resilient compared to systems with a low biodiversity (Downing et al., 2012). This phenomena, known as the diversity-stability hypothesis, is highlighted by the work of Tilman (1996) who measured the above-ground biomass of different plant plots, with varying degrees of biodiversity, over a 11 year period. During times of drought, Tilman (1996) found that higher species diversity had a positive impact on the plot’s resistance to perturbation. Importantly, a higher species diversity is also associated with a higher genetic diversity, which can influence the ability of an ecosystem to resist disease and disorders (Hughes & Stachowicz, 2004; van Helden, 2011). Measuring the total diversity of an ecosystem, known as organismal abundance, could therefore give a preliminary overview of the resilience on an ecosystem. Any decrease in the overall ecosystem diversity, for example through a extinction of a species, can be an indicator that the overall resilience of an ecosystem is decreasing (Hill et al., 2018; Hughes & Stachowicz, 2004). As noted by Gaston et al. (2000, pg 39), a species extinction event represents the “tip of the iceberg of population decline” and can be viewed as a signal for a large range of cascading processes within the ecosystem.

However, there are studies that question the diversity-stability hypothesis. Within the conservation literature, there is a growing consensus that high species biodiversity does not always equate to a more resilient ecosystem and vice versa (Côté & Darling, 2010; Elmqvist et al., 2003). This principle is clearly distinguishable in a review study conducted by Côté et al. (2010), who investigated whether degraded or pristine coral reefs were more resilient to the detrimental effects of climate change. Within the study, the pristine coral reefs were found in protected areas and it was expected that due to the higher levels of biodiversity, the reef would be more resilient to thermal stress. This would then translate into lower levels of coral bleaching and bleaching induced mortality. However, strikingly, it was concluded that thermal stress had a proportionately larger negative influence on the health of the pristine reefs compared to the unprotected and degraded reefs. Côté & Darling (2010) concluded that, due to the protected status of the pristine reefs, the reefs were able to develop a higher abundance of thermally sensitive corals. As a result, the biodiversity of the reef increased, however there was no visible effect on the resilience of the system once the effects of thermal stress and climate change were considered. This has significant implications on the management of socio-ecological systems, as it means that solely protecting the local environment and regenerating the original species could in fact be reducing the resilience of the ecosystem to factors such as climate change. Furthermore, an area with a high level of biodiversity might seem resilient, however in practice, the ecosystem could be fragile and prone to a regime shift following the introduction of an organizational ecological footprint. The problem associated with the diversity-stability hypothesis is summarized by Cernansky (2017, pg 23) who states that concentrating solely on organismal abundance is akin to "listing the parts of a car without saying what they do". When the car starts breaking down, we are left scratching our head wondering what went wrong inside.

4.3 Functional and responsive biodiversity

Instead of focusing on increasing overall biodiversity, Elmqvist et al. (2003) argue that to assess ecosystem resilience, management needs to concentrate on two forms of diversity; functional group and functional response diversity. According to Deutsch et al. (2003, pg 212), functional diversity is any organism in an ecosystem that "pollinate, graze, pre- date, fix nitrogen, spread seeds, decompose, generate soils, modify water flows, open up patches for reorganization and contribute to the colonization of such patches". An example of a species that fulfills such a functional role is the African Elephant. Through their grazing activities, African Elephants create clearings in the landscape which then allow tree regeneration. Furthermore, multiple plants have developed seeds which can only germinate once they have passed through the digestive track of the elephant. Strikingly, it has been estimated that roughly one third of trees species in West Africa rely on elephants for their seeds dispersal (Nunez & Dimarco, 2012). Functional groups form the basis of the ecosystem services which humanity can enjoy.

Any loss in functional groups within an ecosystem can severely impact the ability of an ecosystem to reorganize following a disturbance or change (Deutsch et al., 2003). Importantly, within functional groups, you have different species which contribute to the same ecosystem function. This diversity in organisms and their corresponding responses to environmental change is known as response biodiversity (Folke et al., 2004). Species found in the same functional group could have different responses to the same disturbance or change in the system. An example of the importance of functional and responsive biodiversity can be found in the disappearance of the seals, sea lions and otters in the North Pacific Sea (Springer et al., 2003). Spring et al. (2003) proposes that intensive hunting of the great whales, since WW2, led to a drastic reduction in the number of prey for the killer whale. As a result, the Killer Whales started to more frequently predate on seals and otters closer to the coast. Within the local ecosystem, the seals and otters were part of a functional group which was responsible for removing and controlling the sea urchin population which fed on the local kelp forests. Importantly, Springer et al. (2003) found that in areas where there was lower sea urchin predator diversity, thereby a lower responsive biodiversity, the shift from the kelp forest to a sea urchin dominated landscape occurred quicker and more sudden. This contrasted to areas where there was the presence of other urchin predators, next to the seals and otters. In these areas, consumption of the kelp forest was significantly lower, and, in many cases, there was no shift to an urchin dominated landscape. A higher responsive biodiversity within the functional biodiversity, therefore contributed to the kelp forests being more resilient (Springer et al., 2003).

4.4 Functional redundancy and key stone species

Functional and responsive diversity highlights the importance of conserving species that contribute to building ecosystem resilience. The disparity in the importance of species is accurately captured by Walker (1992, pg 20) who states that "ecologically, all species are not created equal". Regrettably, this means that, if current global biodiversity trends continue, management might have to start considering which species are worth conserving, based on their role in maintaining ecosystem resilience. Walker (1992) pushes the idea that instead of concentrating on preserving biodiversity that acts as "passengers", thereby not filling an important role in the ecosystem's stability, it is more effective to focus on protecting functional groups that act as "drivers" in an ecosystem (Walker, 1992, pg 20). In order to effectively conserve functional groups, it is important that species can compensate each other if lost. Walker (1992) coins this system property as functional redundancy.

Functional redundancy is based on the observation that some species complete near identical functional roles. If there are many species which contribute to the same ecosystem function, then a loss of a species will have little consequence, as there are other species that respond to fill the gap (Dodds & Whiles, 2019; Nunez & Dimarco., 2012). Importantly, it must be stressed that functional redundancy is different than response diversity. While response diversity encompasses the organisms and their responses to a disturbance, functional redundancy is a system property that describes the ability of an ecosystem to compensate for the loss or failure of a system element (Biggs et al., 2012).

The concept of functional redundancy is well observed in studies that concentrate on microbial systems (Jurburg et al., 2015; Stilianos et al., 2018). For example, hundreds of different hydrogen oxidizing microorganisms can be found coexisting with each other in ground water. The loss of a single species of microorganism will therefore have little repercussions for the hydrogen oxidizing capabilities of the system (Louca et al., 2018). Furthermore, functional redundancy can also be observed in seed dispersal within Ugandan rainforests. Within the rainforest, seed dispersal is completed by a wide spectrum of different mammals, ranging from mice to chimpanzees. While the smaller mammals might be more heavily effected by local disturbances, the larger mammals (such as the chimpanzees) are more mobile and can therefore stabilize seed dispersal beyond the local disturbance (Biggs et al., 2012). Importantly, it must be taken into consideration that species redundancy is related to how broad the ecosystem function is. For example, compared to specialist microbe functions such as sulfate respiration, broad functions like oxygen respiration and photo autotrophy seem to be more resistant to taxonomic change (Jurburg et al., 2015; Stilianos et al., 2018).

Managing for functional redundancy improves ecosystem resilience (Biggs et al., 2012; Jurburg et al., 2015; Walker, 1992). However, this also means that the loss of a species in a functional group, with a lower redundancy, will have a larger negative effect on the ecosystem (Rosenfeld, 2002; Walker, 1992). Species that have a proportionally large influence on ecosystem functioning, relative to their abundance, are considered to be keystone species (Dodds & Whiles, 2019; Martin et al. 2012). Notably, the concept of key stone species was established by Professor Robert T. Paine with his removal experiment of the sea star (*Pisaster ochraceous*) on the coast of Makah Bay, Washington. Paine found that the removal of the sea star, which was responsible for controlling mussel populations, resulted in the local ecosystem losing roughly half of its resident biodiversity. This groundbreaking experiment showed that the sea star was in fact part of a functional group with a low redundancy. As a result, when the sea star was lost, the functional gap could not be filled by another species and therefore the aquatic ecosystem started to destabilize (Nunez & Dimarco, 2012; Paine, 1966). As found in the name, a key stone species therefore plays a key function in maintaining ecosystem resilience (Biggs et al., 2012). Importantly, while often so, a keystone species does not solely have to be a top predator in the ecosystem. According to Mills et al. (1993), keystone species can also be prey, a specific plant, a mutualist or an ecosystem modifier. An example of a keystone ecosystem modifier is the detritivorous fish *Prochilodus mariae*. Through its feeding activity, the *Prochilodus mariae* removes sediments from the river floor. This significantly reduces algae growth. Astonishingly, even though there was a high diversity of fish in the system (up to 80 different species), the experimental removal of *Prochilodus mariae* led to large algae blooms and alterations in the ecosystem's carbon flux (Dodds & Whiles, 2019).

While it was not the intention of Walker (1992), the concept of functional redundancy implies that species performing similar functions are redundant and can therefore be lost at a minimal cost (Rosenfeld, 2002). This would justify solely concentrating on redundancy in functional groups, thereby sacrificing the 'passenger' species in the process. Instead, Rosenfeld (2002) states that managing for functional redundancy should be viewed as an important tool to justify and prioritize the protection of a particular species. If a species belongs to a functional group with low redundancy, such as a keystone species, then its preservation should be prioritized above a group with high redundancy. By doing this, you will be managing for resilience in the ecosystem and its biodiversity.

Unfortunately, using functional redundancy in conservation practices has been proven to be difficult. There is still wide discussion about what constitutes a functional group and when species are said to be redundant. According to Loreau (2004), functional redundancy is frequently compared to functional complementarity. While complementarity implies slight differences in niche and resource consumption, redundancy requires that species must overlap in both their environmental tolerances and population level functional effects (Jurburg et al., 2015; Loreau, 2004). Furthermore, while removal experiments are effective, determining a key stone species still requires an extensive overview of the food web and interactions in an ecosystem (Dodds & Whiles, 2019). Nonetheless, functional redundancy is a vital ecosystem quality which can be used by managers to streamline their efforts to increase ecosystem resilience.

4.5 Spatial variability and the importance of connectivity

Managing for functional redundancy is an important quality to ensure the resilience of an ecosystem to change. However, the distribution of the functional group across the ecosystem landscape can have a significant impact on their resilience and ultimately their extinction risk. Importantly, before a species reaches a critical level, reductions in both distribution and abundance will be observed. There is still discussion within the scientific community how both factors are interrelated, however, there is a consensus that, generally, they share a positive relationship. This observation is known as the distribution-abundance relationship and has been found across multiple taxonomies (Fisher et al., 2015; Gaston et al., 2000; Johnson, 1998). In practice, this means that if the range of a species decreases, then this can go hand in hand with a reduction in average species density across the remaining sites. This will lead to a proportionately larger reduction then if you were to consider one of the factors separately (Gaston et al., 2000).

Monitoring of a species spatial variability and its subsequent decline can identify the level of threat a species is facing (Wilson et al., 2004). As a result, next to rarity and rates of decline, the International Union for Conservation of Nature (IUCN) lists habitat fragmentation as an indicator of extinction risk (Hartely & Kunin, 2003). Spatial variability as a predictive tool for extinction was clearly highlighted by Wilson et al. (2004), who studied the distribution of English butterflies between 1970-1982 and 1995-1999. Not only was this study capable of deducing past butterfly populations using recent data, but it was also able to accurately predict future populations based on present species distribution data. Wilson et al. (2004) found that butterfly populations with little distribution size, compared to their abundancy, had undergone a reduction in their population size. This relationship was also concluded when studying the distribution of rare British plants (Wilson et al., 2004). This has important consequences for ecological management practices. For example, concentrating on preserving a small piece of high-quality land, might inadvertently lead to the reduction of the species that you are trying to protect. Therefore, in order to improve the resilience of ecosystems, it is important that biodiversity does not become fragmented across the landscape, thereby increasing the chance of a species regime shift.

Consequently, Biggs et al. (2012) stresses the importance of connectivity in ensuring ecosystem resilience. Patches and habitats are referred to as nodes, which are then connected with each other through links, such as species interactions and habitat corridors. Through strong connectivity, species populations can move between fragmented habitats and therefore increase their spatial distribution, which under normal circumstances would potentially not have been possible. This can also reduce the negative population effects associated with inbreeding. If the positive distribution-abundance relationship is maintained, then an increase in connectivity can also result in higher population size (Biggs et al., 2012; Simonsen, Sturle Hauge, Biggs et al., 2015). Next to stabilizing a species population, Biggs et al. (2012) states that connectivity also increase the recovery ability of an ecological system following a disturbance. For example, the ability of a coral reef to recover following a disturbance is related to its connectivity. This was also concluded when studying the recovery ability of macrobenthic populations (Biggs et al., 2012). Furthermore, connectivity across nodes allows species to migrate following a disturbance. For example, if a species can only be found in a specific ecological niche, then climate change can force it to migrate to a new area (Hooper et al., 2005). However, if connectivity between fragments is hindered through the presence of infrastructure, such as dams and roads, then the species in question cannot migrate (Groffman et al., 2006). Importantly, it should be noted that increasing connectivity between nodes can also bring risks. For example, if a species is more connected then the spread of disease and invasive species can occur (Biggs et al., 2012; Hartely & Kunin, 2003). Managing for connectivity in ecosystems and determining the spatial variability of species can thereby possibly increase the resilience of its biodiversity.

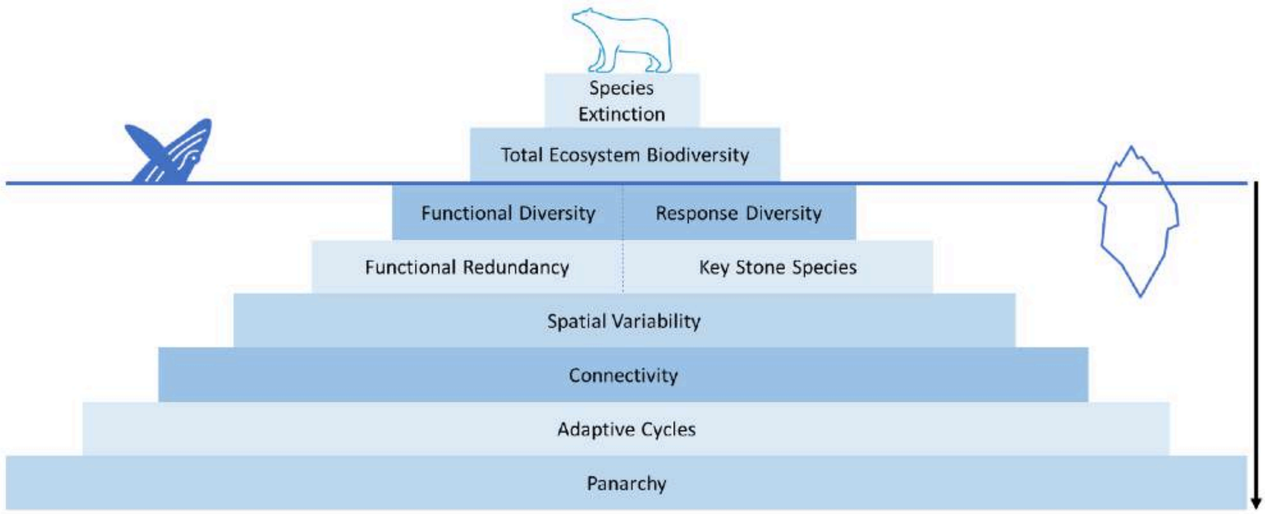
4.6 Adaptive cycles and panarchy

Only managing for the aforementioned resilience properties would not necessarily guarantee a more resilient ecosystem. Notably, controlling for a specific and narrow set of parameters in the short run, known as specified resilience, can have unforeseen consequences and come at the cost of resilience in the long run (Folke et al., 2008, 2016). Managing for resilience therefore requires understanding ecosystems as complex adaptive cycles. Importantly, a key component of complex adaptive systems is that they are characterized by the emergence of macro system properties through the interactions with lower scale interactions (Levin, 1998). As described by Holling (1986), complex adaptive systems are in a constant adaptive cycle of exploitation, conservation, release and reorganization. During the exploitation phase, a rapid colonization of the area occurs followed by the conservation stage, where the ecosystem reaches maturity. At this point the system is stable, however any significant disturbance can cause it to 'release' and cascade into a new system. Following the collapse, the ecosystem will then reorganize and start the cycle again (Holling, 1986).

Importantly, every stage of the adaptive cycle can be connected to the overall resilience of the ecosystem. When an ecosystem approaches the end of the conservation stage, its resilience is at its lowest and it is thereby more prone to undergo a 'release' action. It is therefore crucial that conservation management can assess at what stage a particular ecosystem is in the adaptive cycle. However, instead of operating in isolation, adaptive cycles are, instead, found nested with each other. This concept, known as panarchy, highlights that adaptive cycles are in fact connected at adjacent levels with other cycles (Garmestani & Benson, 2013). As noted by Gunderson et al. (2014), unlike other envisioned ecological hierarchies, the control within a panarchy is not solely dominated by large top down processes. Instead, there is a constant interaction between bottom-up and top down processes which can occur at different temporal and spatial scales. Consequently, cross scale interactions between adaptive cycles can influence their resilience. Importantly, Gunderson et al. (2014) states that understanding panarchy has led to the development of management indicators, such as increasing variance and flickering, which can give a preemptive warning for when an ecosystem is approaching a regime shift. Consequently, implementing ecological resilience mechanisms, such as redundancy and spatial connectivity, needs to be conducted within the backdrop of adaptive cycles and panarchy. While an ecosystem might seem stable within its own adaptive cycle, panarchy highlights that there might be unstable adjacent adaptive cycles which have the potential to reduce the resilience of another cycle upon release.

4.7 The iceberg model

FIGURE 2: THE ICEBERG MODEL



Note: The layers descend according to their spatial frame and complexity
Source: Author

The aforementioned resilience mechanisms are summarized in Figure 2, duly named the Iceberg Model by the researcher. Taking inspiration from Gaston et al. (2000, pg 39), a species extinction only represents the "tip of the iceberg of population decline". While species extinction and a reduction in ecosystem biodiversity can signal deteriorating resilience of an ecosystem, it does not provide an insight into the biodiversity resilience mechanisms that are contributing to the decline. Consequently, the various biodiversity resilience mechanisms, discussed within the literature review, are found below the surface of the water and considered 'hidden', even though they form the foundation for what is eventually made visible above the water. The layers in the Iceberg Model descend according to their spatial frame and complexity. Furthermore, resilience mechanisms found on the same layer means that they are found nested in each other. Importantly, biodiversity impact methodologies containing aspects of the Iceberg model can be considered to include resilience thinking.

4.8 Organizations and biodiversity

Managing for the aforementioned resilience principles is in the best interest of organizations. Importantly, organizations play a significant role in all the significant drivers of biodiversity loss, such as agriculture, direct exploitation of resources (e.g. deforestation) and climate change (Díaz et al., 2019). For example, in order to satisfy our ever growing need for food, organizations, such as farms, have converted half of the world's habitable land to agriculture and livestock purposes (World Economic Forum, 2020). Deforestation activities in the rainforest alone, one of most biodiverse biomes on the planet, results in an annual loss of 3 million hectares of tropical primary forest (World Economic Forum, 2020). While the following impacts on ecosystems are direct, organizations also have a significant indirect impact. Notably, organizational supply chains and international commerce are driving forces in the spread of disease, invasive species and parasites. Since the 1980s, as a result of increased trade activity, the cumulative amount of invasive species recorded has increased by 40 percent (Díaz et al., 2019). Strikingly, it was also calculated that together, supply chains and international commerce are responsible for 30% of the drivers, excluding invasive species, threatening global biodiversity (Lenzen et al., 2012).

