1. Contestant profile

▪ Contestant name:	**Kajsa Jansson**
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2. Project overview

Title:	Enhancing Restoration Guidelines Through a Strategic Sustainable Development Approach
Contest:	Quarry Life Award 2016
Quarry name:	Degerhamn, Öland (Cementa)
Prize category: (select all appropriate)	☐ Education and Raising Awareness ☐ Habitat and Species Research x Biodiversity Management ☐ Student Project x Beyond Quarry Borders

ABSTRACT

Land areas that are being used unsustainably are depleted and degraded which can cause loss of biosphere integrity (biodiversity). To prevent this from happening and to reverse the effects, we need to restore these environments. However, not all restoration practices are equal, some are not strategic enough to be successful in raising biodiversity, and others do not adhere to rigorous standards of sustainability. In this study, restoration guidelines and opinions from field experts were analysed from a strategic sustainability approach according to a particular framework. When analysing HeidelbergCement Group's restoration guideline (among others) according to the framework for strategic sustainable development, gaps were found both in its strategic aspects and coverage of sustainability. One example of a gap found was that there were no boundaries set for reaching goals meaning that it is more likely for misinterpretations or loopholes to lower the quality of the outcome. From these gaps that we found, we formulated recommendations on how to become more strategic and incorporate full sustainability into the guidelines. One such recommendation was having the Sustainability Principles from the framework used as overarching boundaries for success. Incorporating these recommendations into current practices would enable the company to avoid sustainability problems, aiding in the practitioner's ability to be strategic and have long-term success within sustainable limits. The conclusion was that this approach could create great value for the company, for example by lowering the risk of failed projects as a financial loss; societal value for the influence the local community would have in this process; and biodiversity value from the increase of successful projects. The focus of our thesis was limestone quarries in Sweden, however, the findings presented in this report could be applied in all of HeidelbergCement Groups quarries.

1. INTRODUCTION

Society is dependent on ecosystem services, however approximately 60% of these are currently being used unsustainably (MEA 2005). In particular, biodiversity loss (worded in the planetary boundaries as 'loss of biosphere integrity') and land system change are two of the four ecological thresholds that have already been surpassed by humanity (Cornell 2015), these are also two relevant impacts when focusing on quarries. An important process in the recovery of these ecosystem services and bringing the socio-ecological system back towards sustainability is restoration. However, not all restoration practices are equal, and some do not adhere to rigorous standards of sustainability. In order to achieve long-term success of restoration projects, they need to incorporate full sustainability and be strategic.

Our thesis that this report is based on investigated full strategic sustainability as defined by the Framework for Strategic Sustainable Development (FSSD) with quarry restoration in order to facilitate ecosystem recovery and at the same time lead to a sustainable future. This was done by analysing current restoration guidelines and opinions from experts working in the field from a Strategic Sustainable Development (SSD) perspective. The goal was to surface deficiencies and current issues within restoration and subsequently develop advice for how to improve guidelines to facilitate a more strategic sustainable restoration practice. The audience for our thesis was management level restoration, sustainability, or environmental management level professionals that are involved in decision-making processes with regards to restoration practises of different quarry sites. The focus of our thesis was limestone quarries in northern Europe due to quarries' contributions and impacts to the socio-ecological system and the sensitivity of northern ecosystems. This report acts as both a brief summary of the most crucial results of that thesis and gives specific guidance for how HeidelbergCement Group can utilize this approach for enhancing the biodiversity at their quarry sites.

2. BACKGROUND

Restoration in northern regions. Successful restoration is important in all regions but in countries such as Sweden there is particular urgency. Northern regions carry special challenges apparent in restoration including short growing seasons, long recovery periods, slow nutrient turnover that causes slow vegetation development, and long winters that may challenge biota (Nilsson and Aradóttir 2013). Consequently, the northern ecosystems may require long periods of recovery, even if the recovery process was supported by restoration (Forbes and McKendrick 2002). Therefore, failure in restoration projects in these regions is more problematic because of the time lost. This is one of the reasons why quarry sites in Sweden were chosen for the focus of our thesis. (For more information on the importance of restoration in general see Appendix 1.)

Why analyze guidelines? The overall purpose of most guidelines is to help practitioners make appropriate decisions for specific contexts (Lim et al. 2008). Guidelines are also important for effective planning and implementation of restoration projects (Hobbs and Norton 1996). The clearer they are written, and with the inclusion of guiding principles, the higher the chance for success of the project. Guidelines appear to be a strong leverage point for ensuring that full strategic sustainability is incorporated across all HeidelbergCement Group quarry restoration projects. (For more information on guidelines see Appendix 1.)

What is the solution? In order to enable future generations to meet their needs, society needs to change current unsustainable activities. That is why society needs an approach that will help them to strategically plan towards sustainable development. Considering that restoration is an important element in sustainable development, it needs to be planned strategically in order to have long-term success. A fully sustainable and strategic approach can consist of many components such as the framework used in this report and its 8 sustainability principles (8 SPs) (both described below), that aid to not losing a big picture view, and give tools and advice on how to plan strategically while being sustainable.

Five Level Framework (5LF). Ecological systems are unpredictable, nonlinear, and complex (Choi et al. 2008). In order to plan and select relevant measures for complex issues, upstream thinking and backcasting need to be included in the planning procedure. As well as robust non-overlapping principles that define the outcome as to not create new problems (Robèrt 2000). That is where the 5LF can be applied as it was developed to aid understanding and assist simplification and categorization in complex systems such as ecosystems. It is designed for analysing problems, aid in decision-making or creating strategic action plans. When moving strategically towards success it provides analytical clarity to avoid getting lost in the inherent complexity. It does this through organizing the important information that is needed for planning into five categorical levels.

Framework for Strategic Sustainable Development (FSSD). When the 5LF is applied to sustainable development the resulting planning framework is referred to as the FSSD. It supports groups working towards a goal to use a shared language with respect to sustainability. Since it is based on the 5LF, the FSSD consists of five levels, but include specific sustainability criteria for all levels, such as: 1) The systems level includes an analysis of restoration in the global socio-ecological system and an overview of the sustainability challenge. 2) The success level includes the 8 SPs acting as boundaries for success. 3) The strategic level includes backcasting from previously mentioned sustainability principles, the vision and goals of the restoration. As well as guiding prioritization criteria. 4) The actions level includes specific actions to help reach sustainability. 5) The tools level includes tools that enhance sustainability implementation, assessment, analysis, etc (Robèrt 2000). The FSSD is a valuable tool that, when compared to restoration guidelines, can show if they are strategic and sustainable and can highlight the potential areas for improvement.

Sustainability Principles (8 SPs). In order to plan strategically, a clear definition of the goal is needed. In a sustainability context, success has been defined as 8 SPs. The 3 ecological principles state that ”in a sustainable society, nature is not subject to systematically increasing 1) concentration of substances extracted from the Earth’s crust, 2) concentrations of substances produced by society, 3) degradation by physical means. The 5 social principles state that in a sustainable society people are not subject to structural obstacles to 4) health, 5) influence, 6) competence, 7) impartiality, and 8) meaning-making’’ (Missimer, Robèrt, and Broman 2016). These act as constraints within which humanity must operate in, in order to be ecologically and socially sustainable. To restore you must exceed the expectations within the 8 SPs since we do not want to sustain a destroyed ecosystem, we want to enhance it, to reverse the effect of the violation/destruction that has occurred, to promote biodiversity.

ABCD Strategic Planning Process. In order to implement the FSSD in an organizational context, the ABCD Strategic Planning Process was created. In the A step, the planning team build a shared understanding and vision of the organization within a sustainable society in the future. In the B step, the team assess the current reality using the 8 SPs as metrics of success. In the C step, potential actions to reinforce positive areas and mitigate negative impacts found from the B step are brainstormed. Finally, in the D step, actions are analyzed and prioritized based on three criteria as a minimum, they are: the right direction of the actions, flexibility and return on investment (Robèrt et al. 2015). In the context of business planning an E step is added where a strategic action plan is created that outlines budget, timeline, and who is responsible for what action.

If restoration guidelines were to follow the FSSD, guidelines would have a clear socio-ecological system view and connection to the sustainability challenge; a clear success definition of restoration that includes a clear success definition of sustainability; they would be strategic including a clear vision, goals and prioritization process; they would recommend actions that are sustainable; and they would recommend tools in order to enhance the process of restoration. In this way, guidelines would support both the key processes in restoration projects, and full sustainability as defined by the 8 SPs. Ensuring that projects are successful in the long-term will not only improve biodiversity, which is already a large focus of HeidelbergCement Group quarry restoration projects, but also other ecological and social parameters.

3. METHODOLOGY

The research question was: *In which ways could an SSD approach enhance quarry restoration guidelines?* A sub-question to guide the research was: *To what degree do current restoration guidelines take a strategic perspective on sustainability?* In order to answer the main research question, a qualitative pragmatic approach was used and the research was conducted in two phases.

The objective of phase 1 was to answer the secondary research question and included a literature review and a comparative study of five restoration guidelines against the FSSD. The FSSD was chosen as an assessment tool to examine similarities and highlight discrepancies in the guidelines with regards to strategic full scope sustainability. After the initial FSSD comparison was completed, a deeper analysis of the 8 SP’s and principles presented within the guidelines was conducted to get a fuller scope of how the success level was covered.

The objective of phase 2 was to answer the primary research question. In order to compare if the gaps found in phase 1 would also appear in conversation with industry experts, explorative and open-ended semi-structured interviews were conducted. The recurring gaps that surfaced both in the comparative study as well as in interviews revealed the most crucial areas for improvement for restoration to become fully sustainable.

During this project we collaborated with a handful of people and organisations that strengthened the quality and applicability of our research. One was HeidelbergCement Group, especially with Cementa Degerhamn, as well as Cementa Slite. The site visits gave us insights to how the quarries look and the opinions of some employees of the FSSD. Our advisors, teachers, and peers from Blekinge Tekniska Högskola were also helpful with regards to writing the thesis.

Research Methods Phase 1

Literature Review. A literature review was done for an intersystem analysis of the field of restoration, and to find other relevant background information.

Sampling Guidelines. An initial search for guidelines gave a result of 100+ restoration guidelines. 38 guidelines within restoration, conservation, environmental management and quarrying were reviewed, and from which five guidelines were chosen based on the criteria: guideline for restoration or rehabilitation of a natural area, intended audience being project managers, being applicable to a quarry setting. These five were: *Ecological Restoration for Protected Areas: Principles, Guidelines and Best Practices* (IUCN), *Guidelines for Developing and Managing Ecological Restoration Projects* (SER), *Promotion of Biodiversity at the Mineral Extraction Sites of HeidelbergCement* (HC), *HANDBOK:* Inspiration till att skapa bra natur i täkter. Åtgärder under drift och i samband med efterbehandling [Inspiration for developing great nature in quarries. Measures for operations and in conjunction with after-treatment; translation by thesis group] (Handbok), and *Guidelines on Quarry Rehabilitation* (CSI). For this report the focus was kept on CSI, HC, and Handbok since these were the most relevant for HeidelbergCement Group.

Data Collection, Handling, and Analysis. Selected guidelines were thoroughly read and compared to each level of the FSSD. In order to evaluate if the guidelines covered full sustainability, principles presented within the selected guidelines were compared with the 8 SPs (see Table 4.2). Each SP was given a score from 1-5 to help quantify how much each SP was covered in the guidelines and which guideline covered the most SPs (see Table 4.2 legend).

Research Methods Phase 2

Sampling Interviews. A list of interview candidates and quarries from northern Europe were provided by the Finance & Sustainability Project Manager at HeidelbergCement Group. Interview participants that met the following criteria were contacted: currently working in a management position (or similar) with restoration, sustainability or environment at a quarry site; or were independent sustainability or restoration consultants. In total 6 people were interviewed.

Data Collection, Handling, and Analysis. Questions were based on an interview protocol that followed a list of pre-set questions (Savin-Baden and Major 2012). Two interviewers were present during all interviews, and all interviews were digitally voice recorded with participant agreement. A verbatim transcript method (Savin-Baden and Major 2012) was used to transcribe the recorded interviews. Two researchers individually coded the transcripts in order to enhance the validity of the study. A priori codes based on the themes and meanings found from phase 1 was used and co-occurring codes were included when a segment of data got more than one code (Savin-Baden and Major 2012). The coding was followed by a content and thematic analysis in order to discover any similarities and discrepancies between the different interviewee's answers. Themes that emerged from this interviewee analysis were cross-checked and evaluated with the findings from the comparative study in phase 1. This was done in order to triangulate recurring gaps and extrapolate the most crucial areas for improvement for restoration to become fully sustainable and to formulate advice to practitioners.

4. RESULTS

The results include: FSSD assessment of guidelines; 8 SP analysis to principles in guidelines; and interviews. The FSSD comparison table 4.1 shows gaps and strengths of the different guidelines. The 8 SP analysis (found in table 4.2) showed both which of the 8 SP's were covered the most, and which guidelines covered the most SP's.

The full results of the interviews (see Appendix 3) were categorized based on the levels of the 5LF which was the coding categorization as well. The following are a few examples of the results from each level: For the systems level, all interviewees agreed that restoration is an important aspect of sustainability. For the success level, only two of six participants mentioned any type of social aspect for goals, the other four strictly referred to biodiversity and/or ecosystem functions. However, when asked about what were the key criteria for a successful restoration project five of six solely referred to social aspects as being the key drivers. For the strategic level, the biggest gap illustrated from the guideline comparison was the same for the interviews, namely a lack of prioritization criteria. For the actions level, most interviewees explained that actions were site specific. For the tools level, the majority of participants were unable to identify a variety of tools that could be used in the restoration process.

Table 4.1 FSSD Comparison Summary Chart for HC, Handbok, and CSI.

FSSD Level	Strengths/Compliances	Gaps/Violations
System	All three have a large focus on biodiversity, restoration, and renaturation. Overall there are limited connections made to the larger socio-ecological system. HC mentions benefits of quarries, the significance of individual habitats, and sustainability. The Handbok makes strong links between biodiversity to ecosystem services and social benefits. CSI helps understand the system of study, and showcases specific benefits in case studies.	All three documents seem to have slight biases that are in favour of the quarry/cement industries. HC is missing a systems view of the why of restoration, but does have the why on an individual habitat level. However they have no bigger picture referral which is problematic for being strategic and having a long-term plan. The Handbok makes the assumption that all quarries are introduced in areas that initially had very low productivity making quarrying an activity that would always increase biodiversity. CSI had no clear connections to the sustainability challenge.
Success	All three mention increasing biodiversity value as a main focus for success which is highly relevant for this industry. For HC success for the after-use of a site must be long-lasting, safe for humans, sustainable, and efficient. The Handbok defined success specifically for each habitat type. CSI mentions global sustainability briefly in the context of restoration, law, and stakeholders for success.	All three have varying definitions of success for restoration. Success can vary based on the specific site but to avoid misinterpretations the overarching success across guidelines used by the same company should not vary. None of the guidelines cover full sustainability or offer boundaries for avoiding violations when reaching goals. Another example of a gap is that those guidelines do not mention systematic decrease in physical damage to the land or systematic decrease in concentrations of man made substances in the biosphere, they mention solely increase in biodiversity, which is not enough to become sustainable. HC has no clear success definition for restoration. The Handbok and CSI are both lacking in the social sustainability principles. Some of CSI's principles mention social, economic, environmental aspects and legislative requirements, but it doesn't explain what specifically it means, so potential violations may occur due to omission of some important aspects such as employees health or impartiality.
Strategic	All three have some aspects of strategic planning. HC	None of the guidelines help practitioners for strategic prioritization of

	gives four steps for planning, give some guidelines and incorporate environmental sustainability into planning process. The Handbok highlights the importance of making a plan, and there is an action key/ goal how things should look their guide/map for forecasting. CSI has seven principles as the vision for success along with the processes to reach these and they must be monitored and managed continuously (taking into account non-linearity).	actions or show urgency. HC does not tell you how to incorporate the principles into the planning, has potential for violations, and social sustainability is not fully covered in planning process. The Handbok gives steps but no follow up. For the CSI everything must be above legal requirements of the country it is in, but this does not represent levels that are always best for the environment or what is the most sustainable.
Actions	HC promotes actions to take for different habitats for the after use but also actions for currently in use sites, and recommend indicators to monitor development and sustainability. The Handbok shows there are only a few actions needed in order to make a rich biodiversity, and has an entire chapter dedicated to actions with descriptions of which and how actions are appropriate. CSI has actions connected to their principles.	None of the actions recommended by the guidelines cover the full scope of sustainability. HC does not give the when and how to use actions, and interlinkage between actions and goals is lacking. The Handbok guides you to an action from the action key but does not cover full sustainability. CSI has many generalisations.
Tools	Overall these guidelines recommended multiple tools to aid practitioners. HC has recommended documents and tools for all stages, (identification, monitoring, indicators, and assessments). The Handbok gives no tools but does refer to different societies, handbooks, etc. CSI suggests multiple tools during the different phases of restoration for evaluating and managing all impacts of a site and describing the context of project.	N/A

Table 4.2 8 SP Comparison

	HC (Principles)	Handbok (Actions)	CSI (Principles)	Total
1 (Earth's crust)	? + Semi- acknowledged	? - Avoided	? + Semi- acknowledged	33% (5/15)
2 (Made by society)	+ Addressed	? - Avoided	? + Semi- acknowledged	40% (6/15)
3 (Physical degradation)	? + Semi- acknowledged	+ Clearly addressed	? + Semi- acknowledged	53% (8/15)
4 (Health)	? Semi- acknowledged	+ Clearly addressed	? + Semi- acknowledged	53% (8/15)
5 (Competence)	? - Avoided	? - Avoided	? + Semi- acknowledged	26% (4/15)
6 (Influence)	+ Addressed	? - Avoided	? + Semi- acknowledged	40% (6/15)
7 (Impartiality)	+ Addressed	? - Avoided	? + Semi- acknowledged	40% (6/15)
8 (Meaning-making)	? + Semi- acknowledged	? + Semi- acknowledged	? + Semi- acknowledged	40% (6/15)
Total	45% (18/40)	37.5% (15/40)	40% (16/40)	

Table 4.2 - Legend
5 points: *Fully Addressed* meant a clear reference to the SP and the principle was covered fully and left no room for sustainability violations. **This can not be seen in table 4.2 since no guidelines fulfilled its criteria.**
4 points: *Clearly addressed* meant a clear reference to the principle but not necessarily covering the full scope of it. For example, SP4 only addressing physical health and not mental or emotional.
3 points: *Addressed* meant it was indirectly referenced and not fully covered.
2 points: *Semi-acknowledged* meant that it was not directly spoken to but was more likely to comply than to violate. However, it was still unclear and so could potentially lead to sustainability violations.
1 point: *Avoided* meant it was very unclear or that it indirectly promoted violations.

5. DISCUSSION

Gaps found in the FSSD comparison to the guidelines are hypothetical sustainability gaps. From looking at the guidelines alone it is not possible to see if the lack of certain strategic components would lead to sustainability violations or not, just that it would be more likely. The 8 SP analysis showed that there is a clear need for overarching non-overlapping principles since not all aspects of sustainability were fully covered in any of the guidelines.

One major gap, prevalent in both the guidelines and interviews, was within the success level. Since restoration principles in the guidelines did not cover all aspects of sustainability and the guidelines did not give specific restrictions in how to reach their goals, many interviewees had different ideas about what actions were most suited for a successful restoration project. Most guidelines have great goals but not enough specifics or criteria in how to reach them or what to avoid while reaching them, leading to loopholes that lower the strategic perspective. An example of how these guidelines can lead to misinterpretations was described during the interviews. In this case the guideline said re-vegetation but gave no boundaries, such as local species for that particular area (that is covered with SP3). The contracted group planted a common mixture of seeds but did not consider the local flora and landscape. This action caused everything in the area to die and the process of re-vegetation had to be repeated, doubling the initial cost. Resulting in both financial and ecological losses.

Each guideline we looked at included at least one aspect from a level of the FSSD. But each guideline also had gaps. Overall, the results of the study showed that the restoration guidelines are not strategic enough in terms of supporting restoration practitioners effectively towards sustainable development, answering research question 2. Some guidelines partially met strategic criteria but overall no guideline encompassed all aspects of the FSSD. The interviews backed up this conclusion by reinforcing that most of the gaps presented in the guidelines were also gaps in the actual restoration.

Advice to practitioners. These recommendations (formulated from the results of this study) are meant to assist practitioners in the transition towards including full strategic sustainability in restoration projects before better guidelines are developed. The recommendations are focused on the areas that are in need of the most improvement: systems, success, and strategic levels. The recommendations formulated from the thesis for the actions and tools levels have not been included in this report since HeidelbergCement Group encompass these levels moderately well in their guidelines.

Systems Level

What: The connections of the project to the larger socio-ecological system should be understood by everyone involved in the project.

Why: In order to better align ideas for the project and give a sense of greater purpose to the stakeholders. Without understanding the sites role for local ecosystem services, decisions that could

result in negative and expensive long-term consequences could be decided solely based on short-term and site-specific parameters.

Success Level

What: The vision should not be limited to only increase biodiversity, but should be more adapted to the specific site and best solutions should be selected for the area.
Why: Biodiversity is a pivotal success factor for most restoration projects. However, this is not necessarily the most appropriate for every site. For example, some quarry sites have very sensitive environments and it may be difficult to increase biodiversity in such an area.

The interviews show that the 8 SP's acting as boundaries of success can be difficult to understand and use without having a deep understanding of them. Below is a slightly altered formulation of the SPs in order to more specifically be applicable and relevant for restoration in the quarry industry.

In a sustainable society, the environment is not subject to exponential increases in

1) Concentration of substances extracted on site, meaning that the materials (final products and wastes) are handled in a controlled manner so that they do not spread in ecosystems.

2) Concentrations of substances produced by society, meaning that substances, such as pesticides, are only used in a controlled manner so that they do not spread in ecosystems.

3) Degradation by physical means, meaning that habitats and species are not destroyed through the activity. With strong focus on biodiversity protection and improvement.

People are not subject to structural obstacles to:

4) Health, such as safety of workers and visitors on site.

5) Influence, such as involving more local people into the process.

6) Competence, such as making sure employees have opportunities for self-development relevant to the project.

7) Impartiality, such as the choice of stakeholders involved is not based on demographic reasoning.

8) Meaning-making, such as connecting the project to the bigger socio-ecological system to bring meaning and pride to employees work.

Strategic Level

What: Backcasting from the success orientation (vision) should be used.
Why: Backcasting is flexible for incorporating better future technologies as the project progresses. It also ensures goals and actions are aligned with the vision, ensuring progress towards the desired outcome and long-term success.

What: A process in how to prioritize actions according to the 8 SPs, vision, and to criteria best suitable for the site should be developed.
Why: Criteria and planned prioritization is part of good strategic planning. For example, other types of return on investment should be considered that would help inspire or finance other actions.

Expected value. There are expected added values to gain for biodiversity, society and the company at large by integrating a fully strategic and sustainable approach into restoration guidelines. For example, HeidelbergCement Group's restoration guideline already has a very large focus on biodiversity. However, by only presenting a limited scope there is potential for disregarding factors that can negatively affect biodiversity in the long-run such as the SP for meaning-making. If employees aren't engaged or motivated to do the restoration projects well, for example because the guideline does not emphasize the urgency or importance of their work in the larger global context, it might result in lower success rates. Workers who find their work meaningful are more productive than workers who do not. Integrating the approach will also help groups working towards restoration to have a shared language when planning and moving strategically towards success, thus ensuring that biodiversity is not neglected while planning for restoration for the long-term. Furthermore, by having clear boundary conditions for success, loopholes that lower the quality of the restoration and therefore biodiversity value, are avoided.

Restoration can also increase the social cohesion in a community by generating jobs, improve quality of life, and betters' livelihoods. The company's reputation will also be positively affected thorough openly incorporating the 8 SPs into everyday operations and taking a clear social and ecological stand, thus leveraging the company's impact for the public good. This is done also by allowing the local community(ies) to feel more involved in the decisions that affect their environment. Furthermore, educating the community about the importance of biodiversity, as well as the proactive restoration measures that the company has already taken, is one way to showcase how quarries can co-exist with nature.

Overall, the added value to the company from using a strategic and fully sustainable approach can be summarized in 7 bottom line business benefits: Increased revenue & market share, reduced energy expenses, reduced waste expenses, reduced materials & water expenses, increased employee productivity, reduced hiring & attrition expenses, and reduced risks, (Willard, 2012). These business benefits come from the Future-Fit Organisation whose benchmarks and key indicators are based on the same 8 SPs as this study. Biodiversity plays a vital role in these benefits as it is one of the largest and most relevant indicators of successful ecological sustainability.

Elaborating on those business benefits, further acting sustainably, lowers the risks associated with environmental and social impacts such as lawsuits and a negative reputation leading to less customers. One of the biggest benefits will be the support and engagement of the employees and community. Well-done restoration projects are more likely to have the full support, both financially and otherwise, from locals. A negative reputation is one major issue the quarry industry faces. A company's sustainability image has an impact on the business's relationships, both with customers and suppliers, because it demonstrates responsibility and builds loyalty. Therefore, this approach will help strengthen the company's image thus gaining people's trust and thereby gaining loyal or new customers and in turn increase the company's revenue. This will also lower the resistance met from communities for new projects and additional developments.

Implementation. The ABCD process to implement the FSSD into operations has already begun in Cementas' factories in Sweden with Degerhamn's site taking a strong lead (for an example of how the FSSD workshops results look with Degerhamn see Appendix 2). This process can be implemented at any time, at all of HeidelbergCement Groups quarries and factories at large. In fact, many of the existing HeidelbergCement Group visions, goals, and strategies already encompass some of the 8 SPs, so the company is already on the right path.

Using the ABCD tool is a cyclical process that needs to constantly be re-visited. This can be done during already existing annual, monthly, weekly meetings. It is important that this process is as inclusive as possible so

that people feel attached to the vision and strategies, and feel they can influence the process in order for it to be adopted and implemented successfully into operation. There could be difficulties with finding the time to schedule workshops for the employees. However, the costs for the workshops are relatively low when comparing to other investments HeidelbergCement Group makes and when compared to the possible return on investment from the different strategies that come out of these events. Implementation of this approach has already begun in Sweden where there are relatively strong social standards and environmental procedures in place, but further improvements are necessary to head towards full sustainability. However, the benefits might be even more noticeable at locations in developing countries where more serious sustainability challenges are currently acting as obstacles for the company and local communities. In this way sustainability challenges such as biodiversity loss can be addressed while simultaneously expanding development due to a decreased local resistance. Implementing a strategic and fully sustainable approach into operations as soon as possible does not require an immediate incorporation into the guidelines, but if this approach is to be more widespread within the HeidelbergCement Group, having it in the guidelines will aid in this transition towards sustainability.

6. Conclusion

When analysing HeidelbergCement Group's (and additional relevant) restoration guidelines according to the framework for strategic sustainable development, gaps and compliances were found. There were many areas of compliance in sustainability due to HeidelbergCement Groups' commitment to biodiversity value. However, sustainability covers both ecological and social parameters. Since the environment and society are so interconnected neglecting one can end up negatively impacting the other in the long-term, for example unmotivated workers resulting in a lower quality restoration project. This approach would include and facilitate a higher awareness over the social sustainability parameters which were concluded to be the most essential factors to having a successful restoration project but were the least covered in the guidelines.