Studies by international organizations, such as the IPBES and TEEB, are bringing attention to the interlinkages between organizations and biodiversity. However, the topic of organizations and biodiversity has, up till now, appeared little within the organizational literature. Organizational studies have included the investigation of company motives to implement biodiversity management frameworks, such as ISO 14001 certification ((Boiral et al., 2018), the effect of employee involvement (Boiral et al., 2019) and the effect of stakeholder interactions on the implementation of biodiversity frameworks within organizations (Quarshie et al., 2019). Furthermore, studies have investigated why business strategies regarding biodiversity are changing (Houdet et al., 2012) and how economic instruments can be used to protect biodiversity (Hahn et al., 2015). Importantly, works by Boiral et al. (2019) and Addison et al. (2019) have highlighted the difficulty organizations experience when dealing with the topic of biodiversity. Notably, due to its broad definition, which includes all living things from genes to ecosystems, organizations find it significantly difficult to capture the essence of biodiversity in a single unit or indicator (Addison et al., 2019; Boiral et al., 2019). This in return can negatively affect the ability of management to consider the effect of biodiversity in their operations (Quarshie et al., 2019). Although biodiversity is increasingly entering the corporate lexicon, Winn & Pogutz (2013, pg 206) argue that biodiversity has remained "largely peripheral to mainstream business strategies and investment decisions". Furthermore, as of yet, the value of nature and its functioning has insufficiently been investigated in the organizational literature and theory (Winn & Pogutz, 2013).

Corporate biodiversity reporting

As the intricate relationship between organizations and biodiversity becomes clearer, governments and the public are calling for corporations to report on their biodiversity impact (Boiral et al., 2019; Deplanque, 2014). In addition, next to mounting public pressure, there is also a business case for corporations to measure their biodiversity impact. This business case is found primarily in the form of risk management. According to the OECD, business risks associated to biodiversity loss can be classified as being either ecological, liability, regulatory or market related (OECD, 2019). For example, biodiversity loss can lead to disruptions to business operations. Staple foods like wheat, rice and maize, which are grown in monocultures, have annual production losses of 16% due to invasive species (World Economic Forum, 2020). Furthermore, as the public becomes more aware of the importance of biodiversity, law suites can be filled to curb the ecological footprint of organizations. This was clearly seen when BP and Exxon Valdez were sued for USD 65 billion for the damage incurred to natural resources and marine biodiversity following the 2010 Deepwater Horizon Oil Spill (OECD, 2019).

Financial institutions can also face financial risks, such as stranded assets and asset depreciation, as a result of biodiversity loss (OECD, 2019). While their direct ecological footprint is usually small, financial institutions can have a large biodiversity exposure through their investments and portfolio (Mulder & Koellner, 2011; van Tilburg & Achterberg, 2017). For example, using their BFFI methodology, ASN Bank has calculated that their investments yearly result in 66.154 hectares being completely devoid of biodiversity (Lachmeijer, 2018). In order to manage risk, it is therefore important that organizations and financial institutions record and report on their biodiversity impact. Fortunately, the topic of corporate biodiversity impact measurement has gained momentum within the organizational literature. For example, studies by Addison et al. (2019) and Reale et al. (2019) have critically analyzed corporate sustainability reports on their biodiversity targets. Strikingly, Addison et al. (2019) found that only few attempted to quantify their biodiversity impact. Other notable studies have analyzed the sustainability reports of governments (Gaia & Jones, 2019) and financial institutions (Mulder & Koellner, 2011). While evaluating organizations and organizations on their biodiversity reporting is a step in the right direction, no substantial organizational literature was found which evaluated reporting using insights from the natural sciences.

Biodiversity impact methodologies

In order to facilitate the process of corporate biodiversity reporting, the organizational literature is increasingly advocating for the development of standardized biodiversity accounting methodologies (Addison et al., 2019; Hahn et al., 2015; Jones & Solomon, 2013). This need is appropriately captured by Jones et al. (2013, pg 675) who states that "by accounting for biodiversity (i.e. disclosing, measuring and reporting for biodiversity) we make what was formerly invisible visible". However, up till now, biodiversity accounting has attracted relatively little attention by the accounting literature. Jones et al. (2013) highlights that factors such as philosophical difference (e.g. whether to approach biodiversity from an anthropogenic angle) and difficulties encapsulating biodiversity in a single unit have problematized the process of biodiversity accounting.

Multiple studies have provided recommendations and frameworks which corporates can use to improve their understanding of biodiversity and help develop their biodiversity foot printing methodologies (Addison et al., 2019; Boiral et al., 2018, 2019; Jones, 2003; Jones & Solomon, 2013; Schaltegger & Beständig, 2010). For example, Addison et al. (2019) proposes to introduce science based targets for biodiversity similar to those found in carbon accounting. Jones (2003) has developed a hierarchical accounting method which is based on six levels of biodiversity criticality. Schaltegger & Beständig (2010) go further and developed a guidebook which help organizations understand the importance of biodiversity and also provide practical steps which can be implemented in their operations. Practical steps, amongst others, include compensation methods and biodiversity benchmarking which focuses on state-orientated and impact-orientated indicators. This publication, along with other high key biodiversity guides such as 'Business and Biodiversity: A Guide for the Private Sector', developed by the IUCN, provide a great starting point for organizations to implement biodiversity initiatives, however the terms "resilience", "resilience thinking" or "ecosystem robustness" do not appear once in either publications (Schaltegger & Beständig, 2010; Stone et al., 1997).

As highlighted by sections 4.1-4.7, resilience theory provides organizations with a lens to further scrutinize and evaluate the impact they are having on biodiversity. Incorporating resilience thinking into biodiversity impact methodologies can help organizations understand how their actions are influencing the overall stability of the ecosystem in which they are operating. However, creating interlinkages between management theory and environmental science requires a cross-pollination between academic domains, which up to now, has rarely occurred (Winn & Pogutz, 2013). In practice, while the importance of resilience is widely accepted by the conservation science community, operationalizing it within management and biodiversity impact methodologies remains underdeveloped (Biggs et al., 2012). Importantly, no literature was found which aimed to identify or incorporate resilience thinking in organizational biodiversity measurement frameworks.

4.9 Academic contribution

Academic and public interest in corporate biodiversity impact is growing. However, as highlighted through the literature review, there have only been few studies which have attempted to incorporate aspects of the natural sciences in the organizational literature. As biodiversity impact reporting becomes more mainstream, and in some case required by law, it is important that organizations have methodologies and tools which can satisfy this demand. However, this process is hampered by the fact that biodiversity has garnered little attention within the accounting literature. Even in the rare cases that it is considered, granular insights from the natural sciences are currently lacking and it is unclear whether the methodologies take resilience theory into consideration. Winn & Pogutz (2013, pg 203) accurately capture the essence of this situation when stating that “the promise of infusing management theory with biophysical foundations remains largely unrealized”. As ecosystems across the planet continue to degrade, there is a growing need for the organizational literature to collaborate with the ecological sciences in order to actively contribute to protecting nature (Winn & Pogutz, 2013).

Multiple biodiversity impact methodologies have already emerged from the public and private sector (Lammerant, 2019). A notable methodology is the Biodiversity Footprint Financial Institutions (BFFI), developed by ASN, which has been used to report on the bank’s biodiversity footprint since 2016. By analyzing a case study of the BFFI framework, this thesis will aim to develop a process model which provides insights on how organizations can incorporate resilience thinking into their biodiversity impact measurement methodologies. This will contribute to the organizational literature in two ways. First, this thesis will provide an initial window into how financial organizations approach measuring biodiversity impact and whether they take biodiversity resilience mechanisms into account. Secondly, if resilience thinking is present (as found in the Iceberg model), this research wants to highlight how they operationalize it in their methodology. Consequently, this thesis aims to bridge academic disciplines and allow for cross-pollination between both the organizational and natural sciences which, up till now, has rarely occurred.

5 Methods and data collection

The previous section reviewed the natural science and organizational literature. The following section will outline the methodology employed for this research project. In order to ensure reliability, full transparency is provided on the different steps of the methodology. First, the research design and case selection will be explained, followed by the data collection and analytical strategy. This is then concluded by a section outlining the different approaches this research took to safeguard its reliability, validity and transferability.

5.1 Research approach and design

This thesis aims to provide insights on how organizations can incorporate resilience thinking into their biodiversity impact measurement methodologies. For this research, a **qualitative** research approach was utilized. Unlike quantitative research, which seeks to isolate the phenomena from its context, the aim of this thesis is to understand the presence of resilience thinking within the premise of the BFFI framework (Bell et al., 2019). As the process is not focused on obtaining 'factual data', but rather gathering gaining insight on how resilience thinking can be operationalized, the choice for a qualitative approach is deemed appropriate (Bell et al., 2019; Hammarberg et al., 2016). In order to contribute to the organizational literature, a **revelatory case study** was utilized. A case study is an empirical method that consists of a detailed investigation of a real life phenomena within their own context (Yin, 2018). Case studies are therefore especially suited for the intensive examination of a system with functioning parts and a purpose (Bell et al., 2019). The revelatory nature of the case study is justified as this research is able to shed light on a phenomenon which has been lacking from the organizational literature. As mentioned in the literature review, there is currently no research which investigates the presence of resilience thinking in the biodiversity impact methodology of a financial institution. As a result, conducting this research can help the organizational literature obtain an initial glance at this phenomenon.

This thesis employed a qualitative research method known as a **single case study**. Due to the revelatory nature of the case, Yin (2001) argues that the use of single case study is therefore merited. Furthermore, a single case study was desired because they are especially suited for the collection of rich data and uncovering new and insightful findings (Creswell & Poth, 2018; Yin, 2018). As a result, utilizing a single case study allowed for a comprehensive and in-depth analysis of the BFFI framework.

The single case study employed in this research is **holistic** by design. The single unit of analysis will be the presence of resilience thinking in the BFFI methodology. Within both the BFFI methodology and resilience theory, no clear operational subunits can be distinguished. Even though the BFFI consists of multiple distinct steps, they are all interrelated and connected, thereby making it difficult to effectively distinguish between them. As a result, a holistic case study design was therefore more suited to effectively answering the research question.

Importantly, this thesis utilized an **abductive** reasoning form, based on the **pragmatist perspective**. This form of reasoning starts off with a set number of theoretical rules and observations which are then explained in the light of the phenomena being investigated (Mantere & Ketokivi, 2013). Abduction therefore starts off with a phenomena which cannot be properly explain by existing theory and attempts to make the phenomena less puzzling by "turning surprising facts in a matter of course" (Ketokivi & Mantere, 2013, pg 5). As stated by Timmermans et al. (2012), instead of rejecting the use of preconceived theory throughout the research project, an abductive approach requires a scientist to start with the process with a rich and developed theoretical background. This theoretical background is then applied to the creation of new, surprising, concepts or theories that potentially explain the phenomena better. This process occurs through a continuous back-and-forth feedback between the social world and the existing literature through a process called dialectical shuffling (Bell et al., 2019). Importantly, abductive reasoning has become increasingly popular within the business research as it is considered an integral form of logic from which new hypothesis and, ultimately, scientific discoveries are made (Bell et al., 2019; Mantere & Ketokivi, 2013; Timmermans & Tavory, 2012). Furthermore, due to the action orientated nature of the pragmatist perspective, this approach allows for the formulation of new resilience concepts or practices which can possibly be used by management in the future (Kelemen & Rumens, 2008).

Finally, as highlighted by Nowell et al. (2017), it is important that a study makes explicit the epistemological position that underpin the study's empirical claims. This thesis answered the research question from an **interpretive constructionist** (Naturalist) perspective. As resilience theory has been lacking from both the organizational and accounting literature, the conclusions made in thesis will be largely dependent on the subjective nature of the researcher and his understanding of resilience theory. Consequently, different groups, analyzing the same data, could view the phenomena from alternate lenses and come to different conclusions (Bell et al., 2019; Nowell et al., 2017). As a result, different strategies aiming to safeguard the validity of this research can be found in section 5.6.

5.2 Case selection

In order to answer the research question, a single case study was conducted on the Biodiversity For Financial Institution (BFFI) impact methodology, utilized by ASN Bank. This framework was developed in 2015 and was a joint effort between

ASN Bank, PRé Sustainability and CREM. The BFFI assess biodiversity impact through six steps, which are explained in detail in Section 6.

First, as mentioned, the BFFI is a methodology originating from the financial sector. The researcher chose to study a financial sector methodology due to its ability to indirectly assess an organization on a global scale. While there are local level impact methodologies available, an organization might nonetheless not feel compelled to report on their biodiversity impact unless required by law (Reale et al., 2019). However, in order to effectively fight global biodiversity loss, it is crucial that biodiversity impact reporting becomes the norm. Importantly, the indirect measuring ability of a financial sector methodology can help solve this problem. Even if an organization is unwilling to share information, a financial sector methodology can indirectly calculate that organization's footprint across the globe. If that company is then underperforming or not satisfying the bank's biodiversity investment policy, engagement efforts or even disinvestment can occur (Schoenmaker & Schramade, 2019). Therefore, instead of being motivated by legislation, reluctant companies could be forced to improve their act based on the indirect biodiversity measurements by their financiers. Analyzing a financial sector methodology therefore allows this thesis to investigate the presence of resilience thinking in an influential tool with the potential to regulate the economy until national and accounting legislation catches up. Furthermore, the insights from this thesis can be used to improve other methodologies which allow for the indirect screening of an organization.

From the financial sector, the researcher choose to conduct a case study on ASN's BFFI framework. First of all, ASN is one of the leading financial institutions when it comes to the development of biodiversity impact methodologies (PwC, 2020). Using its BFFI methodology, ASN has been reporting on their biodiversity impact since 2016, making it the first bank globally to do so at the time (PwC, 2020). As a result, the BFFI methodology is embedded within the organization and has gone through multiple cycles of improvements throughout the years. Analyzing the BFFI therefore allows this thesis to investigate one of the most mature portfolio level foot printing methodologies available today (Berger et al., 2018).

Furthermore, the Partnership Biodiversity Accounting Financials (PBAF) was created by the initiative of ASN Bank. This partnership brings together five different financial institutions, such as Robeco and Triodos Bank, in order to find ways to measure the impact of biodiversity positive investments. Importantly, insights from this partnership are being incorporated into the BFFI methodology (ASN, 2020). As a result, by concentrating on the BFFI, this case study is indirectly able to analyze state of the art developments and thinking, in the financial sector, when it comes to biodiversity impact methodologies.

5.3 Data collection

According to Yin (2018), a major strength of employing a case study is its ability to use different sources of evidence. This process, known as triangulation, improves the ability of a case study to conduct an in-depth analysis of the phenomena and allows for the development of converging lines of inquiry (Yin, 2018). Importantly, triangulation within a case study improves the construct validity of the results. This section will give a detailed overview of the data collection methods utilized throughout this research and how they were conducted. Section 5.3 will discuss the use of semi structured interviews, followed by the sampling strategy. Finally, this section will expand on the use of documentary analysis.

Semi structured interviews

Empirical data was collected through in-depth semi-structured interviews. Using interviews as a data collection technique allowed the researcher to effectively analyze the view points and opinions of the participants (Cassell & Symon, 2004; Kvale, 2008). Furthermore, the choice for a semi-structured approach allowed the interviewer the flexibility of following potential leads during the interview (Cassell & Symon, 2004; Rubin & Rubin, 2012).

Interviews were conducted in two distinct rounds. The first round of interviews had the aim of developing an overall understanding of the BFFI methodology and how it works. While a public document, outlining the different steps of the BFFI was available, it was noted that this document was created in 2016 and that the BFFI methodology was still considered a draft at this point. As a result, it was concluded that the insights from the report could potentially by outdated and inaccurately represent the BFFI in its current state. Therefore, the first round of interviews was meant to analyze the current state of the BFFI methodology and to initially probe the reasoning behind the various methodological steps. Following the first round of interviews, the transcripts were pre-coded, as advocated by Saldana (2009). This involved highlighting "codable moments" and jotting down preliminary insights which could later, potentially, form the basis of an first order code (Saldaña, 2009, pg 16). Interesting leads and unanswered questions from the initial analysis then formed the template for the second interview guide to be used for the next round of interviews. Each participant in the first round was interviewed again for the second round. Importantly, while the first round of interviews concentrated primarily on obtaining an accurate overview of the BFFI, the second round had a stronger focus on analyzing the finer details of the ReCiPe LCA methodology. As will be highlighted in Section 6, the ReCiPe methodology, in the BFFI, calculates the pressure – response models which funnel into the final impact score. Consequently, it was deemed necessary by the researcher to develop a deeper understanding of ReCiPe throughout the second round of interviews.

Interview guides, containing **open-ended questions** and potential probes, were constructed for both the first and second rounds. Importantly, two separate interview guides were constructed for each round. As the BFFI methodology was developed by multiple stakeholders, it became clear throughout the initial interview that each organization had a better developed understanding of certain methodological sections. The interview guides tagged with an A (e.g. 1a) concentrated on the general overview of the BFFI, while guides ending with B (e.g. 2b) took a deep dive into the mechanics of the ReCiPe LCA methodology. Importantly, special care was taken to not include any resilience thinking terms in the questions, as to avoid a possible **interviewee bias**. It should be noted that the interview guides were not always followed strictly. As stated by Cassel et al. (2004), flexibility is one of the most important qualities when conducting qualitative research. Therefore, if the interviewee indirectly answered a question in the interview guide, then it would not be repeated. Instead, the interview guide would act as checklist to see whether all relevant topics had been covered in the conversation. Table 1 highlights which interview guide was used per interviewee. Furthermore, all the interview guides can be found in appendix I.

TABLE 1: OVERVIEW OF INTERVIEW LENGTHS AND GUIDE USE

Number	Interviewee	Organization	Round 1		Round 2	
			Length (min)	Interview Protocol Used	Length (min)	Interview Protocol Used
1	A	ASN Bank	66	1a	45	2a
2	B	ASN Bank	47	1a	36	2a
3	C	CREM	60	1a	48	2a
4	D	PRé Consultants	42	1b	46	2a
5	E	Radboud University	40	1b	44	2b

Source: Author

It is important to mention that there are some notable differences between the interview guides. Firstly, interview guide 1b was considerably shorter than 1a. Throughout the first round of interviews, interview guide 1a was deemed too structured and rigid by the researcher. As a result, this reduced the ability of the interviewee to give a running narrative. Consequently, it was decided that 1b would be more 'loose' and allow the interviewee more flexibility in their response. Furthermore, when inspecting Table 1, one can see that interview guide 2b was only delegated to Interviewee E. This was deemed necessary as interview guide 2b contained in-depth ReCiPe related questions which the researcher felt could only be effectively answered by the expertise of Interviewee E.

Interviews were conducted **one on one** using a video calling software. The reasoning for conducting a one on one interview was in order to prevent the interviewees from influencing each other's answers. Interviews were conducted both in English and Dutch, however throughout all the separate rounds, the interview guide questions were explained in English. Importantly, the interviews conducted in the first round started with a personal introduction by the researcher and was followed be a briefing of the project. This was done with the aim of establishing trust between the interviewer and interviewee. Importantly, as highlighted by Kvale (2007), multiple ethical considerations, such as informed consent and anonymity, had to be taken into account when conducting interviews. During the briefing, the interviewer asked consent from the interviewee to be recorded. Once consent was given, the researcher started the recording and repeated the question again in order for the interviewee to reconfirm their consent. In addition, matters concerning confidentiality and data privacy procedures were explained to the interviewee. Following the completion of the interview guide, the interviewer debriefed the interviewee. Next to asking whether they had any additional information they would like to add, the interviewer would explain how the transcripts would be processed and outlined the procedure of adding quotes to the final report. Following the analysis, a list of quotes was sent to the respective interviewees for their approval. If the quotes were in Dutch, then they were translated to English by the researcher and then presented alongside their original quote to the interviewee. In addition, any quotes from internal documents were also asked to be checked and approved for use. This ensured that the interviewee felt comfortable and that there would not be any unintended consequences to their participation in the study (Kvale, 2008). Furthermore, quotes could be altered if deemed necessary by the interviewee.

Sampling strategy

This study used a **snowball sampling** strategy to find participants for the semi-structured interviews. Importantly, snowball sampling is a non-probability sampling technique that focuses on using an initial interviewee to establish contact with other participants relevant to the study (Bell et al., 2019). For this research, initial contact with ASN was made by the thesis co-reader. During the first round of interviews, the interviewer was interested in coming in contact with employees that were involved in the construction of the BFFI methodology. Through this process, it became clear that the BFFI was constructed by a small team of employees from ASN, CREM and PRé Sustainability. While there have been employees working on it part time, there was only a select group that worked full FTE's on the project. Therefore, the primary goal of the snowball sampling was to come in contact with the individuals constituting the core team.

In total, four employees (representing the core team behind the BFFI) were interviewed twice. Unfortunately, a key employee, specializing in ReCiPe, was unavailable due to health-related problems. As a result, the interviewees strongly advised the interviewer to come in contact with interviewee E (see Table 1). Even though the interviewee was not part of the core team constructing the BFFI, interviewee E was a founding member of the ReCiPe LCA methodology, which is incorporated in the BFFI. Interviewee E was therefore able to give key insights on the finer details and specifics of the ReCiPe methodology. Following the same protocol as interviewees A-D, two interviews rounds were conducted with interviewee E. In total, 7.2 hours of interview audio was analyzed, resulting in 157 pages of transcripts. An overview of all interviewees and their lengths can be found in Table 1.

Documentary analysis

Documentary analysis was used alongside the qualitative interviews. This type of analysis involves examining different types of media, such as internal publications, speeches and presentations. According to Rubin et al. (2012), the use of documentary analysis is especially suited when combined with in-depth interviews. Using company terminology and showing awareness of the company's activities can show the interviewee that you are informed and an expert on your topic. This can have a positive influence on their willingness to share information with you (Rubin & Rubin, 2012). As a result, key publications, such as "Towards ASN's Biodiversity Footprint: A Pilot Project", were used as inspiration for the construction of the first round of interview guides.

Throughout the interviews, any document which was mentioned by interviewee would be asked to be elaborated on by the interviewer. When deemed relevant for the study, the interviewer asked if he could gain access to the specific document. This was deemed successful, as the interviewees were considerably generous and provided the interviewer with access to a multitude of different company documents which were, as of yet, not publicly disclosed. This was done on the condition that they would not be shared with a third party. This allowed the researcher to get a unique and detailed perspective on various aspects of the BFFI. Following the same process as the interviews, all the documents were placed in Atlas.ti program and coded. In total, ten different documents, representing 426 pages and 81 power point slides were analyzed. An overview of the documents can be found in Table 2 below. Importantly, when reporting the results in section 7, this thesis refers to the document number instead of its title. When using document quotes, the page number is only reported for the documents that have been published externally.

TABLE 2: OVERVIEW OF SOURCES USED IN THE DOCUMENTARY ANALYSIS

Document Number	Format	Publication Type	Publisher	Reference
1	Report	External	ASN	(ASN, 2016)
2	Report	External	CREM	(CREM, 2019)
3	Report	External	RIVM	(Huijbregts et al., 2016)
4	Report	External	ASN	(Berger et al., 2018)
5	Presentation	Internal	ASN	N/A
6	Summary	Internal	ASN	N/A
7	Report	Internal	ASN	N/A
8	Report	Internal	ASN	N/A
9	Presentation	Internal	PRé	N/A
10	Presentation	Internal	CREM	N/A

Source: Author

5.4 Data analysis

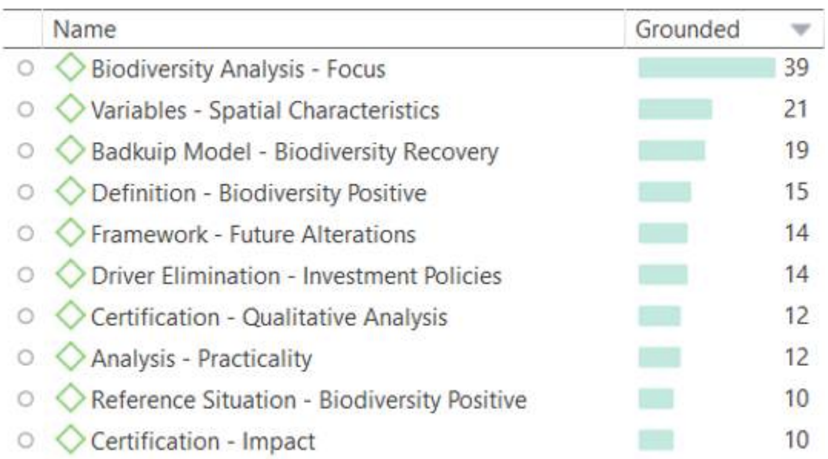
The semi-structured interviews were transcribed verbatim as soon as possible. The transcripts of the first round of interviews were pre-coded, as advocated by Saldana (2009), which involved familiarizing oneself with the data. Significant quotes or passages were highlighted and were recorded as a possible codable moment for later analysis. Importantly, pre-coding the first round of interviews provided the groundwork for the development of the second-round interview guides. In addition, first order codes and subsequent themes were not applied to the first-round transcripts in order to avoid influencing the analysis of the subsequent round of interviews. Once the transcripts were completed, all the documents were inserted into the Atlas.ti (version 8) qualitative analysis program and the process of coding then began.

The transcripts and documents were analyzed using the **thematic analysis** methodology described by Braun & Clarke (2006). A thematic analysis is a method that organizes, identifies, analyzes and reports themes within a set of data (Nowell et al., 2017). Importantly, a thematic analysis analytical strategy was chosen for multiple reasons. First, as it is not bound to a certain theory or epistemology, a thematic analysis is highly flexible and can therefore be adapted to the needs of the research question. Furthermore, a thematic analysis allows for a "a rich and detailed, yet complex account of data" and also forces a researcher to take a structured approach to analyzing the data (Braun & Clarke, 2006; Nowell et al., 2017, pg 2). Lastly, as a novice qualitative researcher, thematic analysis was an accessible methodology which could be learned quickly.

First coding phase

Transcripts and documents were coded using descriptive codes. According to Saldana (2009), a descriptive code is one which identifies the topic of a piece of qualitative data and not its content. Descriptive codes are especially useful when utilizing multiple data forms, such as interviews and documents, and they form the "bread and butter for further analytical work" (Saldana, 2009, pg 71). Descriptive codes were chosen for the first order coding phase due to their ability to provide an organized and tabular account of the data. Throughout the pre-coding phase, the researcher concluded that the respondent answers were especially context dependent in relation to which step of the BFFI was being discussed. It was therefore decided that using different first order coding methods, such as in-vivo coding, could not properly convey the methodological context of the data, which would then hinder further analysis. Consequently, relevant sections of data were coded for their topic and assigned more detailed sub-codes when necessary. An example of the descriptive codes can be found in Figure 3 below.

FIGURE 3: A SCREENSHOT FROM THE ATLAS.IO CODE MANAGER



Name	Grounded
Biodiversity Analysis - Focus	39
Variables - Spatial Characteristics	21
Badkuip Model - Biodiversity Recovery	19
Definition - Biodiversity Positive	15
Framework - Future Alterations	14
Driver Elimination - Investment Policies	14
Certification - Qualitative Analysis	12
Analysis - Practicality	12
Reference Situation - Biodiversity Positive	10
Certification - Impact	10

Source: Author

Following the completion of the coding, all quotes that shared a common topic, such as Biodiversity Analysis, were then extracted from the data corpus and inserted into an excel document for thematic analysis (Gibbs, 2012; Saldaña, 2009). Within the excel document, the quotes were re-coded according to the guidelines of Braun & Clarke (2006) and Boyatzis (1998). Quotes were collated into aggregated first order codes which addressed their most "basic element" (Braun & Clarke, 2006, pg 18). Importantly, first order codes could be named abductively in accordance with the theoretical interests of the researcher. As a result, the use of descriptive codes therefore provided an effective platform on which an organized and coherent thematic analysis could be conducted. Screenshots from the excel documents, showcasing the first order code development, can be found in the appendix II.

FIGURE 4: CREATION OF THE COLLATED FIRST ORDER CODE 'CERTIFICATION SIGNALS LOWER PRESSURE ON BIODIVERSITY'

Certification signals lower pressure on biodiversity

- 'If you invest in aquaculture or fisheries, which is ASC or MSC certified, you expect that the impact of ASC certified aquaculture is lower than aquaculture which is not ASC certified'
- 'For example, when an investor invests in an already existing agricultural field and has it certified according to organic standards, this may lead to a reduction of the impact on biodiversity'
- 'Certification systems such as FSC (Forest Stewardship Council) for wood or MSC (Marine Stewardship Council) for fish provide a guarantee of the prevention of overexploitation'.
- 'Production of paper from wood from FSC & PEFC certified forests will reduce the impact by land use and other forest related impact factors such as overexploitation, disturbance and introduction of invasive species'.
- 'FSC criteria set requirements for sustainable forestry and thus reduce the biodiversity impact of such a forestry company. Never completely to zero, but with an FSC certificate you know that the negative impact of such a forestry company is a lot lower than a company that does not have FSC certification'.

Sub theme development

Once organized and collated, the first order codes were analyzed for patterns and themes. For this research, the codes were analyzed at a latent level. Coinciding with the naturalist perspective of this study, a latent theme is able to "examine the underlying ideas, assumptions, and conceptualizations" (Braun & Clarke, 2006, pg 13). Importantly, the sub-themes were developed inductively, meaning that they emerged from the data instead of from the theoretical preconceptions of the researcher. As a result, by critically comparing and analyzing the first order codes, the second coding phase was able to start identifying resilience sub-themes in the data. When appropriate, sub themes were named abductively using resilience theory concepts discussed in the literature review. For example, the sub-theme 'Adaptive Cycle Thinking' was inspired by section 4.6, in which the concepts of resilience in ecosystem adaptive cycles was discussed.

The first order codes were inserted into a separate excel file and sorted into themes using a constant comparative method (Timmermans & Tavory, 2012). Screenshots showcasing the sub-theme development can be found in appendix II. In addition, meticulous memos were written which explain the thinking behind the theme development and the sorting of the first order codes. As appropriately stated by Saldana (2009, pg 32), "memos are sites of conversation with ourselves about our data". Figure 5 gives an example of an analytic memo constructed though out the second coding phase.

FIGURE 5: SCREENSHOT OF AN ANALYTICAL MEMO NAMED 'ANALYSIS 22-6-2020'

Possible Sub-themes:

- Direct biodiversity influence

- Indirect biodiversity impact (certification, driver elimination)

- overexploitation and invasive species could be found within the theme of data quality and uncertainity. Its use therefore warrants the use of proxies?

- Top down versus bottom up data

Insights: everything operates in the context of data availability and pragmatic solutions

I decided to reread all the data today, just to make sure that I coded for all the relevant segments. I have been altering some quotes by recoding or deleting them in their entirty.

Source: Author

Aggregate theme development

Once the first order codes were sorted into sub-themes, the researcher then started searching for aggregate themes. This was conducted within the same excel file as the sub theme development. Importantly, the process of creating aggregate themes was lengthy and required multiple modifications and re-drafting. While drafting the aggregate themes, the principles of internal homogeneity and external heterogeneity were considered and the steps of refining themes, as proposed by Braun & Clarke (2006), were adhered to. This involved re-reading the coded data extracts within the sub-themes to check whether they created a coherent pattern, followed by constantly comparing the aggregate themes to see if they were distinct and unique enough. Throughout these steps, any additional data, which had been potentially missed in the first coding stage, was subsequently coded and appointed to a theme. As stated by Braun & Clarke (2006, pg 21), "coding is an ongoing organic process". For example, the aggregate theme 'Improving Impact Score Quality' had to go through multiple iterations. It was first called 'Anticipating and Reducing Damage' and then later 'Ensuring Ecosystem Quality', however, in both instances the researcher thought that the titles were either not actionable enough or not clearly distinguishable from the aggregate theme 'Proxies for Ecosystem Quality'. Consequently, a final name change to 'Improving Impact Score Quality' was made. Another example of theory development includes splitting the first order code 'Biodiversity assessment needs to be pragmatic and understandable for stakeholders' into two more granular first codes. These include 'Biodiversity assessment needs to be pragmatic but reliable' and 'Impact results needs to be understandable for stakeholders'. In this instance, the researcher felt that the initial code did not accurately aggregate the quotes and therefore required alteration.

The final coding structure can be found in Figure 6. Screen shots of the aggregate theme development and coding trees can be found in appendix II and III. Furthermore, the thought processes behind the theme development have been recorded in the analytic memos in Atlas.ti.

FIGURE 6: FINAL CODING STRUCTURE

1st Order Codes	Sub Theme	Aggregate Themes
Biodiversity as a proxy for ecosystem quality	Ecosystem Focus	Proxies for Ecosystem Quality
Interpreting biodiversity as a means to safeguard ecosystem services		
All organisms are valued equally within an ecosystem		
Meta-analysis assess species richness		
Focusing on lower trophics levels as an indicator for species health	Foundational Resilience	
Higher level species having little effect on ecosystem functionality		
Broader taxonomic focus within ReCiPe		
Higher Trophic levels being dependent on lower trophic levels		
Certification signals lower pressure on biodiversity	Certification as a Signal	
Certification is assumed to lead to better management practices		
Certified Investments can possibly increase biodiversity		
Impact of certification is difficult to determine		
Requiring certification for investment requirements	Precautionary Approach	Improving Impact Score Quality
Investment Policies that complement certification		
Having environmental safeguards for ReCiPe		
Including biodiversity opportunity cost in PDF unit	Adaptive Cycle Thinking	
Recovery rate calculations can be biome specific		
Including continious negative impact throughout recovery time		
Reflecting organizational intervention in a lower PDF score		
Pristine reference condition reflects organizational responsibility for biodiverity degradation		
Landuse damage can be assessed per biome		
Discussing with stakeholders how to make positive biodiversity	Towards Biodiversity Neutrality	
Investing in green projects that avoid negative impact		
Using reference situation that reflect biodiversity improving activities		
Allowing flexibility in framework to accomodate project level data	Considering Geographic Ecosystem Sensitivity	
Linking driver impact to country characteristics		
Difficulties in modeling higher level species	Limited Modeling Ability	Striking a Balance
Data quality as a bottleneck for effective analysis		
Certification impact calculation hindered by data availability		
Full spatial analysis hindered by data availability		
Biodiversity impact measurement is still in its baby shoes		
Accurate hotspot assessment limited by portfolio size	Industry Requirements and Limitations	
Biodiversity assessment needs to be pragmatic but reliable		
Impact results needs to be understandble for stakeholders		
ReCiPe based on peer reviewed biodiversity meta-analysis		

Note: The first order codes were organized into sub themes, which were then sorted into aggregated themes.
Source: Author

5.5 Research quality

The following sections introduces criteria by which the quality of this thesis can be assessed. Next to describing the various concepts, this section will highlight how this thesis has attempted to satisfy their requirements. Furthermore, limitations are also presented and expanded upon. Section 5.5 will focus on achieving reliability in the research process, followed by the research validity. Finally, issues pertaining the transferability of results will be discussed.

Reliability

The reliability of a case study refers to its repeatability by another researcher. In practice, this would mean that if another researcher were to follow the same procedure as the earlier one, then they would arrive to the same conclusions and insights (Bell et al., 2019; Kvale, 2008). This research aimed to guarantee reliability through the use of a transparent methodology and by constructing a case study database. As noted by Bell et al. (2019), if the researcher does not describe their methodology in full detail, then the replicability of the study can be jeopardized. As a result, the methodology of this research aims to provide a detailed and complete overview of the decisions and steps taken. First, the process of developing and utilizing the interview guides is explained, along with the thought process behind them. In addition, all final interview guides can be found in appendix I. Furthermore, the development of theory is documented. Along with the development of first order codes, examples are provided on how these were used to get to second order themes and, finally, to the aggregate themes. This process is illustrated through excel snapshots and coding trees, which can be found in appendix II and III. Lastly, this research aimed to increase the reliability through the construction of a case study database. A case study database is an organized collection of the evidentiary base which could be used by an external researcher for a second analysis (Kvale, 2008). As a result, an organized database containing the original interview audio and transcripts, along with all the relevant documentation, was created for a potential second analysis.

It has to be noted that, due to the importance of the researcher's perspective for abductive research, perfect replication of the study is not possible. Even with the creation of a transparent methodology and organized case study database, another researcher might come to different conclusions based on the empirical data. In addition, as the interviews were semi-structured, another researcher might follow different leads through the interviews compared to the original researcher. Consequently, the researcher could obtain different qualitative information from which to build their theory on. These factors can be considered as barriers to achieving full reliability.

Validity

The validity of research is concerned about the credibility of the interpretations made by the researcher (Silverman, 2013). Specifically, measures need to be taken that limit the subjective nature of the researcher. If another researcher were to analyze the same data, then they should be able to find themselves in the conclusions drawn by the original researcher (Bell et al., 2019; Nowell et al., 2017; Yin, 2018). This thesis strived to attain a high level of validity through the use of **data triangulation**, maintaining a **chain of evidence** and by reviewing the study conclusions with **key informants**. As mentioned in section 5.4, this thesis uses multiple source of empirical evidence, ranging from semi-structured interviews to internal publications, to allow for the triangulation of data and data incidents (Yin, 2018). Furthermore, a chain of evidence was maintained throughout the data collection and analysis sections of this thesis. According to Yin (2018), maintaining a chain of evidence allows a reader to see how the researcher came to their final conclusions. As a result, maintaining a chain of evidence should give insight into the thoughts, feelings and theoretical developments of the researcher (Nowell et al., 2017; Yin, 2018). Consequently, throughout this thesis, a reflexive journal and database of analytic memos was created. The reflexive journal consists of initial insights and impressions following the interviews and consists of both written reflections and audio recordings. Furthermore, throughout the data analysis, ideas for codes, insights and ideas were recorded as analytic memos within Atlas.ti. Taken together, the analytic memo database and the reflexive journal aim to provide external researchers with an insight into the thought and reasoning process. Lastly, testing findings with key informants can help improve the validity of the research (Nowell et al., 2017; Yin, 2018). As a result, validation interviews were conducted with interviewee C and D. These individuals were chosen for the validation interviews because they acted as key informants throughout the research process.

Unfortunately, this thesis was unable to employ peer debriefing and researcher triangulation. In an ideal situation, the analysis of the data would be conducted with another researcher, after which their insights are compared. However, due to time constraints, this was not possible for this research. As a result, the researcher was the only individual who collected and analyzed the data. It is therefore important to realize and accept the importance of the researcher, and their perspective, in relation to the research.