One specific example of a gap was that there were no boundaries set for reaching goals. The recommendation to address this gap was having the Sustainability Principles from the framework used as overarching boundaries for success. By incorporating sustainability boundary conditions to the definition of successful restoration, it can minimize misinterpretations of the guidelines, and give more guidance on what to avoid while reaching goals. Incorporating all of the recommendations into current practices would fill the sustainability gaps, aiding in the practitioner's ability to be strategic and have long-term success whilst simultaneously transitioning towards being sustainable.

The conclusion was that this approach could create great value for the company, for example by lowering the risk of failed projects as a financial loss, societal value for the influence the local community would have in this process, and biodiversity value from the increase in successful projects.

Overall, this approach will aid in transitioning to a society based on trust with abundant resources and healthy environments, ultimately reversing the degradation to land systems that occur as a consequence of quarrying activities. The end-products from quarrying play a crucial role in the high standard of living around the world and it is therefore imperative that the industry continues their work in sustainability to ensure they can deliver their services globally for a prolonged period of time; making them a significant part of the movement towards sustainability.

REFERENCES

Aronson, James, Andre F. Clewell, James N. Blignaut, and Sue J. Milton. 2006. 'Ecological Restoration: A New Frontier for Nature Conservation and Economics.' *Journal for Nature Conservation* 14 (s 3–4). Elsevier. doi:10.1016/j.jnc.2006.05.005.

Aronson, James, James N. Blignaut, Suzanne J. Milton, David Le Maitre, Karen J. Esler, Amandine Limouzin, Christelle Fontaine, et al. 2010. 'Are Socioeconomic Benefits of Restoration Adequately Quantified? A Meta-Analysis of Recent Papers (2000-2008) in Restoration Ecology and 12 Other Scientific Journals.' *Restoration Ecology* 18 (2). Wiley-Blackwell: 143–54. doi:10.1111/j.1526-100x.2009.00638.x.

Blignaut, James, James Aronson, and Rudolf de Groot. 2014. 'Restoration of Natural Capital: A Key Strategy on the Path to Sustainability.' *Ecological Engineering* 65 (April). Elsevier: 54–61. doi:10.1016/j.ecoleng.2013.09.003.

Choi, Young D, Vicky M Temperton, Edith B Allen, Albert P Grootjans, Melinda Halassy, J Richard, M Hobbs, Anne Naeth, and Katalin Torok. 2008. 'Ecological Restoration for Future Sustainability in a Changing Environment.' *Écoscience* 15 (1): 53–64. doi:10.2980/1195-6860(2008)15[53ERFFSI]2.0.CO;2.

Cornell, Sarah. 2015. *Planetary Boundaries A Safe Operating Space for Humanity*. n.p., http://www.stockholmresilience.org/download/18.6d8f5d4d14b32b2493577/1459560273797/SOS+for+Business+2015.pdf.

Costanza, Robert, Ralph D 'arge, Rudolf De Groot, Stephen Farberk, Monica Grasso, Bruce Hannon, Karin Limburg#, et al. 1997. 'The Value of the World's Ecosystem Services and Natural Capital.' *NATURE* 387 (15). http://www.esd.ornl.gov/benefits_conference/nature_paper.pdf.

Forbes, B. C., and J. D. McKendrick. 2002. Polar tundra. Pages 355-375 *in* M. R. Perrow, and A. J. Davy, editors. *Handbook of ecological restoration. Volume 2. Restoration in practice*. Cambridge University Press, Cambridge.

Hobbs, Richard J., and David A. Norton. 1996. "Towards a Conceptual Framework for Restoration Ecology." *Restoration Ecology* 4 (2). Wiley-Blackwell: 93–110. doi:10.1111/j.1526-100x.1996.tb00112.x.

Lim, Wendy, Donald M Arnold, Veronika Bachanova, Richard L Haspel, Rachel P Rosovsky, Andrei R Shustov, and Mark A Crowther. 2008. "Evidence-Based Guidelines—An Introduction." *ASH Education Program Book* 2008 (1). American Society of Hematology: 26–30. doi:10.1182/asheducation-2008.1.26.

MEA - Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Missimer, Merlina, Karl-Henrik Robèrt, and Göran Broman. 2016. “A Strategic Approach to Social Sustainability – Part 1: Exploring the Social System.” *Journal of Cleaner Production*, April. Elsevier BV. doi:10.1016/j.jclepro.2016.03.170.

Nilsson, Christer, and Ása L. Aradóttir. 2013. ‘Ecological and Social Aspects of Ecological Restoration: New Challenges and Opportunities for Northern Regions.’ *Ecology and Society* 18 (4). Resilience Alliance. doi:10.5751/es-06045-180435.

Robèrt, Karl-Henrik. 2000. Tools and concepts for sustainable development, how do they relate to a general framework for sustainable development, and to each other? *Journal of Cleaner Production* 8, no. 3: 243-254.

Robèrt, Karl-Henrik, Göran Broman, David Waldron, Henrik Ny, Sophie Byggeth, David Cook, Lena Johansson, et al. 2015. *Strategic Leadership Towards Sustainability*. 9th ed. Karlskrona.

Savin-Baden, Maggi, and Claire Howell Major. 2012. *Qualitative Research: The Essential Guide to Theory and Practice*. New York: Routledge.

Suding, K. 2011. Toward an Era of Restoration in Ecology: Successes, Failures, and Opportunities Ahead. *Annual Review of Ecology, Evolution, and Systematics.* 42:465–87. Doi:10.1146/annurev-ecolsys-102710-145115.

Willard, Bob. *The New Sustainability Advantage: Seven Business Case Benefits of a Triple Bottom Line*. Gabriola Island, B.C.: New Society, 2012.

APPENDIX 1 - Background Information

Why is restoration important?

Restoring ecosystems is important not only for the ecological system by for example increasing biodiversity, but also for the social system since it generates jobs, improves the quality of life for everyone in the economy, and betters' livelihoods (Aronson et al. 2006). Society is dependant on both extracted materials and all other ecosystem services, but without restoration the process of extracting materials would continue to degrade the ecosystems that we rely on (Blignaut, Aronson, and de Groot 2014). Studies have also shown that restoration also gives return-on-investment when adopting a mid- to long-term perspective (Blignaut, Aronson, and de Groot 2014). Furthermore, "[...] ecosystem restoration is among the most profitable public investment for economic growth and overcoming poverty" (Suding 2011). These are just some of the many reasonings why successful restoration is so crucial for our modern society: it gives ecological, social, and economical benefits.

Why guidelines?

General guiding principles can be applied to multiple areas and site conditions. This is one reason why guidelines are a key component for restoration projects and were a large focus for the thesis (Hobbs and Norton 1996). The overall purpose of most guidelines is to help practitioners make appropriate decisions for specific contexts. They are often used for qualitative measurements, allocating resources, and determining further actions. Guidelines can also contain summaries of relevant background information and give case examples highlighting lessons learned and best practices (Lim et al. 2008). An example of background information may be the guideline highlighting which stakeholders are important for the restoration process such as (in the context of restoration projects): the company doing the project, NGOs, local community, collaborating universities, and local government bodies. Guidelines for restoration also give practitioners direction for deciding on actions to take in order to aid in the recovery of a degraded ecosystem.

APPENDIX 2 - Example of results from ABCD Workshop Process with Degerhamn, Öland (Cementa)

Summary of the ABCD Process and Results with Degerhamn, Cementa

November 18th , 2015- February 25th, 2016

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Kelly Lyons Sweet

This report was prepared for Degerhamn Cementa's management team in preparation for an ABCD workshop with all of Cementa, facilitated by The Natural Step. The results of this document were the ideas of both Degerhamn's employees and the students from the Masters program in Strategic Leadership towards Sustainability at BTH.

A Step:

The A step in an ABCD process includes establishing a common understanding of the company's vision, and the organisation's connection to the broader socio--ecological system. During this step the main importance is that all employees feel connected to the vision and other aspects of the organisation. The results of this step are presented below.

Core Ideology (Core Purpose & Core Values):

Core Purpose: The core purpose of Cementa Degerhamn is to provide quality building materials to satisfied customers, and money to our owners. Our heightened purpose is to develop society towards sustainability through sustainable infrastructure.

Core Values: The way in which Degerhamn interacts with employees is through active participation, and with stakeholders through open dialogue. It operates with functionality, stability, credibility, health, quality, and the environment in mind. A core value for Degerhamn is to be the leader in innovation within the cement industry.

Stretch Goals:

• All employees are proud working at Cementa Degerhamn

• Working conditions that generate health

• Negative CO2 emissions

• 100% recycled materials

• Create a new cement plant

• Highest net profit in HCNE

• Safest cement factory in HCNE

• Zero pollution

Vivid Description/Envisioned Future:

Degerhamn is the leader in innovative cement technologies and products. They have done this by initiating only actions that are aligned with sustainability principles. Other industries not limited to cement come to learn what they've done at management level to inspire their employees. They have negative net CO2 emissions and employee health improves by working at the plant. The journey to sustainability began with cross disciplinary cooperation both within the plant and with other industries. The employees were engaged and this process developed a sense of pride over their work. The community is honoured to have Degerhamn plant as a part of the social system and feel that it is a prestigious place to work.

Intersystem Analysis:

Cementa AB's (Cementa) factory in Degerhamn is part of the HeidelbergCement Group, which is the world's third largest producer of cement and building materials. The plant is linked to the central administration, but operates autonomously on several levels. The main intersystems that connect Cementa-Degerhamn to the global socio-ecological system include (but are not limited to) the following: Energy/Fuel Industry, Mining Industry, Construction Industry, Transport/Global Traffic System, & Chemical Industry. (For the detailed intersystem analysis see the appendix).

Vision:

Cementa Degerhamn is the home of the most innovative and sustainable cement production in Europe.

We lead the industry towards better practices and contribute to a healthier society and environment.

We steward a workplace and community of diversity, trust, competence, and confidence.

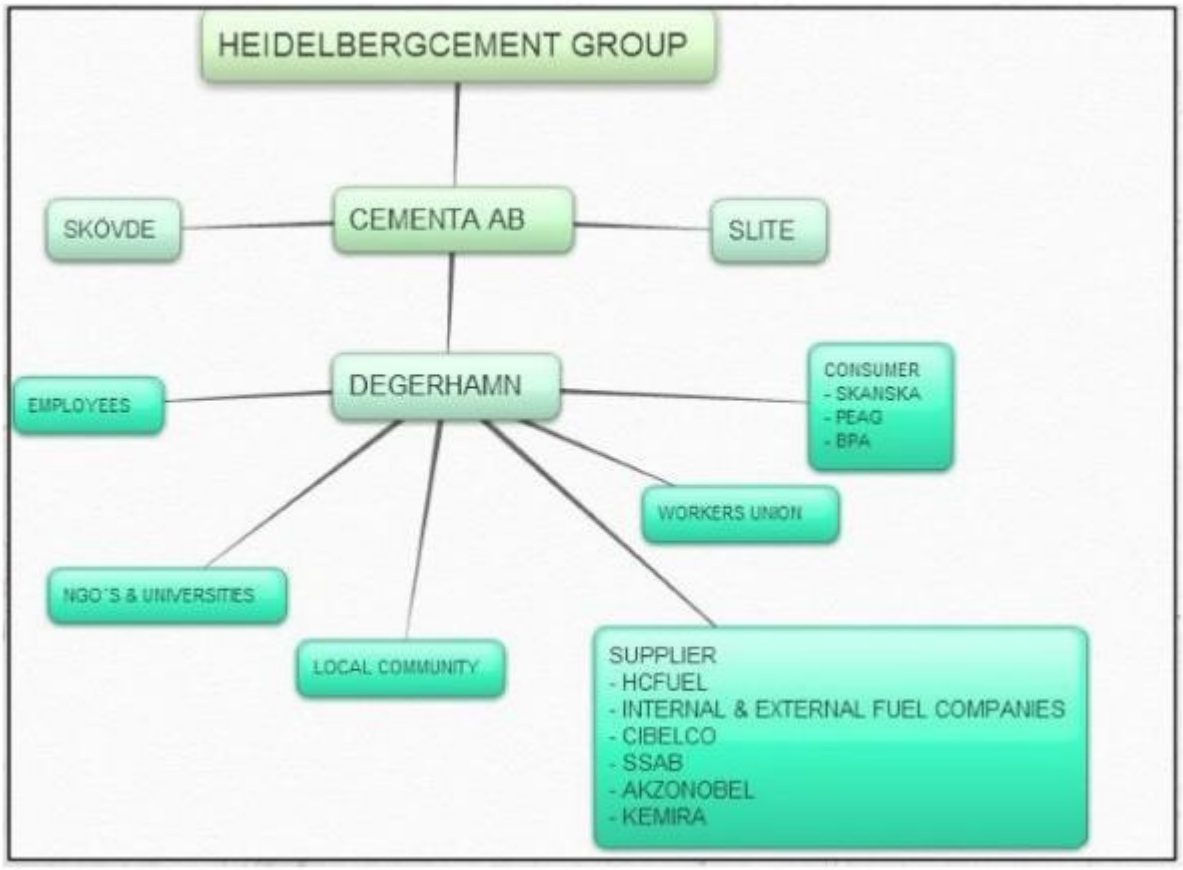
B Step:

The B step of the ABCD process is about the current reality of the organisation based on both an internal and external analysis. The internal analysis is about mapping out the organisation's own operations and the external is about the external world and operational analysis. These include a sustainability principle analysis, success aspect analysis for the core ideology & envisioned future, a stakeholder analysis, and a pestle analysis. Everything should be summarized in a SWOT analysis for simplicity. The results of this step are presented below. For a list of the sustainability principles (SPs) in Swedish see the appendix.

Pestle Analysis:

POLITICAL	ECONOMIC	SOCIAL	TECHNOLOGICAL	LEGAL	ENVIRONMENTAL
New environmental regulations Increased political focus on sustainable dvlpmnt. COP 21 consequences 6-hour work days	Instability on financial markets Forecasted growth in demand on global cement market Increased emission taxation Very low oil price Low coal price	Immigration to local community Steadily increasing attention on climate 'sinners' Rising urbanization Local community engagement	Development of Carbon Storage Solutions (CSS) Electric combustion processes as known from steel production (e.g. induction) Quality requirements	Strict environmental regulations Increased risk of fines if status quo continues Anti-protectionism (Central European legislation)	Restoration Regenerative biodiversity initiatives Recycling

Stakeholder Analysis:



SP Analysis:

Ecological Principles

SP1	SP2	SP3
(+) Aluminium (-) Iron material and ore (-) Oil (-) Coal (-) Steel	(-) Heavy metals (-) Emissions in combustion (DOx, NOx, SOx) (-) Pet coke (by product from oil) (-) Chemical (solvents) (+) Algae to capture flue gasses	(+/-) Limestone quarry (+) Sand (+) Biodiversity & habitat creation (+) Land restoration (-) Heat emissions to Ocean (-) Heavy transportation (land & sea) (-/+) Land area covered in concrete

Social Principles

SP4	SP5	SP6	SP7	SP8
(+) Continuous safety trainings (-) Exposure heavy metals and chromium 6 (-) Repetitive tasks	(-) Restricted financial resources (+) Unios (-) Long approval time on projects (+) Workers encouraged to organize unions	(+/-) Attraction of competent workers needed (-) Lack of resources (-/+) R&D limitations but in progress (+/-) Chances to climb up the career ladder (+) Staff engaged in sustainability work (+) Head start on FSSD	(-) High dependency on HeidelbergGroup (-) No job advertisements in female oriented outlets (+) Diverse workforce (nationalities) (-) Gender imbalance (-) Genabb	(+) Opportunity to rotate duties (+) Strong local anchoring (-) General lack of connection to larger purpose in industry

SWOT Analysis:

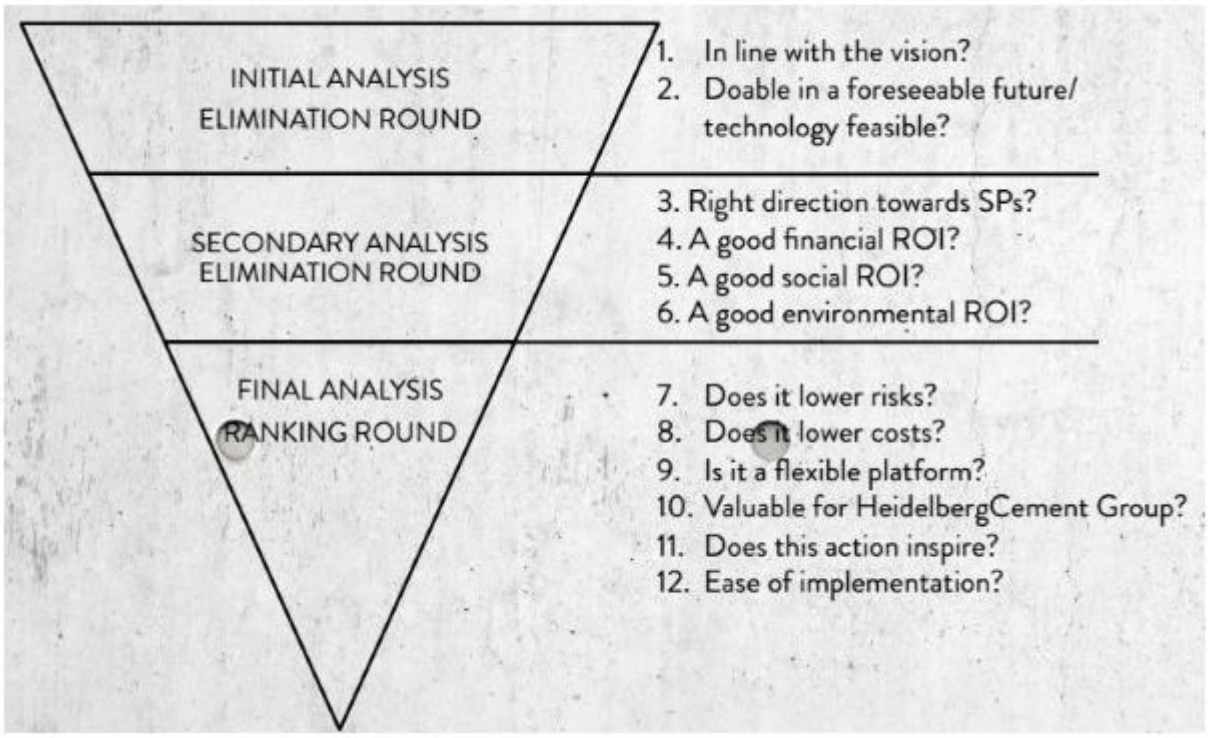
C Step:

The C step is brainstorming compelling actions based on the baseline analysis results. There should be as many as possible. This step is about quantity rather than quality so there should be no ideas shut down during this phase, and there should be a safe creative space for sharing. In total this phase of the process resulted in 86 actions. 5 examples of the results are presented below but for a full list of the brainstormed actions see the appendix.

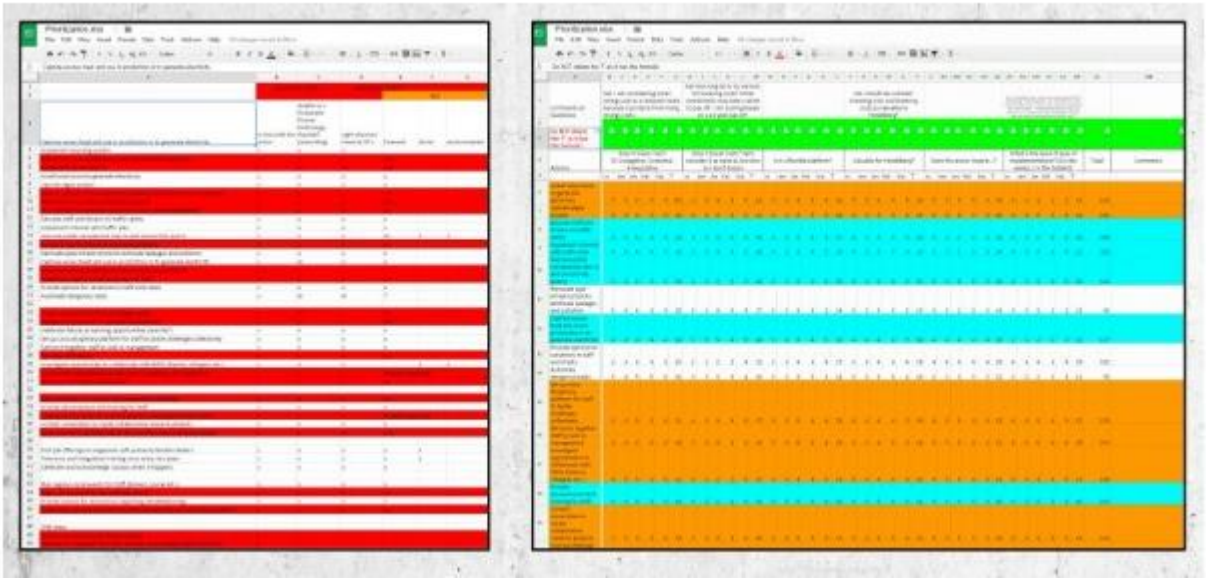
- R&D into how to separate concrete into recyclable elements
- Implement CSS to capture
- Install solar/wind to generate electricity
- Upscale algae project
- Actions related to eliminate local pollutions and emissions to community

D Step:

The D step is the prioritization of the listed actions. There were different rounds of elimination with certain questions adjusted to Degerhamn Cementa's values. The process is shown below.



After the first round of elimination the 86 actions were reduced to 61, second round 36, and third round was 12. It is good to note here that when having a final list of prioritized actions for your action plan that you use a maximum of 15 actions for easier planning and implementation (to begin with). The following images show the rough matrices of these prioritization rounds.



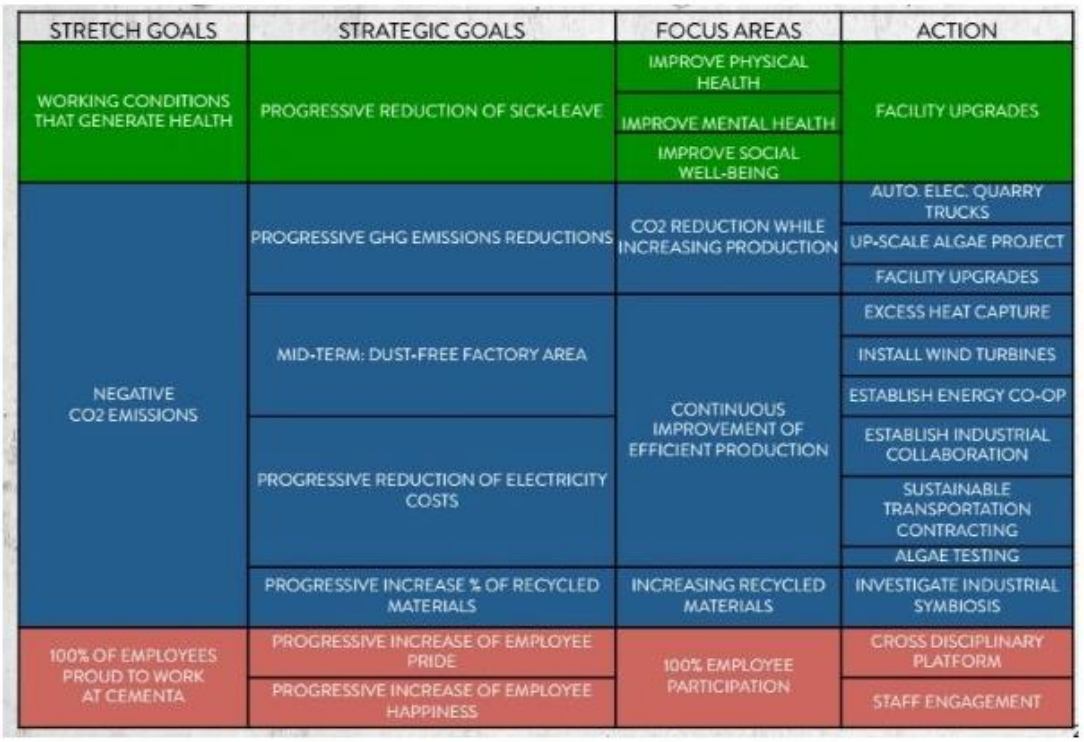
The image on the left shows the first two rounds of prioritization which was done by marking yes or no to the question. If no the action was highlighted red to be removed for the next round. The image on the right shows the final round which was done by ranking from 1 (low, bad) to 6 (high, good) by all 5 students. The prioritization step was done by the students due to time constraints within the workshops for Degerhamn. The questions chosen ended up being favourable to low-hanging short term fruits. When Degerhamn is doing this ABCD process with TNS they should keep in mind what questions could also highlight the importance of mid and long term actions.

The final 12 actions categorized by short, mid, and long term are:

Short Term	**Mid Term**	**Long Term**
Algae testing	Up-scale algae project	Automatic electric quarry trucks for transporting limestone
Establish possibilities for social & physical leisure	Investigate industrial symbiosis (industrial ecology)	Establish energy co-op
Set up cross disciplinary platform	Sustainable distribution of Degerhamns cement	Initiate industry collaboration platform
Facility upgrades	Install wind turbines	
	Capture excess heat to generate electricity	

E Step:

Step E which is an unique step for organisations working with the ABCD is using the prioritized actions to make a strategic action plan with actions, resources needed, key performance indicators (KPIs), budget, and persons responsible. The budget factor was not included in this initial ABCD process but should be included in the action plan. The results from this step were formulated by the student consultancy team and are presented below.