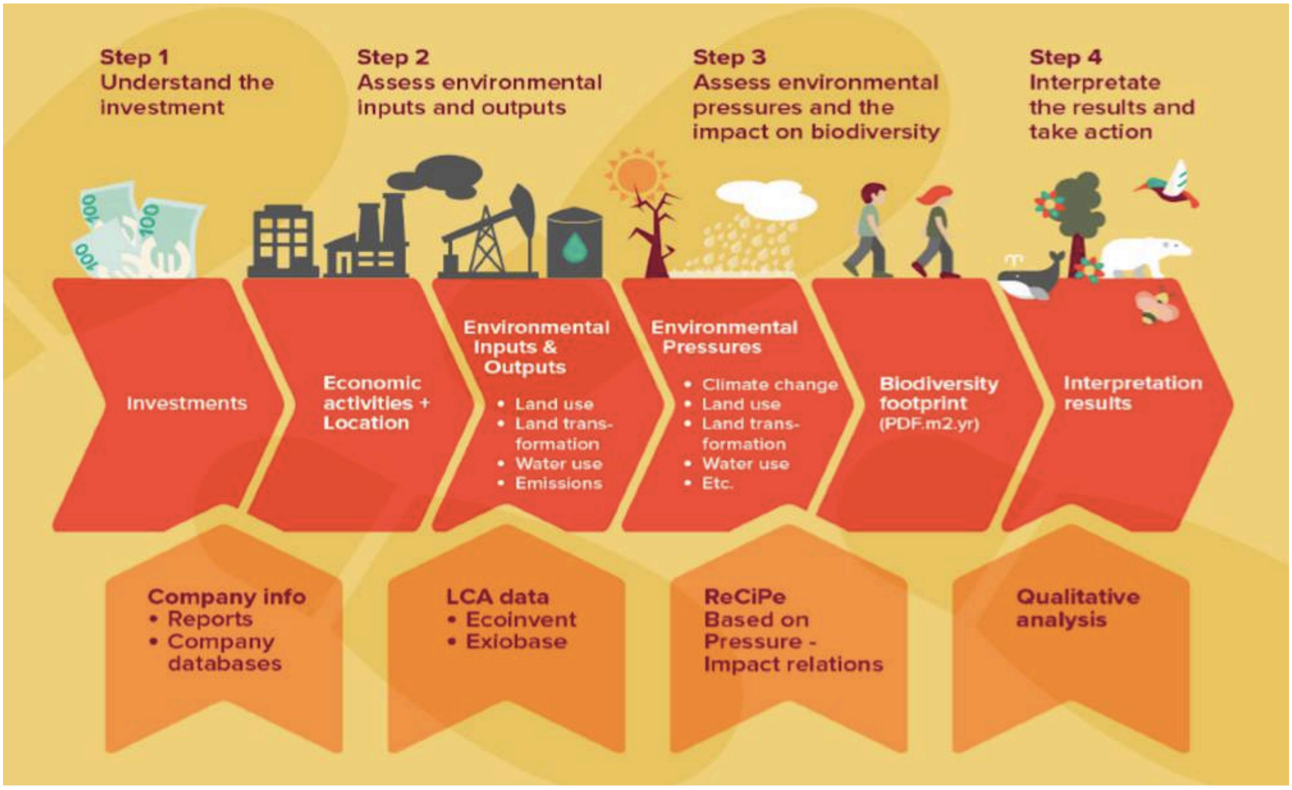
Transferability

The transferability of research, also known as external validity, focuses on "showing whether and how a case study's findings can be generalized" (Yin, 2018, pg 78). As this research is taking an abductive approach, based on the pragmatist perspective, the aim of this project is to come with recommendations on how organizations can include resilience thinking into their biodiversity impact methodologies. Unfortunately, by using a single case study instead of a multiple case study, the transferability of the thesis results could be considered reduced. However, as noted by Yin (2018), qualitative case studies rely on analytical instead of statistical generalizations. Unlike its statistical counterpart, which aims to generalize to populations of cases, analytical generalization focuses on the transferability of insights to theoretical propositions and models (Schwandt, 2007). This thesis believes that the results could therefore, potentially, be transferable to other methodologies which aim to indirectly measure an organization's biodiversity impact. These methodologies would not necessarily have to be limited to the financial sector or a portfolio level analysis. Importantly, readers attempting to transfer results to other contexts should assess transferability themselves when analyzing the results (Nowell et al., 2017). In order to effectively facilitate this process, this research provided **thick descriptions** of the results and full transparency regarding the research questions and the methodology.

6 Case description

The previous section gave a detailed overview of the methodology employed for this thesis. In order to critically analyze the findings in chapter 7, it is important that the reader understands the BFFI methodology. As a result, this section will provide a brief overview of the BFFI and its respective steps. Figure 7, below, shows an infographic of the BFFI, which will be expanded upon throughout the rest of this section. As the methodology is rather complex, this section will provide examples by referring to a fictive company, called Ingen Inc., which produces textiles and can be found in ASN's investment portfolio.

FIGURE 7: THE BFFI METHODOLOGY PRESENTED AS AN INFOGRAPHIC



Source: CREM & PRé (2020)

Step 1: Understand the investment

The first step in the BFFI methodology is understanding the nature of the investment. By analyzing reports and company databases, ASN determines the economic activities and factory locations associated to the investment (ASN, 2016). For example, by analyzing the company reports of Ingen Inc., ASN would determine that it solely produces cotton and wool based clothing accessories. Furthermore, it would be pinpointed that Ingen Inc. has factories in the Netherlands, Belgium and Bangladesh.

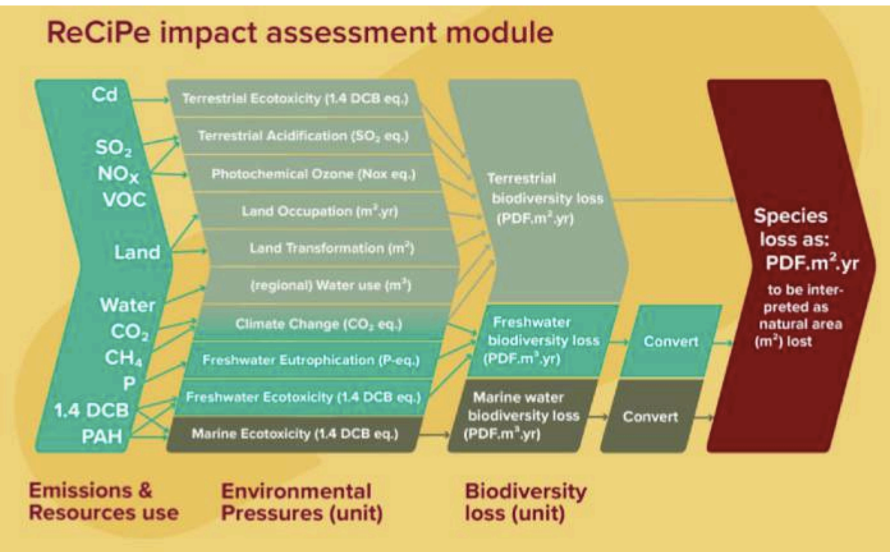
Step 2: Assess environmental inputs and outputs

Once the economic activity and location of Ingen Inc. has been determined, a life cycle inventory is created. Specifically, a life cycle inventory measures the different material inputs and waste outputs of a company. For example, a life cycle inventory for Ingen Inc. would include raw material inputs such as cotton and wool. Outputs could include CO_2 from the factories and contaminated water which has been used for the staining process. Unfortunately, due to data constraints, the BFFI is currently unable to create a company specific life cycle inventory. Instead, using the complementary modeling programs Exiobase and Ecoinvent, ASN creates a sector 'average' life cycle inventory which is specific for a certain country. For example, based on the results of the first step, ASN knows that Ingen Inc. has factories in three different countries. Using the modeling programs, ASN determines the average life cycle inventory of a textile company operating in each respective country (ASN, 2016). This sector average score is then used as a representative for the life cycle inventory of Ingen Inc.. Following this step, ASN now has a rough estimation of the different inputs and outputs for Ingen Inc.

Step 3: Assess environmental pressures and the impact on biodiversity

With step 3, ASN wants to know how the inputs and outputs of Ingen Inc. are negatively affecting biodiversity. This calculation is executed using the ReCiPe life cycle analysis methodology, which is a modeling tool developed by PRé Sustainability, the Radboud University Nijmegen, Leiden Universiteit and the RIVM. Importantly, ReCiPe translates inputs and outputs into environmental impact through 'doses-response' relationships. In practice, this involves estimating how much biodiversity decreases per unit increase of an environmental pressure. This is assessed through four consecutive stages in ReCiPe (as seen in Figure 8).

FIGURE 8: THE FOUR STAGES OF THE RECIPE METHODOLOGY



Source: CREM & PRé (2020)

Starting on the left side of Figure 8, ReCiPe starts off by converting the inputs and outputs of Ingen Inc. into environmental pressures. For example, within ReCiPe, the CO_2 output of Ingen Inc. will contribute to the environmental pressure climate change and the presence of PAH in its water waste will result in freshwater ecotoxicity. The presence of these environmental pressures, which are the result of Ingen Inc.'s economic activities, will have a negative effect on biodiversity. The scientific link between input, output and final environmental pressure are based on complex meta-analysis studies (Huijbregts et al., 2016).

In order to calculate their effect on biodiversity, each environmental pressure is assigned a characterization factor. The characterization factor is key to the calculation of the pressure-response relationships because it tells the researcher how much biodiversity will decrease if that certain pressure will increase. For example, the characterization factor of terrestrial ecotoxicity could be higher than that of terrestrial acidification. As a result, the loss of biodiversity associated to a X amount increase in terrestrial ecotoxicity will be greater than the biodiversity loss associated to an equal increase in terrestrial acidification. Again, the separate characterization factors have been determined through the use of meta-analysis studies (Huijbregts et al., 2016). The economic inputs and outputs are combined with their characterization factors in order to calculate the overall size of the environmental pressure.

Once the size of the environmental pressures has been determined, the translation to a unit representing biodiversity loss is made. ASN measures biodiversity loss as the potentially disappeared fraction of species per area per unit of time (PDF.m^2.y). This unit communicates the amount of species that have been lost as a result of man-made impacts. Importantly, ASN chooses to use a PDF of 100%. This means that all results are calculated as the amount of m^2 per year which are completely devoid of biodiversity due to the investments of ASN (ASN, 2016). Following a final unit conversion, a single encapsulating PDF.m^2.y result is produced by the ReCiPe methodology. By translating the inputs and outputs into a final biodiversity score, ASN now has a rough estimation of the biodiversity loss attributable to the economic activities of Ingen Inc. The higher the PDF score, the higher the damage and, thereby, the higher the urgency for ASN to intervene.

Step 4: Interpret the results and take action

Finally, the last step in the BFFI methodology is to interpret the results. As mentioned in step 2, the BFFI only uses sector average data. Unfortunately, this means that company specific qualities are not considered. Furthermore, some environmental pressures, such as overexploitation and invasive species, cannot be calculated in ReCiPe. As a result, ASN conducts an additional qualitative assessment in which it can either increase or decrease the final company PDF score. For example, if ASN believes that overexploitation is a particular risk for a certain industry, they can then choose to increase the final PDF score by a certain percentage. In addition, ASN can also choose to reduce a company's PDF score if it believes that it has certification that reduces its impact on biodiversity. For example, if Ingen Inc. only sources organic cotton, then ASN could choose to lower their PDF score as the positive effect of this certification is not reflected in the sector average data. Following the qualitative adjustments, the finalized biodiversity impact score can then be reported and used to identify biodiversity loss ‘hotspots’ which ASN needs to focus their engagement efforts on (ASN, 2016).

7 Findings

The previous section provided a brief overview of the BFFI methodology and how it works. The following chapter will present the findings of this thesis and, ultimately, lead to the final theoretical framework showcased in section 8. Based on the data analysis methodology, described in chapter 5.5 and visualized in the appendix, three themes were identified: Proxies for ecosystem quality, Improving impact score quality and Striking a balance.

7.1 Proxies for Ecosystem Quality

As highlighted by Jones et al. (2013), biodiversity and its use can be interpreted from multiple angles. The aggregate theme 'Proxies for Ecosystem Quality' investigates how the BFFI approaches biodiversity from an anthropogenic perspective and how it uses a variety of proxies to determine ecosystem quality. Within this section, different resilience mechanisms, such as organismal abundance and panarchy are discussed. The following sub-themes will be analyzed in depth; Ecosystem Focus, Foundational Resilience and Certification as a Signal.

Ecosystem focus

As illustrated in chapter 4, the BFFI uses the Potentially Disappeared Fraction (PDF) to quantify the damage done to an ecosystem. However, instead of measuring the PDF of a specific species, for example from a functional group, the BFFI calculates the PDF across the ecosystem in its entirety. The reasoning for not concentrating on individual species could be explained by the BFFI's more anthropogenic centered perspective where biodiversity and healthy ecosystems ensure that "ecosystem services can be provided" (Interviewee D). When it comes to ensuring ecosystem services, species are considered only "one indicator of biodiversity" (Interviewee A).

"We do not focus on individual species, but rather on resilient, rich ecosystems" (Interviewee B)

Within the BFFI, ecosystem quality is determined by the total amount of biodiversity and not so much its composition. This was reaffirmed by all the interviewees. However, this also means that the BFFI does "not differentiate between protected, rare and common species, leaving insecurities with regard to the relevance of a species disappearance" (Document 1, pg 22). Interviewee B states that "instead of focusing on conserving iconic species, we concentrate on creating stable ecosystems which, in return, will provide a resilient flow of ecosystem services". This is reinforced by the notion that "we do not make a distinction between different species, such as a bacteria or a mammal, which from the public eye could be deemed more interesting" (Interviewee B). While concentrating on endangered species can be justified from an ethical point of view, differentiating between species and their respective populations sizes will provide a limited insight into the functionality of the ecosystem (Interviewee A). Furthermore, if you concentrate on a single species and "you don't look at what's happening with the rest, you can still destroy ecosystem" (Interviewee D).

"Ecological functionality depends on common as well as charismatic or endangered species. It is therefore necessary to assess the changes in the populations of common species to maintain these functions. Focusing only on species extinction risk overlooks rapid declines in the number of individuals of species that are not at risk of extinction" (Document 4, pg 17)

As a result, multiple interviewees state that species diversity can be seen as a proxy for the health of the ecosystem (Interviewee D and C). Consequently, a rapid decline in overall biodiversity can signal an overall deterioration of the ecosystem quality.

"The diversity of species can be seen somewhat as a proxy for the health of an ecosystem. So maybe it doesn't matter if one animal goes extinct, but if half of the animals in an ecosystem die out at once, then there is probably something going on. The quality of nature is then probably deteriorating" (Interviewee D)

Monitoring for species biodiversity is the first resilience mechanism identified in the Iceberg model. As pointed out by interviewee D, a decrease in the total amount of biodiversity might say little about the individual species interactions, however it could highlight that larger negative processes are at work. This concept was accurately encapsulated by Interviewee E when saying that the "resilience of species richness is by definition greater than species abundance, the amount of individuals will decrease faster than that species are completely lost". Even though monitoring for species abundance is only the first step in measuring ecosystem quality, it does provide a preliminary warning to ASN if conditions are rapidly deteriorating. Importantly, Interviewee C acknowledged the limitations of the PDF unit when saying "species diversity is taken as a proxy for ecosystem quality, even though the relations between species and ecosystem quality are not yet always clear" (Interviewee C).

Foundational resilience

In order to calculate the PDF of an area, a pressure-impact model needs to concentrate on a certain level of biodiversity. When it comes to the level of analysis, the BFFI and ReCiPe primarily measure the impact on the lower level species in the ecosystem (Interviewee A). For example, Document 1 (pg 9) states "when we talk about species in ReCipe, we typically refer to vascular plants on land and lower organisms in water and sometimes other lower organisms". Throughout the interviews, it became clear that the reasoning behind the focus on lower trophic levels was due to its role as a signal for decline in ecosystems. As stated by Interviewee D, "ReCiPe mostly uses lower trophic level organisms and plants, with the idea that they are a good indicator for the health of an ecosystem".

"The focus of ReCiPe on lower taxa can also be explained by the fact that higher species tend to depend on these lower species. If these lower species disappear, the higher species are also affected" (Interviewee C)

The lower trophic levels are therefore perceived as playing a critical part in securing the rest of the ecosystem and "if you see a very big decline in the amount of different plants, they actually expect that species, found slightly higher in the food chain, will get into trouble" (Interviewee D). This idea is echoed in Document 1 (pg 9) when it is stated that "if something goes wrong at the start of the food chain, most experts assume that this will determine much of the fate of the higher organisms". Consequently, linking the state of lower trophic organisms with the fate of higher trophic levels could be an example of panarchy. Within this context, the BFFI concentrates on the state of lower level trophic organisms in order to secure the well-being of the rest of the ecosystem. While it could be debated that this is solely an example of a cross trophic interaction, the fact that the BFFI uses lower trophic levels as a proxy for overall ecosystem health can be an indicator that it interacts across sub-systems.

"When the amount of krill starts reducing in the ocean, due to global warming or acidification, then we really have a problem. This will have a direct effect on, for example, whales or entire marine food chains that rely on krill" (Interviewee A)

While the BFFI says that it primarily concentrates on the lower level trophic species, this seems to contrast with the data contained within ReCiPe 2016. This distinction is made when Interviewee E said that "for example, if you look at greenhouse gases, different taxonomic groups such as birds, mammals, plants, invertebrates, are taken into account". Furthermore, when calculating the effect of land use "several taxonomic groups: plants, vertebrates (mammals and birds) and invertebrates (mainly arthropods)" are included (Document 3, pg 87). Consequently, ReCiPe can take into account different taxonomic groups depending on the driver that is being investigated, however, this contrasts with what the BFFI says that it focuses on. This discrepancy was discussed with Interview E, who said that even though this could be a misinterpretation of some aspects of ReCiPe, natural vegetation is still "considered to be a vital component of the terrestrial ecosystem" and that this "is one of the main underlying assumptions for some impact categories, such as terrestrial acidification, in ReCiPe2016". During the validation interview with Interviewee C and D, it was agreed that if there was different information in ReCiPe, then the trophic level focus communicated in the BFFI would require altering. Nonetheless, terrestrial plants and lower trophic level organisms still form the brunt of the data contained in ReCiPe.

Next to their foundational importance, the reasoning behind focusing on the lower level trophic level seems to be routed in relation to their functionality within the ecosystem. Interviewee A states that "many species, especially iconic ones, can be considered to not have an important effect on ecosystems" and therefore "the extinction of an iconic mammal could have, potentially, little effect on the functioning of the ecosystem" (Interviewee A). The reasoning behind concentrating on lower trophic levels could also be viewed from a functional perspective. While no differentiation is made between different plant types, they do provide a functional service which maintains the rest of the ecosystem. Higher level species, on the other hand, are deemed not to play a functional role in maintaining ecosystem services and its functionality. By concentrating on lower trophic organisms, and using it as a proxy, the rest of the ecosystem can be stabilized, and populations of higher-level organisms can be assumed to be more stable. This could be an example of how the BFFI connects the state of the lower trophic level adaptive cycles with the state of those found in the higher levels through the concept of panarchy.

Certification as a signal

As mentioned in the previous section, the BFFI aims to safeguard ecosystem quality. It does this by using total ecosystem biodiversity as a proxy and by mostly concentrating on lower trophic level organisms to ensure foundational resilience. While these indicators focus on different aspects of biodiversity, there are also qualitative elements in the BFFI that signal higher ecosystem quality. This is namely through the presence of investment certification such as the Forest Stewardship Council (FSC) and the Marine Stewardship Council (MSC). Importantly, throughout the interviews, it became clear that the presence of investment certification could signal multiple positive ecosystem attributes.

> *"Production of paper from wood from FSC & PEFC certified forests will reduce the impact by land use and other forest related impact factors such as overexploitation, disturbance and introduction of invasive species" (Document 1, pg 56)*

> *"FSC criteria set requirements for sustainable forestry and thus reduce the biodiversity impact of such a forestry company, never completely to zero, but with an FSC certificate you know that the negative impact of this company is significantly lower than a company without FSC certification" (Interviewee A)*

When analyzing investments on a portfolio level, the presence of certification could signal lower driver pressures and ensure that biodiversity, therefore also ecosystem quality, remain stable. Using certification therefore provides ASN with a rough indication that a certain investment is operating at a higher standard. Consequently, if an investment, such as an agricultural field, switches to a verified organic certification then this "may lead to a reduction of the impact on biodiversity" (Interviewee C). Along with a reduction in biodiversity loss drivers, certification like FSC could even “be considered a positive contribution compared to non-forestry reserves” (Document 1, pg 56).

“Before a FSC forest can become a FSC forest, it first needs to be assessed what biodiversity is initially present. A precondition for obtaining a FSC certification is that biodiversity in the area cannot be reduced by the economic activity taking place in the vicinity” (Interviewee B)

While it is assumed that certification contributes to a higher ecosystem quality, its benefits cannot currently be calculated and inserted in the final PDF score (Document 1,7). The biodiversity benefits of certification “cannot just be calculated” as they “usually include a wide variety of management practices” (Document 2, pg 39). For example, FSC criteria, in the Brazilian state of Acre, “has not only created wildlife corridors and conserved ecologically sensitive areas” but also contributed to cultivating a culture of “conservation and respect for wildlife among community members” (Document 1, pg 56)

“In Cameroon, mammal density on FSC-certified enterprises or those in the process of getting certified was higher than in forestry businesses that were not pursuing certification” (Document 1, pg 56)

Instead, the impact of certification is qualitatively assessed, and the final PDF score can be adjusted using a percentage correction. For example, if certification is found in a certain investment, then ASN can choose to lower the calculated PDF with “a 20% lower negative impact” (Interviewee B). While the use of certification might not explicitly focus on biodiversity resilience mechanisms, the fact that it encapsulates different management strategies which indirectly improve ecosystem quality, makes certification a proxy for higher ecosystem quality and stability. Consequently, alongside total ecosystem biodiversity and stable lower trophic level organisms, the presence of certification signals to ASN that an investment is contributing to a higher ecosystem quality and thereby, indirectly, to an ecosystem with higher resilience to change.