STRETCH GOALS	STRATEGIC GOALS	FOCUS AREAS	ACTION
WORKING CONDITIONS THAT GENERATE HEALTH	PROGRESSIVE REDUCTION OF SICK-LEAVE	IMPROVE PHYSICAL HEALTH	FACILITY UPGRADES
		IMPROVE MENTAL HEALTH	
		IMPROVE SOCIAL WELL-BEING	
NEGATIVE CO2 EMISSIONS	PROGRESSIVE GHG EMISSIONS REDUCTIONS	CO2 REDUCTION WHILE INCREASING PRODUCTION	AUTO. ELEC. QUARRY TRUCKS
			UP-SCALE ALGAE PROJECT
			FACILITY UPGRADES
	MID-TERM: DUST-FREE FACTORY AREA	CONTINUOUS IMPROVEMENT OF EFFICIENT PRODUCTION	EXCESS HEAT CAPTURE
			INSTALL WIND TURBINES
			ESTABLISH ENERGY CO-OP
	PROGRESSIVE REDUCTION OF ELECTRICITY COSTS		ESTABLISH INDUSTRIAL COLLABORATION
			SUSTAINABLE TRANSPORTATION CONTRACTING
			ALGAE TESTING
	PROGRESSIVE INCREASE % OF RECYCLED MATERIALS	INCREASING RECYCLED MATERIALS	INVESTIGATE INDUSTRIAL SYMBIOSIS
100% OF EMPLOYEES PROUD TO WORK AT CEMENTA	PROGRESSIVE INCREASE OF EMPLOYEE PRIDE	100% EMPLOYEE PARTICIPATION	CROSS DISCIPLINARY PLATFORM
	PROGRESSIVE INCREASE OF EMPLOYEE HAPPINESS		STAFF ENGAGEMENT

Action plan for short term actions:

ACTIONS	RESOURCES NEEDED	KPIs	RESPONSIBLES
TEST ALGAE FOR ALGAE PROJECT	TECHNOLOGY FINANCIAL COOPERATION WITH UNIVERSITIES	AMOUNT OF CO_2 CAPTURED	ENVIRONMENTAL MANAGER/ ENGINEERS
SET UP CROSS DISCIPLINARY PLATFORM FOR INTER-TEAM COLLABORATION	FINANCIAL TEAM DAYS WILLINGNESS TO ENGAGE	KILN RUN FACTOR (HIGHER THE BETTER)	HR MANAGER
ESTABLISH FACILITIES AND OPPORTUNITIES FOR STAFF SOCIALISING	FINANCIAL LOCATIONS WILLINGNESS TO ENGAGE	SICK-LEAVE REDUCTION	MANAGEMENT TEAM/ HR MANAGER
UPGRADE REFRESHMENTS AND BUILDINGS TOWARDS SUSTAINABILITY	FINANCIAL ERGONOMICS EXPERT KNOWLEDGE	ENERGY COST SAVINGS HIGHER WORKER PRODUCTIVITY SICK-LEAVE REDUCTION	MANAGEMENT TEAM

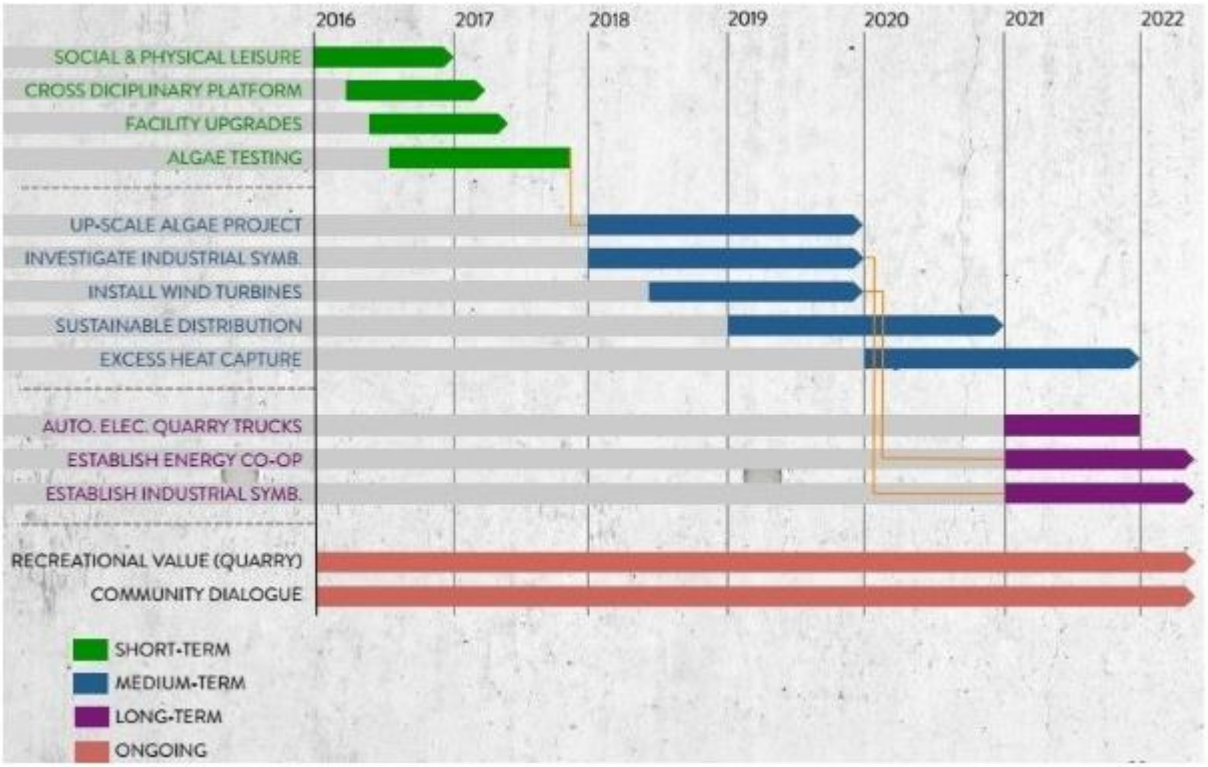
Action plan for mid term actions:

ACTIONS	RESOURCES	KPIs	RESPONSIBLES
UPSCALE ALGAE PROJECT	SUCCESSFUL IMPLEMENTATION OF SHORT-TERM ALGAE PROJECT FINANCIAL SPACE	AMOUNT OF CO_2 CAPTURED	ENVIRONMENTAL MANAGER/ENGINEERS
NVESTIGATE OPPORTUNITIES FOR INDUSTRIAL COLLABORATION AND SYMBIOSIS	FINANCIAL NETWORKING	REDUCED GREENHOUSE EMISSIONS COST SAVINGS	CEO/ ENVIRONMENTAL MANAGER
CAPTURE EXCESS HEAT TO GENERATE ELECTRICITY	TECHNOLOGY COOPERATION WITH SLITE PLANT FINANCIAL	ENERGY COST SAVINGS	ENGINEERS
CONTRACT SUSTAINABLE TRANSPORT COMPANIES	NETWORKING FINANCIAL	REDUCED GREENHOUSE EMISSIONS	CEO
INSTALL WIND TURBINES/ SOLAR PANELS	TECHNOLOGY COOPERATION WITH ALTERNATIVE ENERGY SUPPLIERS	REDUCED ELECTRICITY BILL	ENGINEERS

Action plan for long term actions:

ACTIONS	RESOURCES	KPIs	RESPONSIBLES
SWITCH TO AUTOMATED ELECTRIC TRUCKS IN QUARRY	TECHNOLOGY FINANCIAL	DECREASED NUMBER OF ACCIDENTS REDUCED SALARY COSTS	CEO/ ENGINEERS
ESTABLISH ENERGY CO-OP WITH THE DEGERHAMN COMMUNITY	NETWORKING TECHNOLOGY FINANCIAL	NO COMPLAINTS FROM COMMUNITY	CEO/ ENVIRONMENTAL MANAGER
ESTABLISH INDUSTRIAL COLLABORATION/SYMBIOSIS	NETWORKING FINANCIAL SUCCESSFUL INVESTIGATION (MID-TERM) AND PLAN FOR INDUSTRIAL COLLABORATION	REDUCED EMISSIONS COST SAVINGS	CEO/ ENVIRONMENTAL MANAGER

Timeline:


2016
2017
2018
2019
2020
2021
2022
SOCIAL & PHYSICAL LEISURE
CROSS DICIPLINARY PLATFORM
FACILITY UPGRADES
ALGAE TESTING
UP-SCALE ALGAE PROJECT
INVESTIGATE INDUSTRIAL SYMB.
INSTALL WIND TURBINES
SUSTAINABLE DISTRIBUTION
EXCESS HEAT CAPTURE
AUTO. ELEC. QUARRY TRUCKS
ESTABLISH ENERGY CO-OP
ESTABLISH INDUSTRIAL SYMB.
RECREATIONAL VALUE (QUARRY)
COMMUNITY DIALOGUE
SHORT-TERM
MEDIUM-TERM
LONG-TERM
ONGOING

REFERENCES:

African Journals Online. 2013. The Impact of Urbanization on Housing Development: The Lagos Experience, Nigeria. http://www.ajol.info/index.php/ejesm/article/view/63967 (13 Nov. 2015).

HeidelbergCement Group. 2015. Cement Is Sturdy, Strong & Durable. Cementa. http://www.cementa.se/en# (13 Nov. 2015)

Marshak, Stephen. 2012. Earth Portrait of a Planet. 4th ed. New York: W.W.Norton &Company.

Pabon, Armando. 2014. Must-know: A business overview of the cement industry. Cement preparation. Market Realist http://marketrealist.com/2014/08/must-know-cement-preparation/ (18 Nov. 2015)

Rubenstein, Madeleine. 2012. Emissions from the Cement Industry. Earth Institute, Columbia University. blogs.ei.columbia.edu/2012/05/09/emissions-from-the-cement-industry/ (13 Nov. 2015)

United States Environmental Protection Agency. 2015. Cement Manufacturing Enforcement Initiative. http://www2.epa.gov/enforcement/cement-manufacturing-enforcement-initiative (13 Nov. 2015).

Wang, Kejin, ed. 2004. Proceedings of the International Workshop on Sustainable

Development and Concrete & Technology. Iowa State University. http://core.ac.uk/pdf/11346106.pdf#page=88 (13 Nov. 2015)

Appendix (to Summary of the ABCD Process and Results with Degerhamn, Cementa)

All brainstormed stretch goals: zero emissions, zero accidents, zero unplanned production stoppages, zero quality mishaps, zero dust, zero quality related customer complaints zero stress leave (employees), employees have better mental and physical health (regenerative) as a result of working here, negative CO_2 emissions, 100% renewable energy, zero use of virgin limestone, increase quarry biodiversity (regenerative), alternative products, CO_2 reduction while increasing production, 100% renewable fuels (biofuels/electric), fully automated plant, <1% sick leave (work-related), induction energy, and construction industry synergy.

All brainstormed actions:

- Implement recycling system
- R&D into how to separate concrete into recyclable elements
- Implement CSS to capture
- Install solar/wind to generate electricity
- Upscale algae project
- Actions related to eliminate local pollutions and emissions to community
- R&D into how to make sustainable concrete
- Find out how to eliminate chromium 6 from cement
- Educate staff and drivers on traffic safety
- Implement internal safe traffic plan
- Improve public recreational sites in and around the quarry
- Research how to eliminate local noise pollution
- Renovate pipe infrastructure to eliminate leakages and pollution
- Capture excess heat and use in production or to generate electricity
- Determine safe boundaries for airborne dust in production
- Implement regular health check-ups for staff
- Provide options for variations in staff work tasks
- Automate dangerous tasks
- Create partnership with local refugee center

- Engage with customers in product development
- Celebrate failure as learning opportunities
- Set up cross disciplinary platform for staff to tackle challenges collectively
- Eat lunch together staff as well as management
- Monthly staff dinner
- Investigate opportunities to collaborate with NGOs (Nature, refugees, etc).
- Community representative to take part in meetings with Degerhamn
- Sponsor a local sports tournament
- Each one teach one among staff (competence building)
- Provide advancement skill training for staff
- Implement processes for in-house problem solving (Particularly tech)
- Contact universities to create collaborative research projects
- Send workers to building sites to see how they work with the products
- Post job offerings in magazines with primarily female readers
- Tolerance and integration training once every two years
- Celebrate and acknowledge success when it happens
- Plan regular social events for staff (dinners, soccer, etc)
- Make social events for the local community
- Provide avenue for anonymous reporting (whistleblowing)
- Implement a proper international (internal/external) communication platform
- Get the next James Bond movie filmed at the island
- Operate in complete harmony with the surrounding nature
- Pump all the CO2 to the algae and use it as biofuel, sell it as biofuel, sell it to L'oreal for them to make cosmetics out of it
- Rotate job positions

● Have refugees working at the factory

● Make the necessary changes to operate as the most modern Cement Laboratory in the world, researching for the most sustainable cement in the world

● Introduce a salary system that is based on sustainable performance, responsibility of one's and others' actions, and individual unique innovativeness

● Make a movie about the whole island of Öland and discreetly show how amazing place the factory is to work

● For any new construction, use building materials that absorb emissions from air and break them down

● Increase algae production and sell it as a biofuel to the vessels that come to pick up the cement! This decreases transportation of the algae fuel as well.

● R&D into how biomimicry could innovate cement

● Use old cement to create marine life habitats e.g. artificial reefs or mussel farms. Or, create an island to grow seaweed for biofuels or for Öland's livestock

● Use Öland's compost in an area of the quarry to create topsoil for reforestation.

● Increase community dialogue and ensure good relationship with the whole Öland community

● Borrowing from Google, everyone can spend 20% from their time doing anything they want (somehow related to the business) or working on other jobs within the plant. This is to build off from the existing positive innovative momentum

● Establish financial/in-kind incentives for sustainability innovation

● Increase tourism in the quarry's natural areas (and get publicity).

● Start a limestone crafting competition...?

● In collaborations with the surrounding universities, look for businesses that could benefit from Degerhamn's waste and emissions and build industrial symbiosis around that.

● Make working in a cement factory look cool to attract talent.

● Build and showcase female--friendly facilities to improve conditions and gender imbalance

● Grow crops in the potato hills area that could be used as biofuel for the kiln (or, as food for the factory workers)

● Instead of pouring to ocean, use the excess heat of hot water to steam generate electricity for the offices.

● Leasing roads with smart sensors

● Investigate virgin coal vs. slag (high metal content)

- Merge with steel industry by-products like slag.
- New product lines from solely recycled cement.
- Research additives to higher the cements CO2 absorption capacity
- Make bike paths. from crushed concrete to re-use
- Incentive for going to the health club/bike to work etc..
- Allocate 5 hour/ month for NGO work and you get similar hours off work
- Do gardening
- Credit for good deeds
- Sky lights instead of lighting
- Fair trade, organic coffee in machines
- Everyone gets a sustainability course
- Don’t run the dishwasher half empty
- Fix all dripping water taps
- Motion sensor lighting, energy efficient light bulbs
- Low water toilets
- Discontinue water coolers/water bottle
- Buy local snacks for office - improve relationship with local establishments community greenhouses
- Heat fed from kiln waste heat
- Heat fed sauna on the sea!!
- Celebrate successes (small and big)
- Shorter work days
- Exercise classes
- Stress reduction workshops
- Organic lunches
- Memberships to health club

- Massages
- Fun: ping pong table, billiards table,bowling/golf league, social activities, video games
- Bring in an ergonomic expert (offices etc..)
- Energy co-op with wind turbines between factory
- Retro fit trucks etc. for biofuels
- Contract sustainable transport companies
- Get new kiln for testing
- Investigate wave power

Intersystem Analysis:

MINING INDUSTRY

SYSTEMS LEVEL

Cement production requires mined raw materials, primarily limestone. The mining process is fuel intensive and the machinery used on sites releases greenhouse gas emissions. Depending on the type of mining and processes applied the system can be physically degrading and emit chemicals into the biosphere (Markshak, 2012). So the cement industry's need for mined materials contributes indirectly to the sustainability challenges that the mining industry faces.

SUCCESS LEVEL

Cementa can put pressure on mines to only use renewable fuels, implement site rehabilitation, use non-invasive, sustainable methods, eliminate contamination, assure health and safety for both workers and the community and introduce electrical and biodiesel equipment. These could drive change within the mining sector. By implementing these initiatives, the mining sector can comply with regulations and environmental permits, cooperate with neighboring communities, and situate themselves as leaders in industrial CO2 emission reductions. When Cementa buys exclusively from mines with these conditions it will promote other mines to adopt these in order to stay competitive. Cementa could also target recycling of concrete in order to have zero dependency on the mining intersystem by needing no virgin raw materials.

CONSTRUCTION INDUSTRY

SYSTEMS LEVEL

The demand for cement primarily comes from the construction sector. More specifically the following segments: Housing at 60%–65%, infrastructure at 20%–25%, commercial construction at 10%–15%, and industrial at 5%–10% (Pabon 2015).

Cement is the primary ingredient in concrete. After water, concrete is the second most consumed substance on Earth (Rubenstein 2012). Concrete is used globally for buildings, bridges, tunnels, roads, runways, sidewalks, dams etc. Cement is indispensable for construction activity and thus tightly linked to the global economy. Cement production is growing by app. 2.5% annually, and is expected to rise from 2.55 billion tons in 2006 to 3.7-4.4 billion tons by 2050 (Rubenstein 2012). Furthermore, the growth in global population and urbanization is projected to drive and reinforce an increasingly high demand for cement (Karantonis N.d. 1). This development leads to increased demand for mined materials, chemicals, transportation, water, and land. Unless the industry takes serious measures to shift towards sustainable cement production, the expected and significant growth in production will inevitably lead to increased emissions of the CO2, sulphur dioxide, nitrogen oxide, and carbon monoxide (United States Environmental Protection Agency). Cement production currently requires immense fossil fuel input to heat the big kilns (ovens) that are used in the production process, where limestone is heated to1400°C in a process called calcination. This process alone accounts for 50% of all emissions from cement production (Rubenstein 2012).

SUCCESS LEVEL

The cement industry collectively accounts for approximately 5% of global CO2 emissions. Given the current rate of emissions and critical importance to society, cement production is an obvious place to look to reduce or eliminate greenhouse gas emissions. In order for the sector to succeed in the transition towards sustainability, the cement industry would have to make substitutions in its material and chemical formulas, as well as production processes to eliminate emissions. Some benefits of this include lighter cement and improving the indoor air quality in buildings that otherwise negatively affects people's health (Wang, 2004). Environmental improvements to the formulas of cement could also improve the functionality of the concrete. Research in this field is ongoing, but results are promising for alternative cements that are stronger and have lower emissions than standard cement (Wang, 2004). Indirect emissions from burning fossil fuels to heat the kilns can be reduced by switching to other types of fuels such as biomass and waste-derived fuels such as tires, sewage sludge and municipal solid wastes" (Rubenstein 2012).

Additionally, carbon storage solutions could be used to lower the CO2 emissions, however the technology should be viewed as a stepping--stone in the transition towards a fully sustainable solution. Currently a pilot project using algae to sequester CO2 emissions from the kiln is in place at Degerhamn -Cementa. At this point nearly half of the CO2 can be sequestered but further experimentation with this technology should be developed, in order to increase the algae's capacity to show other factories owned by Cementa that is a viable solution to lower or eliminate CO2 emissions (Cementa, 2015).

TRANSPORT/GLOBAL TRAFFIC SYSTEM

SYSTEMS LEVEL

The global traffic system plays a major part in the socio--ecological system. Transport is required for mined raw materials from the mines to the factories and also for global and domestic transportation of the end products that

are delivered to clients via trucks, trains, and cargo ships. Approximately half of the cement produced by Cementa- Degerhamn is exported to North America and Africa. The other half is used domestically, but even here the final product is transported over significant distances (HeidelbergCement, Northern Europe 2015). The global transportation of cement is heavily reliant on fossil fuels, which ultimately increase emissions of CO2. From another perspective, one has to mention the soil system as such in this context as well, because it is directly related to the transportation system as extensive use of concrete for road networks, covering fertile soil and land and thus threaten lowering biodiversity and water permeability.

SUCCESS LEVEL

An essential step in making Cementa- Degerhamn's cement more sustainable is to switch to sustainable transportation. Cementa could use their bargaining power to push for the introduction and use of more sustainable transport e.g. electrical or bio-diesel trucks and more fuel--efficient cargo ships. By committing to such a shift, Cementa- Degerhamn would provide an incentive for transport companies to shift to sustainable solutions, as the demand for such transportation would increase. Furthermore, by leading the way in terms of sustainable transportation, Cementa- Degerhamn could potentially inspire the rest of Cementa to follow and ultimately the rest of the HeidelbergCement Group. Thus creating a positive cascading effect as other industries join the shift based on the increased accessibility of sustainable transportation possibilities. Hence, the potential may be given that the company´s return on investment increases as they increase their competitiveness within the construction sectors. Furthermore, HeidelbergCement Group could drive policy change for their advantage, forcing the cement industry towards sustainability overall. Reducing long distance shipping and putting emphasis on geographical location to shorten the distance between manufacturers, distributors, and end consumers would also reduce the impacts of transportation such as extensive road networks. Research should be done into lightweight cement that lowers transport emissions.

<u>The Sustainability Principles (Svenska):</u>

I ett hållbart samhälle utsätts inte naturen för systematisk…

1... koncentrationsökning av ämnen från berggrunden (Till exempel fossilt kol, olja och metaller.)

2... koncentrationsökning av ämnen från samhällets produktion (Till exempel kväveoxider, freoner och hormonliknande kemikalier.)

3... undanträngning med fysiska metoder (Till exempel storskaliga kalhyggen och överfiskning.)

Människor utsätts inte för systematiska barriärer avseende...

4... personlig hälsa (Människor utsätts inte för direkt skada)

5... inflytande (Människor hindras inte att påverka de sociala system som de ingår i och är beroende av)

6... kompetens (Människor hindras inte att utveckla kompetens)

7... opartiskhet (Människors lika rättigheter och värde erkänns och respekteras)

8... mening (Människor och organisationer hindras inte att utveckla en mening med att finnas)

APPENDIX 3 - Full Thesis

Blekinge Institute of Technology

Karlskrona, Sweden

2016

Enhancing Restoration Guidelines Through a Strategic Sustainable Development Approach

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Abstract:

Land areas being used unsustainably are depleted and/or degraded. To prevent this from happening and/or to reverse the effects, we need to restore these environments. However, not all restoration practices are equal, and some do not adhere to rigorous standards of sustainability. In this study, restoration guidelines and opinions from field experts were analysed from an SSD perspective. The focus of this thesis was limestone quarries in northern Europe due to quarries' impacts to the socio-ecological system and the sensitivity of northern ecosystems. The results were divided into two sub-sections: FSSD comparison to guidelines, which included an SP analysis to principles in guidelines, and interviews. The conclusion was that the SSD approach could enhance these quarry restoration guidelines by incorporating the recommendations formulated from the results and discussion. One recommendation was having the eight SPs as overarching boundaries for success. Incorporating these recommendations would fill the sustainability gaps, aiding in the practitioner's ability to be strategic and have long-term success within sustainable limits.

Keywords:

Restoration, quarries, biodiversity, sustainability, strategic planning, ecosystem services.

Statement of Contribution

This thesis research has been undertaken in a truly collaborative manner. Each of the three team members contributed an equal amount of the required work. The common passion of our team for environmental science and sustainable development brought us together in this research process. The effective combination of different previous educational backgrounds and the overall common knowledge on the framework used helped us in sharing a common language and brought great value during the whole research process. The majority of the results, discussion and conclusion were written collectively. The following paragraphs highlight a small fraction of the individual research conducted by each team member.

Kajsa, the member bringing occasional comedic relief to the stressful thesis writing environment, took on a strong responsibility for the research on the background information on quarrying. She also had the tasks of finding and arranging interview candidates and times, and editing. The background information on quarrying was to reinforce the relevance of this industry when tackling sustainability issues. The interview candidates were important for cross-checking our findings and getting new insights so the appropriate people were needed. Since she was the only native English speaker she took on a major role for editing the grammar and sentence structures. Overall she contributed to many other sections such as results, alongside the other team members.

Martyna, the one keeping expectations realistic to the timeline, took on a strong responsibility for the research for the introduction and background information on the larger socio-ecological system and restoration examples. She conducted a brief intersystem analysis in order to write a clear introduction and situate restorations relevance in the bigger sustainability challenge. She also conducted the majority of the background examples of different types of restoration and after-treatment from around the world to give context to the readers. As well as the other two team members she also contributed to the most collaborative sections, such as results and discussion.

Katarina, the group coordinator, took on a strong responsibility for our research methodologies. Although everyone contributed to this she had the lead on making sure we had the most appropriate methods for answering each specific research question. She also made sure that the methods for sampling and data handling were the most efficient and valuable for this research. Katarina did the majority of the research regarding the background information on success. This included what the different orientations of successful restoration were, and general problems in the field today. These were her major research areas however, she contributed to the more collaborative sections as well, such as results and discussion.

Acknowledgements

This thesis team would like to acknowledge a handful of supportive people that aided us throughout the writing process, and without whom this thesis would have been much more tedious.

Firstly our primary adviser, Edith Callaghan, for giving continuous constructive feedback and advice from day one to the last day. Our writing process has improved immensely due to your advice and guidance. We would also like to thank you for being patient with our scoping process. Another acknowledgement goes to our secondary adviser, Alexander Craig, for demonstrating through visuals what our initial research approach would look like with some modifications. The feedback and support received from our peers throughout this intense and stressful process is also greatly appreciated.

There are external figures from outside the University that we would also like to acknowledge. Thank you to all of those who aided in finding contacts, participated in the interviews, and offered excursions to their restoration sites. We appreciate all of you for enriching our results and experience.

With gratitude, the thesis team of Katarina Nordbeck, Martyna Jasinska & Kajsa Jansson.

Executive Summary

Introduction
There are currently anthropogenic pressures on Earth causing our ecosystem's carrying capacities to decrease. An intermediate step in the recovery of these ecosystem services and bringing the socio-ecological system back towards sustainability is through restoration. This thesis merged full sustainability as defined by the Framework for Strategic Sustainable Development (FSSD) as eight Sustainability Principles (8 SPs), with restoration guidelines in order to facilitate ecosystem recovery and at the same time lead to a sustainable future.

Background
Society is dependent on ecosystem services, however approximately 60% of these are currently being used unsustainably (MEA 2005). When a resource is used unsustainably it is either being depleted and/or degraded. To prevent this from happening, we need to restore damaged and degraded environments. Additionally, in order to achieve long-term success of restoration projects, they need to incorporate full sustainability. However, not all restoration practices are equal, and some do not adhere to rigorous standards of sustainability. The focus of this thesis is limestone quarries in northern Europe due to quarries' contributions and impacts to the socio-ecological system and the sensitivity of northern ecosystems.

Methods
Following are the research questions for this thesis: In which ways could an SSD approach enhance quarry restoration guidelines?

Sub-question to guide our research:

- To what degree do current restoration guidelines take a strategic perspective on sustainability?

In order to answer the main research question, a qualitative pragmatic approach was used. The research was conducted in two phases which are described below.

The first research phase included a comparative study of five guidelines against the FSSD, in order to examine similarities and highlight discrepancies between sustainable development and restoration practises. These highlighted gaps formed the foundation for the second phase of this study.

In the second phase of this study explorative open-ended, semi-structured interviews were conducted. This phase was both in order to triangulate recurring gaps found earlier both in the comparative study as well as in interviews, but also to extrapolate the most crucial areas for improvement for restoration to become fully sustainable.

Results
The results were divided into two sub-sections: FSSD assessment of guidelines, and interviews. The FSSD comparison table, found in the appendix, showed gaps and strengths of the different guidelines. For example, a significant gap was that no guideline had a process for prioritizing actions. The SP analysis showed both which

SP's were covered the most, and which guidelines covered the most SP's. For example, the SP for health was 60% in the five guidelines, referring to worker and visitor safety at restoration sites.

The results of the interviews were categorized based on the five levels of the 5LF which was the coding categorization as well. The following are examples of results from each level. For the system level, all interviewees agreed that restoration is an important aspect of sustainability. For the success level, only two of six participants mentioned any type of social aspect for goals, the other four strictly referred to biodiversity and/or ecosystem functions. However, when asked about what were the key criteria for a successful restoration project five of six solely referred to social aspects as being the key drivers. For the strategic level, the biggest gap illustrated from the guideline comparison was the same for the interviews, namely a lack of prioritization criteria. For the actions level, most interviewees explained that actions were site specific. For the tools level, the majority of participants were unable to identify a variety of tools that could be used in the restoration process.