5.2 Improving impact score quality

As highlighted in section 5.1, the BFFI focuses on ecosystem quality and uses multiple different proxies in order to get an indication of its state. However, by focusing on ecosystem biodiversity, the BFFI does not differentiate between species. Consequently, resilience mechanisms such as redundancy, functional/ response diversity, key stone species and spatial variability cannot and are not being assessed within the BFFI. While there might be few explicit forms of resilience thinking present in the BFFI, there are different methodological steps which help to improve the quality of impact score interpretation and the resilience proxies that represent it. These steps are encapsulated and explored in the aggregate theme ‘Improving Impact Score Quality’. While the following steps do not explicitly contain resilience thinking, they are still considered important in order to obtain a final accurate depiction of the ecosystem quality. The following chapter will explore the following sub-themes; adaptive cycle thinking, considering geographic ecosystem sensitivity, precautionary approach and towards biodiversity neutrality.

Adaptive cycle thinking

As mentioned in section 6, ReCiPe calculates the PDF of an ecosystem through a selection of impact factors, each utilizing a different impact pathway. Importantly, for a majority of the drivers discussed in ReCiPe, the information regarding their calculation remains 'locked' in the meta-analysis on which they are based. While analyzing the different ReCiPe meta-analyses fell outside the scope of this research, there was detailed and accessible information available regarding the calculation of the land use driver in Document 3.

Land use is primarily concerned with the process of land transformation for different agricultural practices. Importantly, calculating the process of land transformation is visualized using the "bath tub model" (Interviewee D), which is explained in Diagram 1. The size and depth of the transformation stage is calculated by comparing the expected damage of a land use form, determined through a meta-analysis, with a pristine reference (Document 3).

"The impact assessment factors of ReCiPe for land use are biome specific. So in a particular biome, if you replace one square meter of forest with a square meter of agriculture, in one biome, that will cause a greater decrease in the fraction of species than in the other" (Interviewee D)

In this case, the pristine condition "should reflect the impact on biodiversity without the investment taking place" (Document 2, pg 6). However, it should be noted that the definition of a pristine condition is still hotly debated and that is depends on the "cutoff date" (Interviewee C).

"Of course, a pristine situation needs to be defined and is subject to debate. Some may argue that a pristine situation in The Netherlands includes eagles and bears" (Interviewee C)

Next to determining the size of the transformation stage, the bath tub model calculates the recovery rate of the land once the economic activity stops. The length of the recovery time, also known as the relaxation period, contributes to the size of the ecological opportunity cost (Document 3). Based on meta-analysis studies, ReCiPe is able to calculate the total biodiversity damage before the activity takes place and allocates this damage to the owner of the economic activity (Interviewee C).

"The impact during the time the land is occupied and during the time it takes to go back to the natural state after land abandonment is allocated to the activity on that land, for instance, farming". (Interviewee E)

Importantly, the gradient of the relaxation period can be influenced, by a limited degree, by the biome type in which the economic activity takes place. Within ReCiPe, the recovery rate is determined by referring to two different natural reference vegetation: forest and open vegetation (Document 3). Due to data constraints, ReCiPe is not able to further differentiate between different biomes, but instead are either grouped under the encapsulating biomes forest or open vegetation reference states.

"open vegetation should be used when assessing the impact of land use in grassland, savanna, shrubland, tundra or desert biomes, and those for forest vegetation should be used in the different forest and woodland biomes" (Document 3, pg 84)

Again, through the use of meta-analysis, ReCiPe found that across all taxonomic groups and regions "forested biomes require a median of 73.5 years (range 46.7-138.8) and open biomes require 7.5 years (range 4.7-14) before species richness is at a level comparable to the pre-transformation state" (Document 3, pg 83). While it was not possible to obtain an accurate insight into how the meta-analysis came to this conclusion, the fact that ReCiPe includes and calculates an area specific restoration period could be seen as a form of adaptive cycle thinking. While the land transformation results in an immediate decrease in biodiversity, the ability of an ecosystem to recover is also taking into consideration and measured. Furthermore, the gradient of the relaxation period, therefore the recovery rate can be increased if habitats are actively restored by the organization responsible for the land transformation (Document 3, 4).

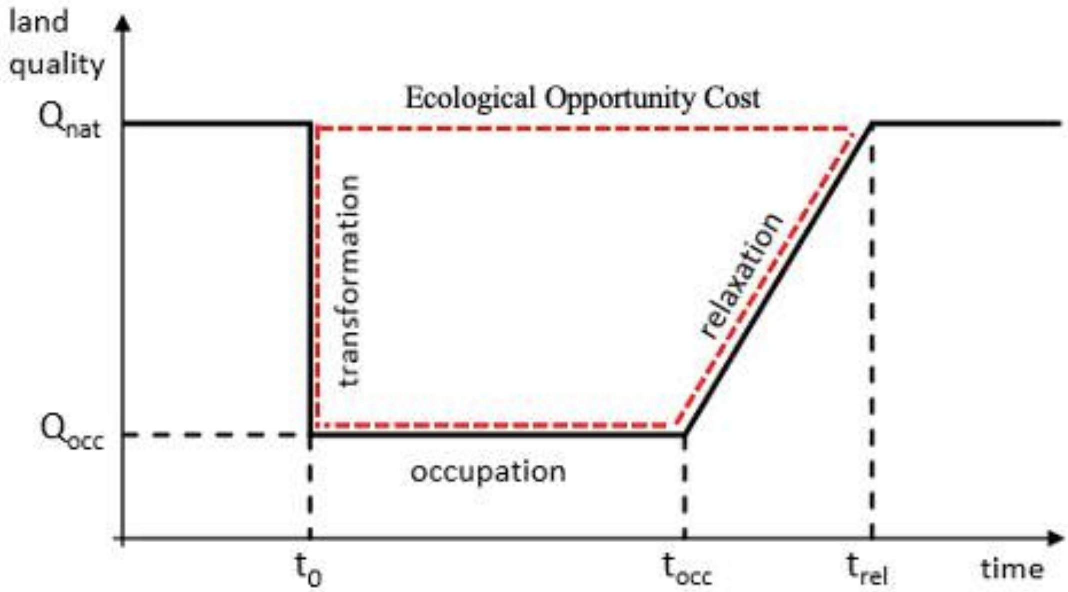
"When habitats are restored actively (including e.g. vegetation planning, animal reintroductions and replacement of top soil), the recovery of species richness accelerates by approximately 80%, thereby reducing the CFs for relaxation by the same percentage" (Document 3. pg 85)

Interestingly, as explained in Diagram 1, the time associated with restoration period is also assigned a negative impact on biodiversity "given that it is not immediately returned to primary habitat or will not return to the original habitat, but rather to a different state" (Document 3, pg 82)

"By the way, in most cases you see that the ground never really goes back to the natural situation. We cannot take this into account in LCA. Let me say, that the relaxation period is quite an uncertain factor in the whole methodology" (Interviewee E)

While the bath tub model is able to analyze land use from an adaptive cycle perspective, it was interesting to see that both in the documents and from the interviewee account the presence of alternate stable states were considered. While this cannot, as of yet, be reflected accurately in the PDF score, it does show that the BFFI and ReCiPe takes into consideration the complexities regarding the adaptive cycles of ecosystems.

DIAGRAM 1: LAND USE AND THE BATHTUB MODEL



Land transformation is calculated using the Bath tub model, which consists of three different phases: transformation, occupation and relaxation. Before the land transformation, the land quality is set at Q_{nat} (pristine level), however rapidly drops to Q_{OCC} (occupation) following the land transformation. Within the bath tub model, the land transformation occurs instantaneously at t_0. As long as the economic activity occurs, the land will remain in the 'occupation' phase and the biodiversity remains at $Q_{occ.}$ However, once the economic activity stops, it is assumed that the environment will undergo a relaxation phase, between t_{occ} and t_{rel}, and slowly return to the land quality found at $Q_{nat.}$ The biodiversity damage, as a result of the land transformation, will be the volume of the ecological opportunity cost (marked in red). Image taken from Huijbregts et al. (2016).

Considering geographic ecosystem sensitivity

As highlighted by the previous section, ReCiPe can model land transformation, though limited, from a biome specific point of view. While other drivers lack such granularity, they are drivers which are able to model impact damage based on country level characteristics.

"The impacts of water use, for example, can be very different in water-poor countries, such as Algeria, compared to water-rich countries, such as Norway. So, we also derived a country-specific characterization factors, both from midpoints and for endpoints" (Interviewee E)

As demonstrated by the quote above, the effect of water use can be country specific. In order to determine the relative effect of water use, the "information is mapped on a global water stress model" (Document 1, pg 15) after which a long list of characterization factors are produced per country. Importantly, the country specific analyses is not only limited to water use, but also include other characterization factors such as terrestrial acidification and eutrophication (Document 3). Again, the majority of the information concerning the transformation from drivers, for example water stress, to biodiversity loss was found in the ReCiPe meta-analyses. When asked about the different factors and variables which were considered in the meta-analysis, the interviewees were unsure and instead referred to reading the analyses.

"For example, emissions of sulfur dioxide, nitrogen oxide or ammonia in Norway have a different impact on ecosystems compared to the same emissions in Spain. These acidifying emissions can end up in Norway in highly acid-sensitive ecosystems, while in the south of Europe, there are more calcareous areas where acidifying emissions have less impact" (Interviewee E)

Taken together with the previous section, this shows that the BFFI attempts to tailor make biodiversity impact calculations based on both country and biome characteristics. However, as will be mentioned in 7.3, in many cases you will run against "the limits of the data" (Interviewee A). While the precise mechanisms going behind the calculation of drivers such as land and water use are not transparent in the principal documents, the fact that the BFFI attempts to calculate in a location specific manner, shows that they consider the sensitivity and, possibly, the resilience of a specific area. Importantly, the BFFI is planning to improve their ability to focus on a more local, project level scale, where the collection of more detailed information becomes more feasible (Interviewee B, C).

"Collecting direct data on biodiversity impact will require monitoring by ecologists. Not many companies do this. In case of project finance, the decision to invest will often take place at the start of a project when monitoring data are not yet available" (Interviewee C)

Precautionary principle

As mentioned, the BFFI can address driver impact and ecosystem recovery from a location sensitive perspective. However, the BFFI, both in its policy and throughout the ReCiPe calculations, takes steps to avoid a driver from occurring in the first place. This form of driver elimination is a method to increase the reliability of the impact score by reducing the number of drivers that need to be assessed qualitatively. For example, the ReCiPe "results do not show information with regard to habitat fragmentation, overexploitation, disturbance (other important forest-related impacts) or indirect effects" (Document 1, pg 57)

"Because the impact of the introduction of invasive species is not yet part of the ReCiPe methodology, you can try to take this impact driver out of the equation of the footprint calculation by putting investment criteria in place requiring from companies to take measures preventing the introduction of invasive species" (Interviewee C)

The BFFI can reduce driver or impact uncertainty through the use of investment policies (Document 1, 7). By implementing specific investment criteria, ASN can ensure, for example, that an investment is not operating in a high conservation value area (HCVA), as this is currently not being assessed within the ReCiPe framework (Document 1). Furthermore, eliminating drivers through preliminary investment policies can complement the gaps found in the use of certification. For example, habitat fragmentation is an impact which is currently not found within the criteria of FSC or PEFC certified forests (Document 1). Investment criteria, which can work alongside such certification, would have to be developed. ASN therefore already has a large variety of investment policies in place that help with 'avoidance' and 'minimization' of biodiversity loss drivers (Document 1). An example of ASN's biodiversity investment policies for land use can be found in Diagram 2.

"Many impact assessment methodologies that focus on impact drivers are based on a precautionary approach. The impact of impact drivers will depend on the characteristics of the impact location. If you do not know these characteristics you can still take away the drivers to prevent a potential impact from taking place" (Interviewee C)

Consequently, through the use of investment policies and certification, the BFFI tries to ensure exclusion and minimization of biodiversity loss drivers, which otherwise, would go unnoticed with the quantitative calculations of ReCiPe.

"By either not investing in economic activities at such a location (exclusion/divestment) or requiring a biodiversity management plan from businesses operating at such a location, the risk can be excluded or minimized" (Document 4, pg 31)

While the use of investment policies does not explicitly contain resilience mechanisms, it could contribute to ecosystem resilience by reducing shocks and disturbances. For example, by proactively avoiding the negative effects associated to habitat fragmentation, investment policies could possibly ensure that an ecosystem is more resilient to climate change. Strongly connected habitats allows species to migrate to more favorable conditions (Biggs et al., 2012). While it is difficult to evaluate the effect of the investment policy on the environment, it does nonetheless act as a form of precautionary approach. By avoiding drivers, through a precautionary principle, the BFFI is ensuring that those drivers do not add to the biodiversity pressures already present within an ecosystem. Consequently, the score calculated within the quantitative section of the BFFI becomes more reliable.

DIAGRAM 1: LAND USE AND THE BATHTUB MODEL

- The company or institution adheres to the IUCN guidelines for Protected Area Management Categories
- The company or institution does not develop activities in categories I-IV of the IUCN, the UNESCO World Heritage Convention or the Ramsar Convention on Wetlands
- The company or institution restores the original ecosystem after terminating its activities in an area
- No wetland drainage.
- Peat extraction is unacceptable to ASN Bank.
- If the company or institution uses wood from old-growth forests, it solely uses FSC-certified timber.

All assessment guidelines were copied directly from ASN (2018, pg 10)

Towards biodiversity neutrality

In order to achieve the goal of being biodiversity net positive, ASN is also calculating the positive biodiversity impacts of its investments. By the end of 2030, ASN wants that the calculated positive impact of their investment portfolio should at least be equal to the amount of biodiversity negative impact (Interviewee A). While the methodology regarding the calculation of positive impact investments is still developing, the BFFI is currently calculating the positive impact of its renewable energy investments.

When it comes to measuring positive impact, the BFFI realizes that "biodiversity will not increase if you build solar or wind farms" (Interviewee D). Instead, the positive impacts related to sustainable energy investments is its ability to "avoid negative impact" (Interviewee C). When ASN invests in sustainable energy projects, "we assume that by producing more power from solar and wind, we avoid impacts from other electricity generating technologies like from fossil fuels" (Document 7). As a result, solar and wind energy investments will lead to a "transformation" (Interviewee D) of the old energy grid, based on fossil fuels, and therefore avoid the negative impact associated to its use.

"Most scientists agree that the transition from fossil energy to sustainable energy, such as wind or sun, has a positive effect on the environment" (Interviewee D)

"When you're using wind energy instead of energy from the national grid, you have avoided impacts due to carbon emissions that do not take place" (Interviewee C)

The avoided carbon outputs, calculated "according to the Carbon Profit and Loss Methodology" (Document 7), gets inserted into ReCiPe after which it gets transformed, using the same characterization factor of carbon, into a biodiversity impact score. While the number rolling out ReCiPe will be negative, it is interpreted as being 'positive', thereby representing the avoided negative impact (Interviewee C). Importantly, it was noted by Interviewee C and B that there is still discussion within the financial sector on when an investment qualifies as being biodiversity positive and whether an avoided impact can be calculated the same way as negative impact.

"The objective of integrating positive impacts in the BFFI is not just to improve the quality of the footprint result, but also to reward investments in positive impacts by means of a reduced footprint score" (Document 2, pg 26)

While measuring positive impact can increase the quality of the footprint result, the BFFI also includes it to create an incentive for further positive impact activities by investors. For example, if an investor were to gain an organic certification for their agriculture, then this could result in a reduction in pressure, however, if compared to the pristine condition (explained in Section 7.2), the result will always be negative (Interviewee D).

"If you take a pristine situation as a reference, you will always have a negative impact if you invest in an economic activity that was already there, even if the investment is aimed at reducing the impact of the activity" (Interviewee C)

As a result, in order to reward positive impact investments, for land use, the BFFI employs a flexible reference state to which it is compared. Importantly, this reference state should "reflect the impact on biodiversity without the investment taking place" (Document 2, pg 29).

"If an impact investor invests in, let's say, a traditional cocoa plantation to change it into shade grown cocoa production, biodiversity will benefit. The impact investor wants to be rewarded for this positive contribution. If you take the pristine situation as a reference in the footprint calculation, the investment of the impact investor will lead to a negative impact because shade grown cocoa will have a lower level of biodiversity than a pristine situation" (Interviewee C)

Including positive impact in the BFFI makes it possible to improve the quality of a hotspot analysis. By avoiding negative impact and making the effect of positive impact investment visible, the BFFI can get a more refined insight into how its investments are impacting ecosystem quality. Like the other methods discussed in this theme, moving towards biodiversity neutrality does not explicitly contain resilience mechanisms, however, it helps to improve the interpretation of the proxies that do.

5.3 Striking a Balance

While limited resilience thinking can be identified in the BFFI, it became evident that constructing a biodiversity impact methodology does not occur in a vacuum. Qualities such as its focus and complexity are the result of an interplay of different factors and the interviewees highlighted that it is about striking a balance between different interests. The following aggregate theme, Striking a Balance, will explain how data constraints and industry practicalities influence the potential for a biodiversity impact methodology to assess ecosystem resilience.

Limited modelling ability

The goal of the BFFI is to calculate the biodiversity impact of an economic activity, however, the accuracy and validity of the final impact score will be largely dependent on the data granularity and availability. Importantly, throughout the interviews and documentary analysis, it became clear that there is ambition to move the BFFI to new heights. For example, in the future, the BFFI could possibly include data about the planetary boundaries (Interviewee C, Document 10) and even be used to model single species populations (Interviewee E). However, being able to increase accuracy and measuring capabilities needs to go hand in hand with data which is currently lacking.

> *"The result of our analysis is an overview of biodiversity impact hotspots. The accuracy of the quantitative scores is limited, but the overview will point in the right direction" (Interviewee C)*

For example, an important factor which is hindering the accuracy of the BFFI, is that all economic activities in Exiobase are based on sector average data (Document 1, 7). As a result, the biodiversity positive investment policies and company certifications, such as FSC, are not reflected accurately in the impact score (Interviewee A, C).

> *"Our forestry companies are currently scoring as if they don't have a FSC certificate, which is actually not correct, because we only select forestry companies with an FSC certificate" (Interviewee A)*

Consequently, "the footprint calculated is probably more negative than it is in reality" (Document 7). Furthermore, effectively calculating the positive impact of certification is hindered by the fact that the data regarding the size of its impact is "really scattered" (Interviewee B) and that "we currently do not have information which shows how much better a FSC certified company is performing compared to a company without FSC certification" (Interviewee A).

"To put LCA in practice, many assumptions and uncertainties are inevitable. It is important for any methodology to be transparent about all the pros and cons of the methods proposed" (Interviewee E)

Data constraints do not only limit the ability of certification to be reflected in the final score, but it also hinders the ability of the BFFI to analyze biodiversity on a more granular level. For example, an important consideration for focusing on lower trophic level organisms "is that modelling the disappearance of higher organisms is much more difficult, as there are many factors that determine their fate, including hunting, poaching" (Document 1, pg 9). Consequently, measuring resilience mechanisms such as functional redundancy or key stone species could be considered not possible from a data availability point of view.

"Finding data with a good relationship with impact is always a compromise between what is scientifically close to biodiversity and what data is pragmatically available. This can be difficult as they do not always match each other" (Interviewee A)

Furthermore, while the BFFI would like to measure their impact on a more local level, it is stated that "you will quickly run into limits of the data" (Interviewee A). The presence of data constraints and uncertainties therefore have a significant influence on the measuring capabilities of the BFFI. While there is motivation to do more, the ability of the BFFI to even start measuring resilience mechanisms, on a portfolio level is restricted by the amount and quality of the data available. Multiple interviewees therefore made it clear that the BFFI is constantly developing and will see improvements as the rest of the field of biodiversity accounting progresses (Interview A,C). As a result, the BFFI is the "kind of tool which is never finished" because "there is always room for improvement" (Interviewee C).

"We are currently standing at the beginning of the methodology. What you don't hear me say is that we have a methodology that, in all scenarios, is able to measure impact in the right way. We are currently standing at 10% to where we want to go. But that is also the idea behind this approach, we start measuring and that is already a step in the right direction" (Interviewee A)

Industry requirements and limitations

As highlighted by the previous section, a biodiversity impact methodology can be constrained and shaped by the availability and quality of the modeling data. However, next to data constraints, the scope and the ability of a methodology to include resilience thinking is also strongly influenced by the specifications set by the organization and industry that it operates in. This was especially relevant to the BFFI which attempts to measure the biodiversity impact across the portfolio of a financial institution, which can contain thousands of companies that are distributed across the world (Interviewee C).

"Understanding the biodiversity impacts on a local scale is one thing, but understanding the biodiversity impacts on a global scale from investments adds a layer of complexity" (Document 1, pg 8)

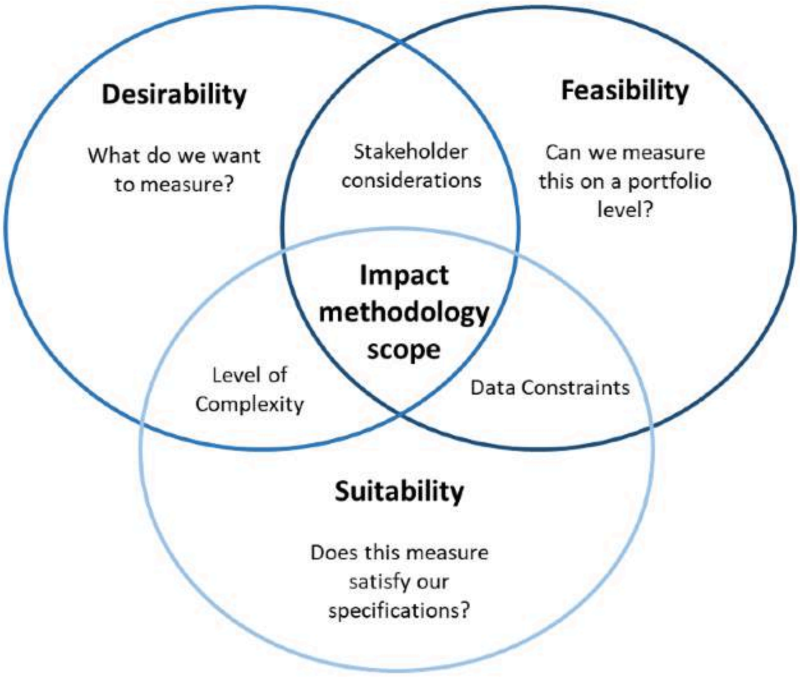
Measuring biodiversity impact across a portfolio requires decision makers to make choices on how in-depth the analysis and complex the methodology should be. For example, ideally, the BFFI would like to conduct a "very specific" analysis of each and every single company, however "that would have taken way too much time on the level of an investment portfolio" (Interviewee C). Taking such practical considerations into mind is important when trying to promote the use of the BFFI to other financial institutions. Document 5 clearly highlights the pre-conditions which were considered during the construction of the BFFI framework. These included, amongst others, that the BFFI should "be transparent, scalable to other banks, cannot be too complex/costly" and that the "approach & results can be explained to our clients" (Document 5).

"A point of departure for this approach is the fact that most banks will probably not be interested in a complex assessment, requiring a high input of time and budget. The approach should therefore be pragmatic, but reliable and transparent at the same time, allowing for a discussion with stakeholders, and use by different financial institutions" (Document 7)

While the aim of a methodology, such as the BFFI, is to start measuring biodiversity impact, it also wants to create methodology which can be endorsed by the industry and stakeholders. Ultimately, the results of the BFFI will form the foundation on which key players can start determining how to reduce their own biodiversity impact. An important factor influencing the complexity of the BFFI is therefore the communicability of its results (Interviewee A). As highlighted by Addison et al. (2019), understanding and communicating biodiversity impact is still a challenge for management. When discussing the possibility of including additional impact drivers and biodiversity mechanisms in ReCiPe, Interviewee E remarked that "to my knowledge, policy makers need information that can be clearly communicated, not necessarily more information" (Interviewee E). This raises the question whether, within the specifications of the BFFI framework, it is desirable to include additional resilience mechanisms which will increase the complexity of the framework unit and methodology. This highlights that the construction of biodiversity impact methodology strongly depends on finding striking a balance between factors concerning the desirability, feasibility and suitability. The interplay between these different factors is visualized by the Three Forces Model (Figure 9), which was created by the researcher.
Figure 9 shows that the scope of a biodiversity impact methodology is also strongly influenced by stakeholder considerations and data constraints. While it is important to measure resilience as accurately as possibly, it needs to be considered whether this contributes to aim of the methodology (desirability –

measuring ecosystem quality) and whether or not it is feasible for a financial institution to complete this measure on the level of an investment portfolio. The importance of striking a balance was confirmed by Interviewee C and D during the validation interviews.

FIGURE 9: THE THREE FORCES MODEL



Note: This figure provides a visualization of the strategic choices which need to be considered when designing a biodiversity impact methodology. Striking a balance between desirability, feasibility and suitability determines the potential for a methodology to consider biodiversity resilience mechanisms.

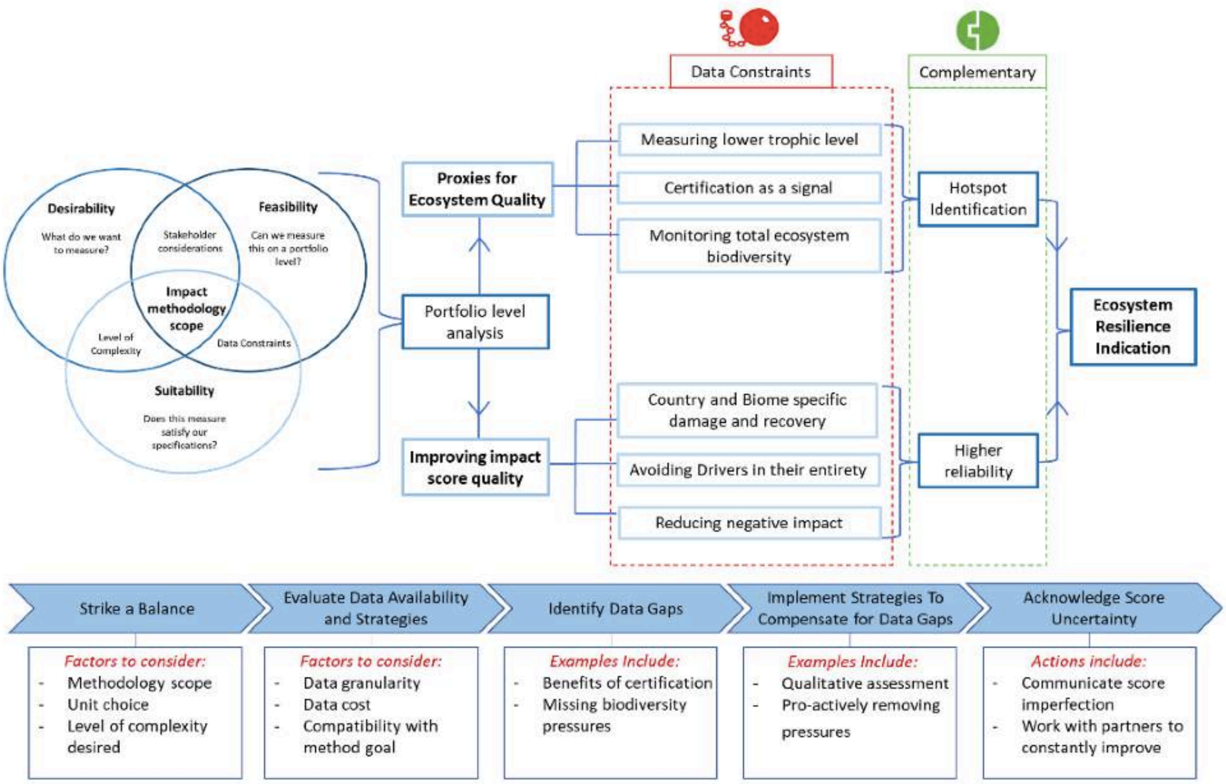
8 Discussion

The previous section showcased the findings of this thesis. The following section delves deeper in the results and places them in the context of a process model created by the researcher. Furthermore, the implications and theoretical contributions of this model will be explored. As this thesis took an abductive research approach, based on the pragmatist perspective, this section will provide recommendations on how the natural sciences can support the development of corporate biodiversity impact methodologies.

6.1 The Process of Incorporating Resilience Thinking

The relationship between the aggregate themes, discussed in section 7, are summarized in Figure 10 below. Representing a theoretical process, this model provides insight into how organizations can start to include resilience thinking into their biodiversity impact methodologies.

FIGURE 10: A PROCESS MODEL



Note: Moving from left to right, the process model highlights how organizations can start to include resilience thinking in corporate biodiversity impact measurement.
Source: Author

Starting on the left side of Figure 10, the first step of the process model involves striking a balance between the data availability, stakeholder specifications and the level of complexity they require/want. This process involves an internal dialogue and requires the organization to think about what they want to measure with their methodology and how they can achieve this. Importantly, the decisions made at this stage can fundamentally influence the ability of a methodology to take into consideration resilience mechanisms. For example, if the organization wants to calculate an impact score which is easily communicated and understandable for stakeholders, then it can be argued that considering a mechanism such as functional redundancy might be too complex. In the end, the goal of the impact score is to provide organizations with data which they can act upon and, as a result, the methodology needs to be in line with the organizational requirements. For example, by striking a balance, the BFFI has become a methodology which works on a portfolio level, but therefore also faces limits in how complex and costly it can be. As was mentioned in section 7, ASN acknowledges that other biodiversity factors should be taken into consideration, however, many currently cannot be assessed from a portfolio and global level. As result, the first step in the process model therefore sets the stage for the steps to follow.

If a methodology decides to focus on a portfolio level analysis (as is the case with the BFFI), the next step involves evaluating the strategies which can be used to provide an insight into ecosystem resilience. Set within the constraints of a portfolio level analysis, this model identifies two different strategies which, when used together, can be used to provide an insight into ecosystem resilience. The first involves the use of proxies, such as measuring lower trophic levels and total ecosystem biodiversity. By measuring for these proxies, a methodology can consider ecosystem resilience by accounting for organismal abundance and panarchy. Consequently, using proxies gives an indirect, although limited, indication of biodiversity hotspots which require further attention from the financial institution. Unfortunately, the accuracy of hotspots is currently limited by data constraints. As a result, the second strategy aims to improve the impact score quality. By using different methodological steps, such as driver elimination through investment policies, the quality and reliability of the hotspot impact score can be increased.

Together, the themes ‘proxies for ecosystem quality’ and ‘improving impact score reliability’ complement each other and combine to give a more accurate insight on the biodiversity resilience. Though the methods to improve the impact score quality are also affected by data constraints, it does aid the financial institution to get a general indication for hotspots which it needs to focus its engagement efforts on. While the score certainly does not contain all the relevant data to assess ecosystem resilience, it is a step in the right direction and progress will continually be made to refine it. As a result, using these strategies, an organization can obtain an insight, although currently limited, into how their investments are impacting ecosystem quality and its resilience.

6.2 Theoretical Contribution

The development of this process model contributes to the organizational literature in a matter of ways. As highlighted in the literature review, the topic of organizations and biodiversity has, up till now, appeared little within the organizational literature. By approaching organizations with a resilience lens, this thesis has attempted to bridge academic disciplines and include a much-needed natural science perspective into the organizational sciences. While different studies, such as Quarshie et al. (2019), have investigated the implementation of biodiversity in management, this thesis goes a step further and sheds light on how management deals with biodiversity once it has entered its corporate lexicon. The process model highlights how the forces of desirability, feasibility and suitability can influence how organizations choose to interpret biodiversity and act on it.

Furthermore, the concept of 'striking a balance' also hints to the challenge the organizational literature might face when further infusing the natural sciences in management. For example, the interplay between desirability, suitability and feasibility might be specific per organization and therefore a new methodology might have a unique set of specifications and limitations. This, consequently, makes it difficult for the organizational and accounting literature to help develop a blueprint for a standardized biodiversity accounting methodology. As a result, the process model adds to our current understanding by giving a glimpse, although currently limited, at how organizations internally use 'cost-benefit' analyses when working with a complex subject such as biodiversity. This has valuable practical implications because understanding the organizational cost-benefit analyses could potentially help the organizational literature in persuading management to further consider biodiversity impact and its measurement.
By utilizing a resilience theory lens, this thesis has also helped to break new ground in the biodiversity accounting literature. While prestigious institutions, such as TEEB and the IUCN, have been developing biodiversity impact methodologies, the organizational and accounting literature has remained largely quiet on how this is exactly done. This thesis therefore gives a first insight into how a methodology takes into account the natural sciences and resilience thinking. While this thesis is unable to prove whether the resilience mechanisms were knowingly included in the BFFI, the process model does highlight that limited aspects of resilience can be considered. This insight adds to our current understanding as it helps to reduce notion of Winn & Pogutz (2013a, pg 203) that "the promise of infusing management theory with biophysical foundations remains largely unrealized". This thesis shows that certain aspects of the natural science have been include in management and that there is potential for more. This should signal to the organizational literature that a 'bridge' between the academic domains can be built and that cooperation between the domains can be further fostered.

Lastly, the results of this thesis contribute to the academic literature by being the first study to providing insights on how resilience mechanisms can be operationalized. While a large array of resilience mechanisms have been identified in ecosystems, there has been no organizational studies which currently show how these mechanisms can be used in the context of a corporate biodiversity impact methodology (Biggs et al., 2012). The formulation of the process model therefore provides organizations with an insight, although limited, into what practical steps can be taken to include resilience thinking into their methodologies. These insights could potentially be used to enrich existing methodologies, such as those developed by Jones (1996) and Schaltegger & Beständig (2010). Furthermore, by identifying these practical steps, the process model also potentially highlights areas which the organizational literature can focus on. For example, considering the importance of proxies, academia can potentially start to investigate their use and improve their granularity.

6.3 The Iceberg Model Revisited

While this thesis strived to identify resilience mechanisms in the BFFI, it also exposed the lack thereof. As discussed in section 7, the researcher believes that the use of proxies allows the BFFI to measure organismal abundance and to consider panarchy. Referring to section 4.7, these two resilience mechanisms represent both the top and bottom layers of the Iceberg Model. Although only two resilience mechanisms were clearly identified, the researcher believes that additional mechanisms, albeit in a considerably weaker form, can be found in the thinking of the BFFI. For example, as mentioned in section 7.2, the BFFI takes into consideration the recovery rate of an ecosystem after a period of land transformation. While it cannot be considered a clear use of adaptive cycles, it does suggest that a form of adaptive cycle thinking is present in the BFFI. Another example includes the preliminary elimination of drivers (section 7.2) which can potentially contribute to ecosystem resilience by reducing shocks and disturbances.

While these examples can potentially contribute to ecosystem resilience, the researcher chose not to consider them in the process model due to their ambiguity. More specifically, this thesis strived to identify clear cut resilience mechanisms, as visualized by the Iceberg Model, however the aforementioned examples are found between the lines and cannot be attributed to a single mechanism. Instead, it can be argued that these forms of 'resilience thinking' require a separate Iceberg Model which is tailored for management. For example, the current Iceberg model is rigid in the fact that something either counts as a resilience mechanism or not. There is no in between. However, as previously highlighted, there should be a spectrum to which the different mechanisms are considered. An Iceberg Model tailored for management would therefore assess resilience mechanisms and thinking on spectrum according to how prominently they feature in the methodology. Different levels in the spectrum can be assigned a score, with the total score visualizing the extent to which resilience is considered.

Furthermore, an important discussion is whether biodiversity impact methodologies should consider all resilience mechanisms or rather prioritize specific ones. In an ideal world, an impact methodology would consider all nine resilience mechanisms discussed in the Iceberg Model. However, as highlighted by the process model, a balance needs to be struck between the Three Forces. As seen in the BFFI methodology, the force of desirability can significantly influence the resilience mechanisms to be considered. For example, the primary goal of the BFFI was to ensure for rich, resilient ecosystems which, in return, can provide a steady flow of ecosystem services. By taking this approach, the BFFI does not consider individual species and their populations. This means that resilience mechanisms such as functional & responsive diversity, functional redundancy, keystone species and spatial variability cannot be assessed. This has consequences for the actionability of the methodology.

Importantly, each resilience mechanism can be considered a puzzle piece and, when put together, can create an overall 'picture' of the ecosystem resilience. However, by excluding mechanisms, you are removing pieces of the puzzle and making it increasingly difficult to understand what you are looking at. The BFFI is an example of a methodology which currently sketches an outline of the puzzle by identifying investments which have a high biodiversity impact. By taking total ecosystem biodiversity and aspects of panarchy into account, the BFFI can roughly highlight where ecosystem resilience might be deteriorating. However, by missing the other puzzle pieces, the BFFI cannot determine exactly what is going wrong in the ecosystem. In return, this could reduce the effectiveness of their engagement efforts and conservation interventions.

This thesis does not promote the prioritization of specific resilience mechanisms. Instead it pushes the notion that increased granularity results in clearer and more actionable results. However, it is also important to stay realistic. As highlighted in the results, ASN made it clear that a significant amount of data is just not available yet. Furthermore, the science of biodiversity is still rapidly developing and there is a need for more precise monitoring tools. The BFFI therefore tries to make do with what is currently available. Although it is currently not all encompassing, one could argue that you do not need all pieces to understand what the puzzle is trying to depict. If you can get a general indication, then you can already start acting on the results and move in the right direction. The granularity of the methodology can subsequently be refined when more data and tools are made available.

6.4 Suggestions to Improve the Implementation of Resilience Thinking

The results of this thesis have shown that incorporating resilience thinking into an impact methodology is strongly influenced by data availability and the tools at hand. In order to further incorporate resilience thinking, the natural sciences need to develop new practical tools which coincide with the requirements and specifications of a corporate biodiversity impact methodology. For example, as mentioned in section 7.3, ASN wants to have a methodology which is "transparent, scalable to other banks” (Document 5) and which cannot be too complex or costly. Furthermore, the methodology needs to produce results which “can be explained to our clients” (Document 5). Taking these factors into consideration, a methodology such as the BFFI might not be interested in a complex and time-consuming assessment measuring functional redundancy. Instead, there is a need for the natural sciences to develop tools which are “pragmatic, but reliable and transparent at the same time” (Document 7). Considering these conditions, this thesis proposes two areas which the natural sciences could focus on in order to further stimulate resilience thinking in biodiversity impact methodologies.

Firstly, the natural sciences can help stimulate resilience thinking by quantifying the impact of certification. As highlighted by the process model, the presence of certification can signal a lower pressure on the local biodiversity. However, it is currently unclear to organizations how and to what extent certification can improve biodiversity. This insight was confirmed by Boiral et al. (2018, pg 399), who stated that the outcomes of corporate biodiversity initiatives “remain, to a large extent, invisible, intangible and immeasurable”. This is contrasting with the literature in the natural sciences where, for example, studies such as Di Girolami & Arts (2018) have conducted a comprehensive literature review on the positive effects of forest certifications. Although the positive effects of certification are becoming increasingly clear, the translation to a practical tool for management has yet to occur. This thesis therefore proposes that the natural sciences help develop a practical scoring system for popular certifications, such as FSC. Based on the criteria for the certification, the natural sciences can then decide how large a correction factor should be for the final impact score. For example, a certification considering spatial variability could achieve a relatively higher correction factor then one which only monitors total ecosystem biodiversity. Using these granular correction factors, the BFFI can then calculate a more precise and in-depth impact for an organization.