Discussion

Gaps found in the FSSD comparison to the guidelines are hypothetical sustainability gaps. From looking at the guidelines alone it is not possible to see if the lack of certain strategic components would lead to sustainability violations or not, just that it would be more likely. The SP analysis showed that there is a clear need for overarching non-overlapping principles since not all aspects of sustainability were fully covered in any one guideline. The correlations between the results of the comparative studies and interviews were also discussed. One major gap that was prevalent in both the guidelines and interviews was in the success level. Since the principles in the guidelines did not cover all aspects of sustainability and the guidelines did not give specific restrictions to reaching their goals many interviewees had different ideas about what actions were best to be successful. Some of these ideas were in clear violation to sustainability while others were compliant. This showed that misinterpretations were clear consequences of these guidelines.

Conclusion

The most appropriate goal for restoration, with regards to sustainability, is to bring back the ecosystem to a certain *level of resilience* with the aim to enhance the adaptive capacity.

Quarry restoration can be a significant part of the movement towards sustainability. The industry has both ecological and social impacts and its end products play an imperative role in the high standard of living around the world. Restoration can lower the impacts during the operations and also ensure that the end-of-life has ecosystem services, social value, or both.

Incorporating the recommendations formulated from the results and discussion into restoration guidelines is how the SSD approach could enhance these quarry restoration guidelines. Some of these include having clear connections to the sustainability challenge to show its relevance and significance for sustainability and having the eight SPs as overarching guiding principles for success. These were all concluded to be gaps in some or all of the interviews and guidelines. Incorporating these recommendations would fill these gaps aiding in the practitioner's ability to be strategic and have long-term success whilst simultaneously transitioning towards being sustainable. Misinterpretations and other inconveniences of the guidelines would expectantly lower.

By incorporating sustainable boundary conditions to the definition of successful restoration, it can minimize the problems occurring with competing goals and target criteria among stakeholders. At least for the problem of moving society further towards sustainability. The SSD makes sure that both a sociological and ecological perspective is brought into consideration. This approach would include and facilitate a higher awareness over the social influences, which were concluded to be the most essential factors to having a successful restoration project.

Glossary

Backcasting: A planning method where vision of success in the future is built first and then planners ask “What do we need to do today to reach this vision?’’ (Holmberg and Robèrt 2000).

Biodiversity: The variability among living organisms. It includes diversity within and among species and also ecosystems. Biodiversity is the source of many ecosystem goods, such as food and genetic resources. The supply of ecosystem services can be influenced by the change in biodiversity (Millennium Ecosystem Assessment 2005).

Ecosystem services: The benefits people obtain from ecosystems such as provisioning services like food and water; regulating services like flood and disease control; cultural services like spiritual, recreational, and cultural benefits; and supporting services for example nutrient cycling, that maintain the conditions for life on Earth (Millennium Ecosystem Assessment 2005).

Socio-ecological system: The system which is made up of the human society, biosphere, and the complex interactions between them (Broman et al. 2000).

Sustainable development: “The transitions from the current, unsustainable society to a sustainable society” (Robèrt 2000). The essence of sustainable development is to meet the basic human needs and at the same time preserving the life support systems of planet Earth (Kates et. al. 2001).

Quarry: A type of open-pit mine from which rocks such as limestone, marble and granite are extracted for industrial use (McCandless 2013).

List of Abbreviations

FSSD (Framework for Strategic Sustainable Development): A comprehensive model based on the 5LF, which is used for planning in complex systems. This framework was created to bring clarity, rigour, and insight to planning and decision-making towards a sustainable society in the biosphere (Robèrt 2000).

SSD (Strategic Sustainable Development): A strategic transition from the current, unsustainable society to a sustainable society (Robèrt 2000).

SPs (Sustainability Principles): The eight basic principles for a sustainable society in the biosphere, established by scientific laws and knowledge (Missimer, Robèrt, and Broman 2016).

PBs (Planetary Boundaries): Boundaries that set out a safe operating space for human societies to develop and thrive. It is based on "[…] evolving an understanding of the functioning and resilience of the Earth System'' (Steffen, Richardson, Rockstrom, Cornell, Fetzer, Bennett, Biggs, Carpenter, et al. 2015).

5LF (Five Level Framework): A conceptual framework that is used in analysis, decision-making, and planning in complex systems. It is divided into five distinct, interrelated levels: system, success, strategic, actions, and tools (Robèrt 2000).

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1 Introduction

The anthropogenic pressures on the earth's natural resources are systematically increasing, and these pressures decrease our ecosystem's carrying capacity because of the current direction of the higher rate of consumption than replenishment (Kates et al. 2001). Coupled with an ever-growing population, this issue poses a big challenge to a society where time is of the essence. The Planetary Boundaries (PBs) (see appendix A) represents nine boundaries within which humanity should operate in order to support economic growth and human development and to avoid the disruption of the Earth system stability (Steffen et al. 2015). PBs represents urgent problems and high risks for the planet on which society should take immediate actions. So far, four of nine planetary boundaries have been crossed as a result of human activities, they are climate change, loss of biosphere integrity, land-system change, altered biogeochemical cycles ('Planetary Boundaries 2.0 – New and Improved - Stockholm Resilience Centre' 2015). This represents why and how restoration is important, although it is a small part in aiding in the bigger sustainability challenge.

A gradual societal transformation towards sustainability may not be sufficient and therefore, an engagement in more immediate restoration projects to aid in the recovery of essential ecosystem services would be necessary. There is where the aim of this thesis lay, to fully merge sustainability as defined by the Sustainability Principles (SPs) with restoration in order to facilitate ecosystem recovery and at the same time lead to a sustainable future. This is done by analysing current restoration guidelines and opinions from experts working in the field from a strategic sustainable development (SSD) perspective. To better highlight challenges associated with restoration, a sample industry has been set as an example. Hence, limestone quarrying, a form of open pit mining, has been chosen for this thesis, mostly due to society's current need for extracted materials.

1.1 What is restoration and why is it important?

To achieve full sustainability, it is not enough to change unsustainable patterns, but it is also crucial to restore damaged environments. Ecological restoration has been defined as "[...] the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (p.3 SER 2004) and is a deliberate activity that supports the recovery of a damaged ecosystem. The need for restoration of ecosystems is most often resulting from a direct or indirect impact from human activities (SER 2004).

Society is dependent on ecosystem services for instance: food; regulating services that affect for example the climate; cultural services that provide things like aesthetic benefits; and supporting features such as soil formation. However, approximately 60% of ecosystem services are currently being degraded or used unsustainably (MEA 2005). This, in turn, leads to side effects and reinforces issues such as climate change, biodiversity loss, economic instability, environmental pollution, and ecological degradation. This creates the sustainability challenge, which may be explained by the funnel metaphor: "The closing walls of the funnel illustrate the degradation of the socio-ecological system by society's current unsustainable activities'' (Robèrt 2000). The area within the funnel decreases, increasing the risk of hitting the walls and decreasing the possibilities to manoeuvre. The goal of sustainable development, in the context of the funnel metaphor, is to stop the walls of the funnel from closing (Robèrt 2000). Restoration is the step towards opening the walls of the funnel as it aims to repair past damage and pollution to increase the biosphere's resilience as well as increase the strength of the social system. Opening the walls of the funnel through the ecological restoration of degraded

systems is vital to sustainability and ecological accountability since natural capital is the base for our economy (Blignaut, Aronson, and de Groot 2014). Figure 1.1 below illustrates this metaphor.

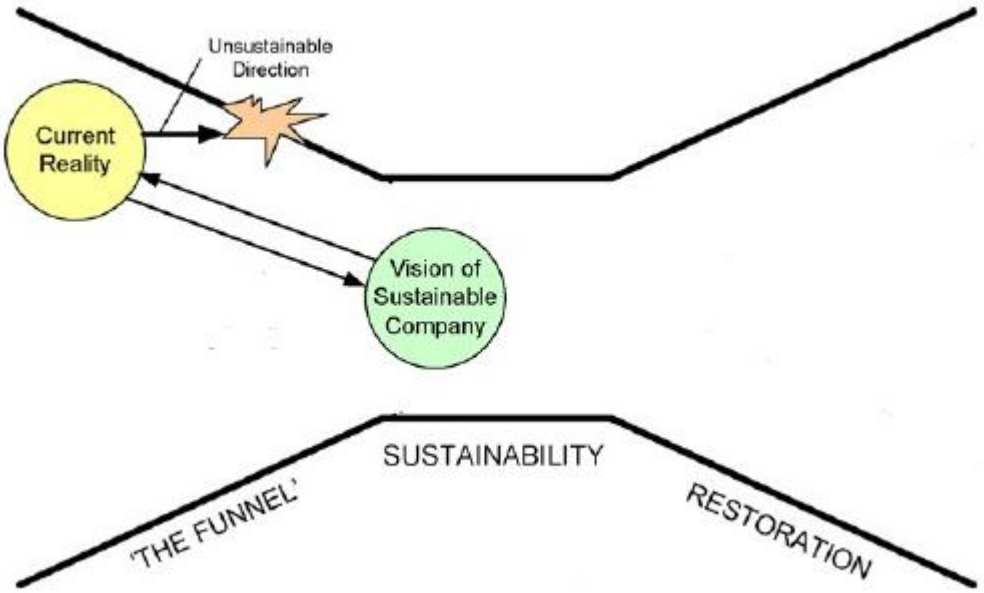

Figure 1.1 The funnel metaphor. The closing walls of the funnel represent the degradation of the socio-ecological system caused by society's current unsustainable activities. This degradation decreases the room to manoeuvre. The walls levelled out, illustrated on the right side, symbolize the steadying of the socio-ecological system when society has become sustainable (García-Serna and Cocero 2008).

In an ideal world, both technology and behavioural changes would act as key strategies in moving towards sustainability. They would lower the demand for new materials and therefore lower the extraction needed to obtain these materials, hence, these ideal changes would result in a decreased need for restoration in the first place. However, due to the time, it takes for both technology and behavioural changes to occur, as well as the resource requirements of today's society, restoration is the only viable option. This is because restoration can be done in the meantime to immediately mitigate harmful impacts and extraction can continue, meeting the high living standard. Restoration has the potential to increase the supply of ecosystem resources and services, as well as increase the social cohesion in a community. This is important because society is dependant on both extracted materials and all other ecosystem services, but without restoration the process of extracting materials would continue to degrade ecosystem services (Blignaut, Aronson, and de Groot 2014). Restoring ecosystems is important not only for the ecological system but also for the social system since it generates jobs, improves the quality of life for everyone in the economy, and betters' livelihoods (Aronson et al. 2006). Indeed, the value of ecosystem goods and services has thoroughly been demonstrated (Costanza et al. 1997; Aronson et al. 2010). Even if restoration has mostly been seen as an expense, studies have shown that restoration also gives return-on-investment when adopting a mid- to long-term perspective (Blignaut, Aronson, and de Groot 2014).

Furthermore, “[...] ecosystem restoration is among the most profitable public investment for economic growth and overcoming poverty” (Suding 2011).

1.2 Quarries

The significance of limestone quarrying in the bigger socio-ecological system. Limestone quarries have been set as the sample area for this study. They are relevant in the context of restoration because it is both necessary to continue with their operations, as well as restore the impacts of degradation before they can spread and worsen. Quarrying is a land-use method used for the extraction of limestone (and other non-fuel, non-metal substances) from the rock. Production of carbonate rocks (including limestone) worldwide places third in volume and fourth in value for all, non-fuel, mineral commodities (Langer 2001). Another reason for its significance when discussing sustainability is that, of all materials extracted in a quarry, waste can account for 60% - 90% (Hem 2012). Limestone is harvested for dimension stone, aggregate resources, and raw materials for agricultural and industrial applications including cement. A derivative of cement is concrete, the second most used substance on Earth, second only to water and its production accounts for 5% of the world's carbon dioxide emissions (Crow 2008). Figures 1.2 a) and 1.2 b) below show the significant amount of space a quarry can take up in the landscape.

Figure 1.2 A) Degerhamn limestone quarry, Sweden. A small portion of the working area with two large trucks as reference points (Thesis group photograph May 2016).

Figure 1.2 B) Degerhamn limestone quarry site, Sweden. The same quarry from a different perspective. The photograph shows a wider area with one of the restored lake areas in the front. The working area of the quarry is the beige in the horizon of the picture to better illustrate the immense size of the quarry. It is divided into several areas: some active with operation, some restored, and some undergoing restoration projects. Thesis team photograph, May 2016.

Overview of impacts from quarrying. The specific impacts from mining vary and these effects occur in the surrounding air, water, flora, and land. Mining for limestone is a type of aggregate mining that has operational impacts including (but not limited to) "[...] noise, dust, air quality, suspended particulate matter and gaseous emissions", which can negatively affect inhabitants, workers, and biodiversity (Ukpong 2012). Geomorphological, ecological, and social impacts also arise and limestone quarries, in particular, are soil erosion intense (Urich 2012).

Quarrying impacts on water. Besides erosion, there is often drawdown of water in regions around quarry sites. Quarries that do not require pumping groundwater are less impactful than those that do, and quarries on flat planes are also less impactful because it usually entails a lesser requirement of removal of materials (Urich 2012). Hydrological systems can dry up and changes in flow volumes and directions can change the availability of nutrients and water causing the extinction of biota. Lowering the water table can change the pH of the water, the vulnerability to pollution, and change the nearby biotic environments. Figure 1.3. below shows human-induced sinkholes formed from the nearby quarrys' high water usage.