Furthermore, this thesis believes that the natural science could help make resilience mechanisms, such as managing for connectivity, a requirement for obtaining biodiversity certification. This has two advantages for a corporate biodiversity impact methodology. First, as certification need to be checked yearly, a financial institution could ask their investments to report on the results of these routine checks. This would provide their methodology with an additional stream of data which it can use to assess the state of different resilience mechanisms. Furthermore, renewing certification, such as FSC, usually comes at the cost of the organization and would not have to be paid for by financial institution. As result, by stimulating existing certification to consider resilience mechanisms, impact methodologies such as the BFFI would get access to more indirect granular data without adding to the expense of the methodology itself. By introducing resilience mechanisms and translating the positive effects of certification into a practical quantitative score, the natural science could help improve the consideration of resilience mechanisms in corporate biodiversity impact methodologies.

Secondly, this thesis proposes that the natural sciences help develop rudimentary threshold levels which can be used to flag investments for urgent engagement efforts. For example, the BFFI currently considers engagement efforts based on the size of the impact score. The larger the score, the higher the need to reduce it. However, it could be that an investment operating in a more sensitive environment, but with a lower impact score, requires more urgent intervention in order to prevent a threshold crossing. By developing a form of impact score range which is unique to the environment type (e.g. savannah, tundra), a financial institution could flag investments based on the size of their impact but also on the sensitivity of the environment it is operating in. Metaphorically speaking, this could create a form of environmental impact budget which investments need to safely operate in. This can be considered similar to the planetary boundaries concept described by Steffen et al. (2015).

An example of boundary setting can be found in the Global Biodiversity Score (GBS) methodology developed by CDC Biodiversity. The metric in the GBS methodology is the MSA.km2 (Mean Species Abundance per km2) which "expresses the intactness of ecosystems as a percentage" (PwC, 2020, pg 22). Interestingly, Lucas & Wilting (2018) calculated that the minimum MSA score required to prevent an escalation of global biodiversity loss is 72%. If this threshold is crossed then biodiversity loss will accelerate drastically (Lucas & Wilting, 2018; PwC, 2020). If a boundary level can be calculated or estimated on an environmental scale, then investments approaching the threshold can be flagged for engagement efforts. If deemed necessary by ASN, a more granular biodiversity assessment can then be conducted locally by an external party. Consequently, the calculation of rudimentary threshold levels could help the BFFI pinpoint investments which require extra attention and a more comprehensive biodiversity assessment.

9 Managerial implications

Next to their theoretical contribution, the results of this thesis also have practical and managerial implications. The following section will investigate how the process model can help management to jumpstart or further include resilience thinking in corporate biodiversity impact methodologies.

7.1 The Importance of Being a Change Maker

One of the key insights of this thesis is that the creation of a biodiversity impact methodology does not occur in a vacuum. As visualized by the Three Forces Model, the interplay between desirability, suitability and feasibility can have a profound effect on the ability of a methodology to take resilience mechanisms into consideration. This has important implications because it means that a competent manager, who understands these complex interactions, can potentially have a significant influence on the final resilience thinking capacity. For example, the force of desirability dictates what the methodology should measure. An important factor which influences this force are the desires of the stakeholders and the clients. However, as resilience thinking has appeared little within the organizational and managerial literature, stakeholders currently might not be requesting for resilience thinking to be included in the methodology. Consequently, management could start to inform and educate stakeholders on the importance of managing for ecosystem resilience. This, in return, could cause stakeholders to start demanding the assessment of resilience mechanisms and lead to the development of a more complex methodology.

In addition, the Three Forces Model highlights how data constraints can limit the ambitions of an impact methodology. As mentioned in section 7.3, most financial institutions do not want a methodology which requires a high input of time and budget. Consequently, conducting a comprehensive, local review of each investment is not considered feasible. Yet, in order to complete the puzzle and get a more accurate insight into ecosystem resilience, more granular data will be required in the future. Managers should therefore rethink how the costs and efforts of an impact methodology are distributed amongst stakeholders and clients. For example, the BFFI currently collects all the data and analyses it, with all its costs being paid for by ASN. As there is only limited budget and manpower available, the BFFI can only go to a certain level of detail. Instead, management should consider allocating a portion of the data collection to the investments themselves. This could be made a condition in order to receive funding from ASN. Of course, it would be unrealistic to force investments to conduct an expensive in-depth local biodiversity assessment. Furthermore, in such a scenario, some investments might even choose to switch to a different financier with lower selection criteria. Instead, a significant step in the right direction could be, for example, that investments calculate and report on their own life cycle inventories. This does not necessarily have to be an expensive or time-consuming task. As mentioned in section 6, the BFFI currently calculates a sector average life cycle inventory. However, by using this measure, the life cycle inventories are rough and do not 'reward' organizations which are trying to improve their act. By asking companies to calculate their own life cycle inventories and report on them to ASN, the BFFI could get access to detailed information which it can then use to calculate a more representative impact score. This is just one of the examples of how the efforts of a methodology could be distributed across the stakeholders and clients. Using these insights, management can potentially push for a more complex methodology that can allow for a better assessment of resilience mechanisms.

7.2 Making the First Steps

Furthermore, the results of this thesis provide management with two strategies that allow for ecosystem resilience to be considered in an impact methodology. As highlighted in the process model, ecosystem resilience insights can be achieved by using proxies and implementing steps which improve the final impact score quality. For example, an organization which is in the process of creating its own impact methodology, could start to consider panarchy by choosing to measure the state of the lower trophic levels in an ecosystem. Although this strategy does not result in an all-encompassing overview of panarchy, it does provide a methodology with a foundation which it can build upon and flesh out as more granular detail becomes available. Furthermore, by monitoring for total ecosystem biodiversity, management can start to flag investments which are resulting in a proportionately large decrease in biodiversity. This can be seen as an indication for deteriorating ecosystem resilience and subsequently prompt the initiation of a local biodiversity assessment on sight. Lastly, by qualitatively assessing the positive biodiversity effects of certification, management can ensure that an investment is, at the least, not contributing to local resilience deterioration. While the strategies outlined in the process model can help to provide an initial insight, it should be noted that the management of an organization might have little influence on their implementation. For example, the BFFI did not explicitly choose to asses foundational resilience and to measure total ecosystem biodiversity. Instead, these factors were already considered in the ReCiPe methodology which ASN then used to calculate the pressure impact models in their own methodology. As ReCiPe was developed independently, management might therefore have little say in the factors that should be considered. Instead, the aforementioned strategies could be used by management when deciding upon which life cycle analysis (LCA) methodology to incorporate into their own. If a life cycle analysis methodology assesses foundational resilience and total ecosystem biodiversity, then management knows that resilience aspects are being considered. This can then be a reason for them to choose that specific methodology for their own measurements. In addition, management can then push for the inclusion of more resilience mechanisms if the life cycle analysis methodology gets updated.

Management can, however, improve the quality of the impact score and resilience indication produced by the LCA methodology. Encapsulated in the strategy 'improving the impact score quality', management can consider eliminating drivers which are not being assessed in the LCA methodology. For example, using investments policies, management can ensure that habitat fragmentation is being assessed and avoided. Next to improving the LCA score, this would also help to supplement the gaps present in the use of certification as a proxy. Furthermore, by making steps to measure the positive biodiversity effects of investments, management can subsequently adjust the size of impact scores, thereby better reflecting their urgency. As a result, the process model allows management to make first steps to include resilience insights into their own methodologies. In the case that management outsources certain sections of the methodology (such as the LCA section), the process model instead gives them a couple criteria which allows them to assess whether the method section takes resilience thinking in account.

10 Conclusion

Using resilience thinking is crucial for the effectiveness of a corporate biodiversity impact methodology. Instead of only measuring the current state of an ecosystem, resilience thinking allows organizations to anticipate its ability to withstand and recover from disturbances and changes (Biggs et al., 2012). Considering the biodiversity crisis experienced today, managing for ecosystem resilience will become paramount in preserving our planet's ecosystems. As a result, this thesis has strived to provide insights on how organizations can incorporate resilience thinking into biodiversity impact measurement.

This thesis concludes that a corporate biodiversity impact methodology can consider resilience thinking in several ways. Firstly, the ability to consider resilience mechanisms is strongly influenced by the strategic choices made during its blueprinting phase. As highlighted by the Three Forces Model (5.3.2), a biodiversity impact methodology needs to satisfy the goal of the methodology and the desires of the stakeholders. Furthermore, the organization needs to evaluate the data constraints which the methodology will be operating in. Through the interplay between these different interests, the ability for a methodology to consider resilience can be constrained. For example, if a methodology wants to measure biodiversity on a portfolio level, then measuring each investment on a granular scale might not be considered feasible or even deemed desirable by the stakeholders. As a result, the measurement of more local resilience mechanisms such as functional and response diversity will not occur. Furthermore, if the aim of the methodology is to ensure the healthy provision of ecosystem services, then measuring individual species populations will not be considered necessary in achieving the goal of the methodology. Consequently, the results of this thesis encourage management to make efforts to alter and influence the interplay of the three forces. By educating stakeholders on the importance of resilience thinking and by making steps to more equally distribute the cost and efforts of the methodology, management can help ensure that a methodology can attain a higher level of granularity. This, in return, can positively impact its ability to consider ecosystem resilience thinking.

Furthermore, the results of this thesis provide two strategies which, when used in tandem, can provide a rough indication of ecosystem resilience. The first strategy involves the use of proxies to assess ecosystem quality. For example, by measuring the total ecosystem biodiversity and by modeling the state of the lower trophic biodiversity, a methodology can take into consideration the resilience mechanisms of organismal abundance and panarchy. Consequently, when an organization sees that the biodiversity footprint of an investment is increasing, then it can be assumed that the ecosystem resilience is also decreasing. Furthermore, by using certification as a proxy, an organization can assess that an organization is not contributing to a reduction in ecosystem resilience.

Unfortunately, as certification can encapsulate a wide range of different management practices (such as avoiding habitat fragmentation), the positive impact of certification on the final score cannot be quantitatively determined. Instead, a qualitative correction score can only be assigned for now. Acknowledging this limitation, this thesis therefore calls upon the natural sciences to help organizations to quantify the impact of certification. By using different proxies for ecosystem quality, an organization can obtain a limited insight into the resilience of an ecosystem.

The second strategy helps to improve the accuracy and reliable of the insights originating from the proxies. By considering an ecosystem's geographic sensitivity, the pressure impact relationships can take into account the characteristics of a country and biome. While the insights are limited, it does help the final impact score to take into consideration how the negative effect of a biodiversity pressure can alternate between geographic areas. Furthermore, an organization can choose to implement investment policies which aim to fill the gaps in the methodology. For example, if habitat fragmentation cannot be assessed using the impact methodology, then an organization can choose to avoid investments which could potentially result in this driver. By eliminating drivers before they can even be considered by the methodology, an organization can make sure that the insights from the proxies are more accurate. Lastly, by making steps to measure the avoided impact from an organization, the methodology can make sure that impact score can be compensated for their biodiversity enhancing activities. Together, the following steps allow the insights from the proxies to be more accurate and reliable.

To conclude, by striking a balance, using proxies to assess ecosystem quality and by implementing reliability enhancing steps, an organization can acquire an initial insight into how their activities are influencing ecosystem resilience. This thesis hopes that the process model sparks dialogue within companies. While the results are limited, this thesis has helped to shine a light on the potential for resilience thinking in corporate biodiversity impact methodologies. Resilience thinking is therefore possible, and more is needed in order to save the planet from ourselves.

11 Limitations

While this thesis took steps to safeguard its reliability, validity and transferability, there are, nonetheless, still limitations. This section will provide an overview of both the main methodological limitations and theoretical limitations of this thesis.

9.1 Methodological Limitations

There are several limitations which can be identified regarding the methodology of this thesis. First, this thesis did not analyze the meta-analyses which form the basis of the ReCiPe methodology. Throughout the interviews it became clear that many of the interviewees had a general idea of ReCiPe, however they could not give a precise insight into what aspects were taken into consideration throughout the pressure impact modelling. As highlighted in the findings section, ReCiPe is able to measure, though to a limited extent, the recovery rate and damage to a certain ecosystem or biome. The presence of such calculations could signal that the ReCiPe meta-analyses assess different ecosystem characteristics and possibly even consider additional resilience mechanisms which are not highlighted in the BFFI. Unfortunately, due to time constraints, this thesis was not able to conduct a comprehensive review of the various meta-analyses forming the foundation of ReCiPe. It can be argued that conducting such research would require a more deductive approach and therefore a new methodology. However, by not analyzing the meta-analyses, this thesis might only have scratched the surface regarding the resilience mechanisms which are considered in the ReCiPe methodology.

Secondly, in order to garner a more detailed overview of the ReCiPe methodology, a comprehensive interview protocol (2b) was solely constructed for the second interview with Interviewee E. While interview guide 2b provided the researcher with additional expert insight, using it exclusively for Interviewee E negatively affected the triangulation ability. During the interviewee sampling, the researcher tried to come in contact with an additional ReCiPe expert, who was strongly recommended by the other interviewees, however he was unavailable. While efforts were made to facilitate triangulation regarding the specifics of ReCiPe, this ended up not being possible within the scope of the research. If the thesis were to be conducted again, then additional interviewees specializing in the ReCipe methodology would have to be contacted.

Lastly, as mentioned in section 5.5, peer debriefing and researcher triangulation was not utilized within this research. As a result, the data analysis and theory creation were conducted only by the researcher. Consequently, by not cross-checking codes and interpretations with other individuals, the subsequent theory creation could have been influenced by the predispositions of the researcher.

Steps were taken to increase the research validity, for example by conducting validation interviews, however peer debriefing and research triangulation could have been the final steps to safeguard the research validity.

9.2 Theoretical Limitations

Next to the methodology, limitations in the research theory can also be identified. As this research employed a single case study, the transferability of the results can be put into question. As highlighted in the findings section, the creation of a biodiversity impact methodology, and therefore its ability to include resilience thinking, is influenced by the interplay of desirability, feasibility and suitability. Importantly, stakeholder requirements and methodology specifications can defer between organizations and therefore influence their methodologies in different aspects. While the theory introduced in this thesis is applicable to the BFFI, it might not be broadly transferable to other impact methodologies developed by organizations. Specifically, the theory produced in this thesis is the result of the decisions made by ASN Bank and its partners when 'striking a balance', however, another financial institution could possibly have different priorities, thereby influencing its ability to incorporate resilience thinking. While this theory is able to shed a first light on resilience thinking in biodiversity impact methodologies, its transferability is dependent on the context and priorities of an organization.

Furthermore, the topic of resilience is complex and still developing. Identifying and recognizing resilience mechanisms in a corporate biodiversity impact methodology is therefore strongly influenced by the perspective of the researcher. For example, while this thesis believed that the theme of 'adaptive cycle thinking' did not qualify as a resilience mechanism, another researcher might say that it actually does. As a result, the process model produced by this thesis reflects how the researcher interprets resilience thinking and can thereby be seen as a theoretical limitation.

12 Future research recommendations

While striving to add a valuable contribution to the existing literature, this thesis has also highlighted additional routes of inquiry for further research endeavours. This final section will outline future research recommendations.

First, as pointed out in section 11.1, a comprehensive review of the ReCiPe meta-analyses needs to be conducted. While the information in the ReCiPe 2016 report gives a brief overview of the calculations and pressure impact modelling, it would be of great value if a researcher conducted a granular investigation on the resilience mechanisms considered in the meta-analyses. Not only would this add to a deeper analysis of the BFFI framework, but the findings could also be transferred to other biodiversity impact methodologies that use ReCiPe for their pressure impact modelling.

Furthermore, as highlighted by Biggs et al. (2012), ecosystem resilience can be ensured by managing for key social-ecological properties, but also by developing key governance attributes, such as participation and polycentricity. This thesis took an exclusive look at the key resilience properties present in the BFFI, however an analysis of the different key governance attributes was currently omitted. While there might have been few key resilience mechanisms found in the BFFI, the researcher believes that ASN and its partners do show multiple key governance attributes outlined by Biggs et al. (2012). For example, through the PBAF program, ASN could be significantly contributing to experimentation in the field of biodiversity accounting. It would therefore be interesting for future research projects to focus on identifying such key governance attributes at a financial institution. A possible research question could therefore be 'How can the governance of a financial institution foster the industry wide implementation of biodiversity impact methodologies'?

Finally, a future research project could concentrate on mapping the organizational decisions and cost-benefit analyses that go into the construction of a biodiversity impact methodology. As highlighted in this research, the scope and ability of a biodiversity impact methodology to incorporate resilience thinking is dependent on striking a balance between feasibility, suitability and desirability. At the moment, this theory is shallow and it would therefore be interesting to further investigate the different forces and stakeholders that are at play. If these managerial decisions were mapped out, then it could provide other financial institutions with steppingstones to potentially develop their own biodiversity foot printing methodologies.

13 References

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14 Appendices

APPENDIX I: INTERVIEW GUIDES

Interview guide 1a

1. Structure
   a. Could you start off by explaining your role in the construction of the BFFI framework?
   b. Could you describe what constitutes biodiversity in the context of the framework?
      i. Probe: Why did you choose this definition?
   c. Could you outline the structure of the BFFI framework?
      i. Probe: what is the intended goal of each phase?
      ii. Probe: How was the structure determined?
2. Assessing Biodiversity
   a. Could you explain how the BFFI measures the starting level of biodiversity in an area?
      i. Probe: How does the BFFI distinguish between organisms in an area?
      ii. Probe: Which databases does the BFFI utilize?
   b. How does the BFFI differentiate between ecosystem types and environments?
3. Measuring Biodiversity Loss
   a. How does the BFFI measure the biodiversity footprint of an economic activity?
      i. Probe: Why did you choose for this unit of analysis?
   b. Could you explain how the BFFI determines the impact of a pressure on biodiversity?
      i. Probe: Is this impact calculated differently between drivers?
4. Interpretation of the Footprint
   a. Could you explain how the complementary qualitative analysis impacts the biodiversity footprint score?
      i. Probe: in what instances would a footprint score be increased or decreased?

b. Is there anything else you would like to bring up, or ask about, before we finish the interview?

Interview guide 1b

1. Introduction
   a. Could you explain how you were involved with the ReCiPe methodology?
2. Structure
   a. Could you take me through the ReCiPe methodology?
   b. What are the most important steps within ReCiPe?
3. Is there anything else you would like to bring up, or ask about, before we finish the interview?

Interview guide 2a

1. Biodiversity Negative
   a. In your opinion, to what extent can the BFFI methodology assess ecosystem quality?
   b. How does the qualitative section of the BFFI determine the impact of biodiversity loss drivers not found in ReCiPe?
   c. In ReCiPe 2016, a distinction is made between three different scenarios that deal with uncertainty in the data. These are the individualistic, hierarchist and egalitarian perspective. Which perspective does the BFFI utilize in its calculations?
   d. Could you explain how the recovery time of an ecosystem influences the biodiversity footprint score?
2. Biodiversity Positive
   a. How can the BFFI be used to calculate the impact of biodiversity positive investments?
      i. Probe: Is this process capable of being more exact then the negative impact calculation of the BFFI?
   b. When is a project deemed to be biodiversity positive?
3. Acting on Results
   a. How does ASN steer on the results of the BFFI?
      i. Could you give an example?
   b. How does the BFFI inform ASN's investment policies?
   c. Is there anything else you would like to bring up, or ask about, before we finish the interview?

Interview guide 2b

1) Method Decisions
    a) At what trophic level does ReCiPe primarily module biodiversity?
        i) Probe: Is it able to differentiate between different between species and their environmental function?
    b) Does ReCiPe take into account the relative biodiversity loss versus the absolute value of an area?
2) Module Parameters
    a) Could you explain to what extent ReCiPe takes into account spatial or composition qualities of biodiversity when calculating the effect and damage factor?
    b) To what extent are the environmental pressures in ReCiPe interconnected?
3) The Bath Tub Model
    a) Could you explain the reasoning behind including the restoration period in the biodiversity footprint?
    b) How does the size of the conversion stage influence the length of the restoration period?
    c) Could you explain which factors influence the size of the restoration period?
    d) Following the relaxation period, how does ReCiPe determine whether the environment returns to its original state?
        i) Probe: Are alternate stable states possible?
    e) Is there anything else you would like to bring up, or ask about, before we finish the interview?

APPENDIX II: THEORY CONSTRUCTION

First picture: First ordering of codes. Screenshot of the Excel document in which interview and document quotes, initially coded descriptively, were inserted for thematic analysis. Interviewee and document names have been blacked out.

Picture 2-7 Theory building attempts. Screenshots of the Excel documents.

Descriptive Code	User	Quotation	Ideas for First Order Codes
Biodiversity Analysis - Focus	[redacted]	So we do not focus on specific species. We focus on biodiversity as a whole, which can also be looked at as ecosystem quality as a whole	Focusing on lower trophics levels as an indicator for species health
Biodiversity Analysis - Focus	[redacted]	biodiversity from a life support system point of view, all biodiversity can be important and relevant and not just the Red listed species	Biodiversity as a proxy for ecosystem resilience
Biodiversity Analysis - Focus	[redacted]	is that the focus on the species is the lower species	Higher level species having little effect on ecosystem functionality
Biodiversity Analysis - Focus	[redacted]	a panda can also travel. So it's more difficult to to see why a panda disappeared. Did it just just move or or when it did it go extinct?	Interpreting biodiversity as a means to safeguard ecosystem services
Biodiversity Analysis - Focus	[redacted]	wat ReCIpe het meeste gebruikt zijn beetje lager soorten organismen en planten. En de gedachte daarachter is dat dat een goede indicator is van de gezondheid van een ecosystem	Difficulties in modeling higher level species
Biodiversity Analysis - Focus	[redacted]	Het zijn vaak juist een meer een combinatie van soorten, ook vaak juiste soorten die helemaal niet zo in het oog vallen, die wel belangrijk zijn	Broader taxonomic focus within ReCiPe
Biodiversity Analysis - Focus	[redacted]	Soorten zijn ook maar één indicator van de biodiversiteit. De diversiteit in ecosystemen is bijvoorbeeld een andere vorm van biodiversiteit. Waar het ons vooral om gaat, en waar denk ik ook, In de samenleving omgaat is het instandhouden van de draagkracht die ecosystemen voor onze samenleving bieden	Higher Trophic levels being dependent on lower trophic levels
Biodiversity Analysis - Focus	[redacted]	heel veel soorten en zeker allerlei iconische soorten hebben helemaal niets een belangrijke effecten ecosystemen, de pandabeer, we kunnen, er gaan echt geen ecosystemen instorten wanneer de pandabeer uitsterft	All organisms are valued equally within a ecosystem
Biodiversity Analysis - Focus	[redacted]	Feitelijk gaat het dus met name om dat soort effecten die wij met onze investeringen proberen ofwel te verminderen, ofwel te compenseren. En individuele soorten, spelen daar al helemaal niet zo'n grote rol in	
Biodiversity Analysis - Focus	[redacted]	we started from a really functional, you could say, perspective of biodiversity	
Biodiversity Analysis - Focus	[redacted]	je kunt een heel programma starten voor het behoud van de pandabeer, maar dat draagt waarschijnlijk heel weinig bij aan het behoud van de ecosysteem waar die pandabeer eigenlijk van afhankelijk is	
Biodiversity Analysis - Focus	[redacted]	So we don't focus on species, but we focus on ecosystems and resilient ecosystems, rich ecosystems	
Biodiversity Analysis - Focus	[redacted]	it's not about one species that's really attractive or lovable for for	

Biodiversity Analysis | Analysis | Badkuip Model | Biodiversity Positive | Certification | Driver Elimination | Reference Situation | Spatial Characteristics

1st Order Codes	2nd Order Identification Number	Identification Number	Possible 2nd Order Codes	Embodying Identification Codes	Possible 3rd Order Codes
Focusing on lower trophics levels as an indicator for species health	3	1	Data Constraints	3, 5, 6	Bottom Up Thinking
Biodiversity as a whole representing ecosystem quality	2	2	Focus on Ecosystem Quality	2, 4, 9	Top Down Perspective
Higher level species having little effect on ecosystem functionality	3	3	Ensuring Foundational Stability	1,7,8,10	Challenges in stimulating Change
Anthropogenic perspective on biodiversity	2	4	Certification as a Signal		
Difficulties in modeling higher level species	1	5	Proactively minimizing drivers		
Taxonomic focus can change depending on driver data availability	7	6	Anticipating Change		
Higher Trophic levels being dependent on lower trophic levels	3	7	Opportunistic Data Gathering		
All organisms treated equally	2	8	Keeping the End User in Mind		
Hotspot analysis is step in the right direction	1	9	Spatial Characteristics		
Data quality as a bottleneck for effective analysis	1	10	Rewarding/Making Positive Change Possible		
Accurate hotspot assessment limited by portfolio size	8				
Biodiversity assessment needs to be pragmatic and understandable	8				
Anticipating ecosystem recovery in PDF unit	6				
Calculating ecosystem recovery rate per biome	9				
Including continious negative impact throughout recovery time	6				
Organizational intervention can be reflected in the PDF score	6				
Avoided negative impact is not automatically biodiversity positive	7				
Rewarding investments which are biodiversity positive	10				
Asking more precise data from project level finance	7				
Green energy investments result in avoided negative impact	10				
Discussion with partners on biodiversity positive definition	10				
Investing in landscape projects that indirectly improve biodiversity	7				
Certification signals lower pressure on biodiversity	4				
Certification is assumed to lead to better management practices	4				
Certified Investments can possibly increase biodiversity	4				
Requiring certification for investment requirements	5				
Positive impact of certification is qualitatively assessed	4				
Certification impact calculation hindered by data availability	1				
Having investment policies that eliminates driver data gaps	5				
Using reference situation that reflect biodiversity improving activities	10				
Pristine reference condition used for biodiverity negative calculations	5				
Linking driver impact to country spatial characteristics	9				
Full spatial analysis hindered by data availability	1				

1st Order Codes	2nd Order Identification Number	Identification Number	Possible 2nd Order Codes	Embodying Identification Codes	Possible 3rd Order Codes
Focusing on lower trophics levels as an indicator for species health	3	1	Data Constraints	3, 5, 6	Bottom Up Thinking
Biodiversity as a whole representing ecosystem quality	2	2	Focus on Ecosystem Quality/Biodiversity as a proxy	2, 4, 9	Top Down Perspective
Higher level species having little effect on ecosystem functionality	3	3	Ensuring Foundational Stability	1,7,8,10	Challenges in stimulating Change
Interpreting biodiversity as a means to safeguard ecosystem services	2	4	Certification as a Proxy/Certification as a signal		
Difficulties in modeling higher level species	1	5	Precautionary Approach		
Taxonomic focus can change depending on driver data availability	7	6	Anticipating Change		
Higher Trophic levels being dependent on lower trophic levels	3	7	Flexibility		
All organisms are valued equally within an ecosystem	2	8	Industry Practicalities & Endorsement		
Data quality as a bottleneck for effective analysis	1	9	Spatial Context		
Accurate hotspot assessment limited by portfolio size	8	10	Rewarding/Making Positive Change Possible		
Biodiversity assessment needs to be pragmatic and understandable for stakeholders	8				
Including biodiversity opportunity cost in PDF unit	6				
Calculating ecosystem recovery rate per biome	9				
Including continious negative impact throughout recovery time	6				
Reflecting organizational intervention in a lower PDF score	6				
Discussing with stakeholders how to make positive biodiversity possible	8				
Allowing flexibility in framework to accomodate project level data	7				
Investing in green projects that avoid negative impact	10				
Certification signals lower pressure on biodiversity	4				
Certification is assumed to lead to better management practices	4				
Certified Investments can possibly increase biodiversity	4				
Requiring certification for investment requirements	5				
The impact of certification is under assessed	5				
Certification impact calculation hindered by data availability	1				
Having environmental safeguards for ReCiPe	5				
Using reference situation that reflect biodiversity improving activities	7				
Pristine reference condition used for biodiverity negative calculations	9				
Linking driver impact to country spatial characteristics	9				
Full spatial analysis hindered by data availability	1				
Variable Impact related to land use	9				
BFFI is constantly developing	8				

1st Order Codes	2nd Order Identification Number	Identification Number	Possible 2nd Order Codes	Embodying Identification Codes	Possible 3rd Order Codes
Focusing on lower trophics levels as an indicator for species health	3	1	Limited Modeling Ability	3, 5, 6	Bottom Up Thinking
Biodiversity as a proxy for ecosystem quality	2	2	Focus on Ecosystem Quality	2, 4, 9	Top Down Perspective
Higher level species having little effect on ecosystem functionality	3	3	Cross Scale Resilience	1,7,8,10	Challenges in stimulating Change
Interpreting biodiversity as a means to safeguard ecosystem services	2	4	Certification as a Signal		
Difficulties in modeling higher level species	1	5	Reducing Calculation Uncertainty		
Broader taxonomic focus within ReCiPe	7	6	Anticipating Change		
Higher Trophic levels being dependent on lower trophic levels	3	7	Realizing Positive Impact		
All organisms are valued equally within an ecosystem	2	8	Industry Practicalities & Endorsement		
Data quality as a bottleneck for effective analysis	1	9	Spatial Sensitivity		
Accurate hotspot assessment limited by portfolio size	8	10	Rewarding/Making Positive Change Possible		
Biodiversity assessment needs to be pragmatic but reliable	8				
Including biodiversity opportunity cost in PDF unit	6				
Recovery rate calculations can be biome specific	9				
Including continious negative impact throughout recovery time	6				
Reflecting organizational intervention in a lower PDF score	6				
Impact results needs to be understandble for stakeholders	8				
Discussing with stakeholders how to make positive biodiversity	7				
Allowing flexibility in framework to accomodate project level data	7				
Investing in green projects that avoid negative impact	7				
Certification signals lower pressure on biodiversity	4				
Certification is assumed to lead to better management practices	4				
Certified Investments can possibly increase biodiversity	4				
Requiring certification for investment requirements	5				
The impact of certification is under assessed	5				
Certification impact calculation hindered by data availability	1				
Investment Policies need to complement certification	5				
Having environmental safeguards for ReCiPe	5				
Using reference situation that reflect biodiversity improving activities	7				
Pristine reference condition reflects organizational responsibility for biodiverity degradation	6				
Linking driver impact to country characteristics	9				
Full spatial analysis hindered by data availability	1				
Landuse damage can be assessed per biome	9				
Distinguish between local and regional impact	9				
BFFI is constantly developing	8				
ReCiPe based on peer reviewed biodiversity meta-analysis	8				
Meta-analysis assess species richness	2				

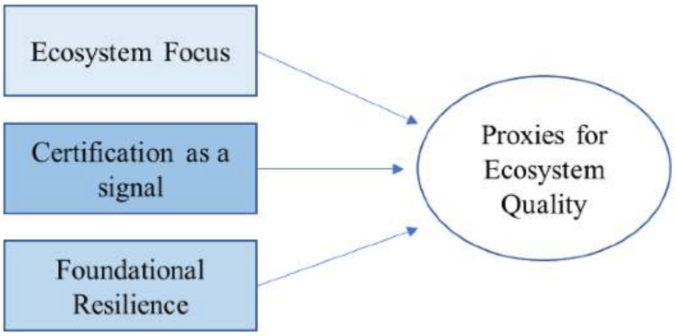
1st Order Codes	2nd Order Identification Number	Identification Number	Possible 2nd Order Codes	Embodying Identification Codes	Possible 3rd Order Codes
Focusing on lower trophics levels as an indicator for species health	3	1	Limited Modeling Ability	3, 5, 6	Bottom Up Thinking
Biodiversity as a proxy for ecosystem quality	2	2	Ensuring Ecosystem Quality	2, 4, 9	Top Down Perspective
Higher level species having little effect on ecosystem functionality	3	3	Cross Scale Resilience	1,7,8,10	Challenges in stimulating Change
Interpreting biodiversity as a means to safeguard ecosystem	2	4	Certification as a Signal	1, 2, 3, 9	Top Down Analysis
Difficulties in modeling higher level species	1	5	Precautionary Approach	4, 5 ,6	Anticipating and Reducing Damage
Broader taxonomic focus within ReCiPe	2	6	Adaptive Cycle Thinking	7, 8	Functionality
Higher Trophic levels being dependent on lower trophic levels	3	7	Towards Biodiversity Neutrality	2, 3, 6, 9	Top Down Analysis
All organisms are valued equally within an ecosystem	2	8	Industry Practicalities & Challenges	1, 4, 5	Anticipating and Reducing Damage
Data quality as a bottleneck for effective analysis	1	9	Spatial Sensitivity	7, 8	Industry Functionality
Accurate hotspot assessment limited by portfolio size	8			2, 3, 6, 9	Top Down Analysis
Biodiversity assessment needs to be pragmatic but reliable	8			1, 4, 5	Anticipating and Reducing Damage
Including biodiversity opportunity cost in PDF unit	6			7, 8	Industry Functionality
Recovery rate calculations can be biome specific	9				
Including continious negative impact throughout recovery time	6				
Reflecting organizational intervention in a lower PDF score	6				
Impact results needs to be understandble for stakeholders	8				
Discussing with stakeholders how to make positive biodiversity	7				
Allowing flexibility in framework to accomodate project level data	7				
Investing in green projects that avoid negative impact	7				
Certification signals lower pressure on biodiversity	4				
Certification is assumed to lead to better management practices	4				
Certified Investments can possibly increase biodiversity	4				
Requiring certification for investment requirements	5				
The impact of certification is under assessed	5				
Certification impact calculation hindered by data availability	1				
Investment Policies need to complement certification	5				
Having environmental safeguards for ReCiPe	5				
Using reference situation that reflect biodiversity improving	7				
Pristine reference condition reflects organizational responsibility for biodiverity degradation	6				
Linking driver impact to country characteristics	9				
Full spatial analysis hindered by data availability	1				
Landuse damage can be assessed per biome	9				
Distinguish between local and regional impact	9				
BFFI is constantly developing	8				
ReCiPe based on peer reviewed biodiversity meta-analysis	8				
Meta-analysis assess species richness	2				

1st Order Codes	2nd Order Identification Number	Identification Number	Possible 2nd Order Codes	Embodying Identification Codes	Possible 3rd Order Codes
Focusing on lower trophics levels as an indicator for species health	3	1	Limited Modeling Ability	2, 3, 9	Ensuring Ecosystem Quality
Biodiversity as a proxy for ecosystem quality	2	2	Ecosystem Focus	6, 7, 4, 5	Anticipating and Reducing Damage
Higher level species having little effect on ecosystem functionality	3	3	Foundational Resilience	1, 8	Striking a Balance
Interpreting biodiversity as a means to safeguard ecosystem	2	4	Certification as a Signal	2, 3	Ensuring Ecosystem Quality
Difficulties in modeling higher level species	1	5	Precautionary Approach	7, 4, 5	Anticipating and Reducing Damage
Broader taxonomic focus within ReCiPe	3	6	Adaptive Cycle Thinking	1, 8	Striking a Balance
Higher Trophic levels being dependent on lower trophic levels	3	7	Towards Biodiversity Neutrality	6, 9	Unkown
All organisms are valued equally within an ecosystem	2	8	Industry Requirements and Limitations	2, 3, 4	Ensuring Ecosystem Quality
Data quality as a bottleneck for effective analysis	1	9	Spatial Context Damage & Recovery	5, 6, 7, 9	Anticipating and Reducing Damage
Accurate hotspot assessment limited by portfolio size	8			1, 8	Striking a Balance
Biodiversity assessment needs to be pragmatic but reliable	8				
Including biodiversity opportunity cost in PDF unit	6				
Recovery rate calculations can be biome specific	9				
Including continious negative impact throughout recovery time	6				
Reflecting organizational intervention in a lower PDF score	6				
Impact results needs to be understandble for stakeholders	8				
Discussing with stakeholders how to make positive biodiversity	7				
Allowing flexibility in framework to accomodate project level data	7				
Investing in green projects that avoid negative impact	7				
Certification signals lower pressure on biodiversity	4				
Certification is assumed to lead to better management practices	4				
Certified Investments can possibly increase biodiversity	4				
Requiring certification for investment requirements	5				
The quantitative impact of certification is under assessed	4				
Certification impact calculation hindered by data availability	1				
Investment Policies that complement certification	5				
Having environmental safeguards for ReCiPe	5				
Using reference situation that reflect biodiversity improving	7				
Pristine reference condition reflects organizational responsibility for biodiverity degradation	6				
Linking driver impact to country characteristics	9				
Full spatial analysis hindered by data availability	1				
Landuse damage can be assessed per biome	9				
Distinguish between local and regional impact	9				
BFFI is constantly developing	8				
ReCiPe based on peer reviewed biodiversity meta-analysis	8				
Meta-analysis assess species richness	2				

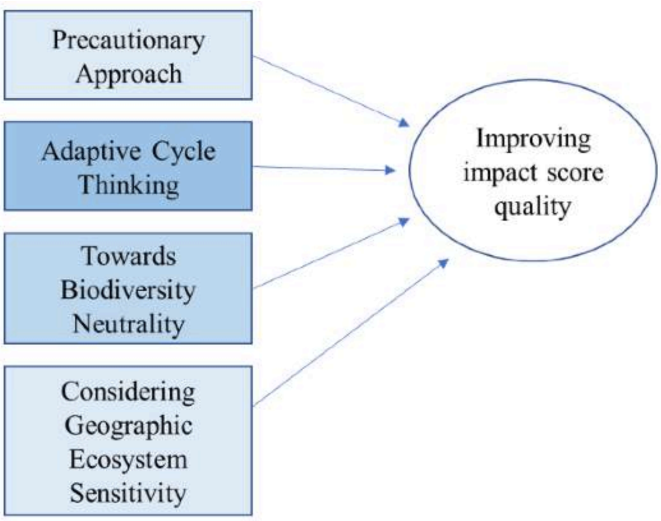
1st Order Codes	2nd Order Identification Number	Identification Number	Final 2nd Order Codes	Embodying Identification Codes	Final 3rd Order Codes
Focusing on lower trophics levels as an indicator for species health	3	1	Limited Modeling Ability	2, 3, 4	Proxies for Ecosystem Quality
Biodiversity as a proxy for ecosystem quality	2	2	Ecosystem Focus	5, 6, 7, 9	Improving Impact Score Quality
Higher level species having little effect on ecosystem functionality	3	3	Foundational Resilience	1, 8	Striking a Balance
Interpreting biodiversity as a means to safeguard ecosystem services	2	4	Certification as a Signal		
Difficulties in modeling higher level species	1	5	Precautionary Approach		
Broader taxonomic focus within ReCiPe	3	6	Adaptive Cycle Thinking		
Higher Trophic levels being dependent on lower trophic levels	3	7	Towards Biodiversity Neutrality		
All organisms are valued equally within an ecosystem	2	8	Industry Requirements and Limitations		
Data quality as a bottleneck for effective analysis	1	9	Considering Geographic Ecosystem Sensitivity		
Accurate hotspot assessment limited by portfolio size	8				
Biodiversity assessment needs to be pragmatic but reliable	8				
Including biodiversity opportunity cost in PDF unit	6				
Recovery rate calculations can be biome specific	6				
Including continious negative impact throughout recovery time	6				
Reflecting organizational intervention in a lower PDF score	6				
Impact results needs to be understandble for stakeholders	8				
Discussing with stakeholders how to make positive biodiversity	7				
Allowing flexibility in framework to accomodate project level data	9				
Investing in green projects that avoid negative impact	7				
Certification signals lower pressure on biodiversity	4				
Certification is assumed to lead to better management practices	4				
Certified Investments can possibly increase biodiversity	4				
Requiring certification for investment requirements	5				
Impact of certification is difficult to determine	4				
Certification impact calculation hindered by data availability	1				
Investment Policies that complement certification	5				
Having environmental safeguards for ReCiPe	5				
Using reference situation that reflect biodiversity improving activities	7				
Pristine reference condition reflects organizational responsibility for biodiverity degradation	6				
Linking driver impact to country characteristics	9				
Full spatial analysis hindered by data availability	1				
Landuse damage can be assessed per biome	6				
Biodiversity impact measurement is still in its baby shoes	1				
ReCiPe based on peer reviewed biodiversity meta-analysis	8				
Meta-analysis assess species richness	2				

APPENDIX III: CODING TREES

Coding tree 1: sub themes to 'proxies for ecosystem quality' aggregate theme



Coding tree 2: sub themes to 'improving impact score quality' aggregate theme



Coding tree 3: sub themes to 'striking a balance' aggregate theme