Figure 1.3 Quarry induced sinkholes (Langer 2001).

Impacts to biodiversity. The process of limestone quarrying can have minimal environmental impacts if done in a controlled manner, however when done in certain habitats the degradation of the ecosystems can result in higher costs for environmental compliance and liability (Langer 2001). lasting can destroy habitats, vibrations from it can cause collapsing or cracking of karst features, and noise can disturb animals up to 1500 meters away from the quarry. Dust, if widespread, may leach into the soil, smother leaf surfaces resulting in lowered photosynthesis, and create negative impacts to local flora and fauna (Langer 2001). An example of biodiversity impact can be seen in karst terrains which are particularly sensitive and vulnerable to limestone quarrying. This land feature, unique to areas with carbonate rock, hosts species with physiological, behavioural, and morphological adaptations to darkness. Therefore, if this habitat is destroyed with no nearby replacements many species will die, unable to adapt to the conditions outside the caves. Many of these species perform significant services such as bats, eating insects that carry diseases harmful to people (Langer 2001).

Importance of successful restoration of quarries. Restoration is important in quarry areas, not only because of the damage done during operations but also since impacts can, as stated earlier, continue if they are not restored. These cascading environmental impacts happen from a cause and effect chain of events. Where at first, an anthropogenic disturbance such as rock removal disrupts the ecosystem. The natural systems response causes another impact, which leads to another response and so forth. For instance, if quarrying lowers the water table it might result in land collapse and sinkholes due to the removal of the buoyant support for the rock. An example of this can be seen near Farmington, Missouri. During the 30 years of operation of several quarries in the area, there were reported collapses. Due to faulty restoration in the area, collapses were recorded up to 10 years after the operation had ended. These impacts were initiated from the lowering of the groundwater table and continued. Once some of the buoyancy support is removed from small areas, small collapses will consecutively continue to cut off water to other places, which would lead to more land collapses (Langer 2001).

Northern ecosystems and restoration. The main difference between the process of limestone quarrying versus other types of quarries depends mainly on the site. The impacts from any type of quarrying depend on factors such as location, method of extraction, site characteristics, waste materials, and the mineral. The potential impacts from these parameters carry special challenges apparent in restoration, especially with regards to northern ecosystems. These challenges include: short growing seasons, long recovery periods, constraints on plant colonization by physical disturbances on micro and meso scales, slow nutrient turnover that causes slow vegetation development, and long winters that may challenge biota (Nilsson and Aradóttir 2013). Consequently, the northern ecosystems may require long periods of recovery, even if the recovery process was supported by restoration (Forbes and McKendrick 2002; Campbell and Bergeron 2012). Therefore, failure in the restoration projects in these regions is more problematic because of the time lost.

Examples of quarry restoration projects. Three cases presented below are successful adaptations of resource depleted quarries into sites that encourage community engagement, housing and practical use of land. The empty Bellwood Quarry (presented in Figure 1.4) was the cause of the environmental and social hazard for Atlanta, such as noise from machinery and air pollution. It will be transformed into a practical water reservoir, which is a good solution for Atlanta's water shortage issue. The Butchart Gardens, (shown in Figure 1.5.), transformed the quarry site into parks that attract tourism for the region, creates new jobs, re-uses resource-depleted land, engages the local community and provides family entertainment. The quarry in China, (shown in Figure 1.6.) will be transformed into Groundscaper Hotel that will create job opportunities, and provide permanent and temporary housing that uses sustainable practices (McCandless 2013).

Figure 1.4 Empty Bellwood quarry, Atlanta, GA. The quarry poses an environmental and social hazard. (McCandless 2013).

Figure 1.5 A) One of the Butchart gardens in spring (McCandless 2013).

Figure 1.5 B) One of the Butchart gardens in autumn (McCandless 2013).

Figure 1.6 A) A quarry outside Shanghai prior to redevelopment (McCandless 2013).

Figure 1.6 B) Proposed exterior of the InterContinental Shimao Shanghai Wonderland Hotel (McCandless 2013).

1.3 General challenges within the field of restoration

Assumptions made in the field of restoration. Within the field of restoration, erroneous assumptions are commonly made. One example is the assumption that nature responds linearly to anthropogenic impacts and that the results thereof are predictable and controllable. The consequence of this assumption is the erroneous idea that it will be possible to predict the outcome based on measures taken, and thus, it will be easy to create a direct plan that, when implemented, leads to previously defined success criteria. Another example of a common assumption is that social and ecological systems can be analyzed independently. A result that stems from this assumption is that some restoration plans only consider the ecological aspects and do not include social one (Gunderson et al. 2009). However, there are strong, contradicting evidence towards these assumptions as Gunderson et al. (2009) states, "[...] natural and social systems behave in nonlinear ways, exhibit marked thresholds in their dynamics, and that social-ecological systems act as strongly coupled, complex and evolving integrated systems."

Challenges in the field of restoration. Some critiques, particularly targeting restoration and not just environmental management in general, are that restoration is mostly site specific and ad hoc (Suding 2011). Another challenge is that there is a lack of a conceptual framework (Standish et al. 2015; Suding 2011). When not following a suitable model, restoration will likely be poorly planned and implemented, and can thus be viewed as "[...] gardening with wild species in natural mosaics" (p. 75, Choi 2004). Hence, there is a need for an ecosystem approach on a larger scale, that focus on ecosystem structure, functions and species composition in contrary to the traditional ad-hoc approaches (Choi 2004).

Another example highlighting the challenge within the field is that the language used to describe nature is often conflicting and biased, thus causing delay and conflict. There is a big discrepancy of what is deemed 'natural' or 'best for nature'; an example of this can be shown in everyday life where you can buy 'all natural cereals' or '100% natural soap'. There are also three broad definitions of naturalness. The first one is that naturalness is associated with a previous state in time; the second is that it is a state found before humans or in absence of human modification. The third definition is that it is a slow or "natural" rate of change (Hull and Robertson 2000).

Convoluting matters further, defining successful restoration depends on who you ask and it can be defined as economical, aesthetical, recreational, educational or ecological (Palmer et al. 2005). The goal of different restoration projects is often coloured by the decision makers responsible for the restoration (Hull and Robertson 2000), and target criteria for restoration vary widely among stakeholders, even within the same project (Palmer et al. 2005). For example, if the quarry company owns the land they may likely want to transform the area into something profitable such as a recreational area for tourists but the hired consultants may argue that a historic replica is the more appropriate end goal. Specific orientations of success will be highlighted further on in the sub-section 1.3.1.

There is a broad consensus that evaluation of successes and failures are key to advancement within the field, however, complete surveys are rare (Suding 2011; Nilsson and Aradóttir 2013) and there are few standards to measure and evaluate success (Palmer et al. 2005; Nilsson and Aradóttir 2013).

1.3.1 Success-Orientations for Restoration

Currently, there are multiple perspectives with regards to successful restoration. Moreover, the inclination to restore stems both from the intrinsic value of nature as well as the provision of ecosystem services (Hobbs 2014). As seen earlier success could be defined as economical, aesthetical, recreational, educational or ecological (Palmer et al. 2005). However, in the light of society's dependence on, and unsustainable use of ecosystem services, it can be argued that the overarching aim for success should be on ecological restoration of the degraded system. This overarching aim for success is vital to sustainability and for opening the walls of the funnel. More recent orientations have a higher awareness of the social influences and the importance of an interdisciplinary approach for measuring and track keeping of changing environmental, economic and social conditions (Standish et al. 2015).

Restoration towards a historic state. Ecological restoration often aims to achieve some historical state of nature (SER 2004; Hobbs 2014). This goal may be difficult or impossible to achieve since the environment has seen changes throughout history and is in no way static. "Restoration's past-oriented, static and idealistic approach has been criticized for subjectivity in determining restoration goals, inapplicability to dynamic ecosystems, and inability for restoring certain irreversible losses'' (Choi 2007). In order to contribute to a solution for environmental problems, restoration needs multiple clear and articulate goals (Standish et al. 2015; Choi et al. 2008), which recognize the changing and unpredictable dynamics of nature. Restoration goals highlighting both the functionality and structure of an ecological system, as well as acknowledging the unpredictability, non-linearity, and complexity of ecological systems are in most contexts, more appropriate than historic replica goals (Choi et al. 2008).

Restoration towards an intended trajectory. One aim for ecological restoration can be to initiate or facilitate the natural processes within an ecosystem as to a return to its' intended, and desired trajectory. Thereafter, it may no longer need external assistance for future health and integrity (SER 2004). The trajectory can be described as "[...] a hypothetical process of succession or ecosystem development" (p.76 Choi 2004). However, along with this comes the problem with the unpredictable nature of succession and the many complex interconnections within nature making it difficult to pinpoint exact rules or how to create the desired trajectory (Choi 2004).

Restoration towards higher resilience. Some degraded ecosystems are pushed over certain thresholds, past the point of being able to spontaneously recover by themselves. Hence, another orientation of success for restoration is to bring the ecosystem back into the same (or improved) level of resilience as before. This has been referred to as full restoration (Hobbs 2014). Resilience in an ecosystem is its capacity to handle change and how well, and quickly, it can buffer, learn, and develop. The idea of resilience also resonates with regards to sustainability, it is important that affected ecosystems are restored to a high level of resilience in order to enhance the adaptive capacity. This is further illustrated by the large and constant impact from human development on the socio-ecological system, which is a complex adaptive system (Gunderson et al. 2009).

Although there are other orientations of success, the top three recurring ones found in the literature are illustrated in figure 1.1. below. It is also important to note that some of these orientations can be overlapping and some may be more appropriate than others depending on the context.

Table 1.1 Restoration Success Orientations

	The aim is to restore to:	**Comments:**
Historic	A historic state in time.	It is difficult to restore a suitable ecosystem after a historic replica since we are aiming to prepare for an unpredictable future environment (Choi 2004).
Intended Trajectory	No longer need external assistance for future health and integrity.	However along with this comes the problem with the unpredictable nature of succession and the many complex interconnections within nature making it difficult to pinpoint exact rules or how to create the desired trajectory (Choi 2004).
Resilience	To the same or improved level of resilience as before. E.g. to increase the capacity to handle change, and how well it can buffer, learn and develop.	In line with sustainability, as to ensure the adaptive capacity (Gunderson et al. 2009).

Attempts to improve the success of restoration. Besides a clear, appropriate definition of success, what is also needed within restoration is a solid ecological foundation and a conceptual framework based on empirical research (Standish et al. 2015). There have been attempts at improving restoration and Nilsson and Aradóttir (2013) presents five actions for improving restoration practises including; documenting projects into a common database; evaluating project progress and outcomes in order to learn and develop; coordinating restoration actions among countries due to migration patterns; place research efforts on a common platform across nations; educating new generations of restoration actors. SER (2004) describes nine attributes for determining when restoration has been accomplished. There have been some attempts at creating criteria for restoration success and for evaluation of different restoration projects. Findings from Nilsson and Aradóttir show that these different projects only partially meet some these evaluated success criteria. Furthermore, these projects are more oriented towards the restoration of structures rather than ecological processes, and the different restoration policies assumed predictable endpoints (Nilsson and Aradóttir 2013).

1.4 Role of restoration guidelines

Purpose of restoration guidelines. The critiques presented earlier, including restoration being ad hoc and site specific, can be handled with general guiding principles that can be found in restoration guidelines. General guiding principles can be applied to multiple areas and site conditions. This is one reason why guidelines are a key component for restoration projects and will be a large focus for this thesis (Hobbs and Norton 1996). The overall purpose of most guidelines is to help practitioners make appropriate decisions for specific contexts. Guidelines can be written by a variety of organisations including governmental bodies, cooperative groups, and professional societies. They are often used for qualitative measurements, allocating resources, and determining further actions. Guidelines can also contain summaries of relevant background information and give case examples highlighting lessons learned and best practices (Lim et al. 2008). An example of background information may be the guideline highlighting which stakeholders are important for the restoration process such as (in the context of restoration projects): the company doing the project, NGOs, local community, collaborating universities, and local government bodies. Guidelines for restoration also give practitioners direction for deciding on actions to take in order to aid in the recovery of a degraded ecosystem.

The importance of restoration guidelines. In theory restoration guidelines will encompass key processes for the restoration project including, "[…] identifying and dealing with the processes leading to degradation in the first place, determining realistic goals and measures of success, developing methods for implementing the goals and incorporating them into land-management and planning strategies, and monitoring the restoration and assessing its success" (Hobbs and Norton 1996). Not all guidelines incorporate guidance on these key processes, and by default, many of these procedures are not incorporated in all restoration projects. Thus, guidelines are important for effective planning and implementation of restoration projects (Hobbs and Norton 1996). The more of these key processes the guidelines include, the clearer they are written, and with the inclusion of guiding principles, the better the success of the project.

Limitations of current restoration guidelines. The literature review did not demonstrate any overarching scientific papers discussing the potential limitations and benefits of restoration guidelines. However, these do exist for specific restoration projects and sectors. Specifically, there are many papers discussing the potential limitations and benefits of restoration guidelines for reef restoration but it appears that there are none for quarry restoration guidelines or restoration guidelines in general. Limitations with regards to SSD are investigated for restoration guidelines in the quarry industry further on in this study.

1.5 Strategic Sustainable Development (SSD)

Strategic Sustainable Development. In order to enable future generations to meet their needs, society needs to change current unsustainable activities. Unsustainable activities lead to a decrease in ecosystem's carrying capacity and create a risk of not leaving necessary resources or a thriving social system for future generations. That is why society needs an approach that will help them to strategically plan towards sustainable development. A Strategic Sustainable Development (SSD) approach may also help in strategic planning towards sustainable restoration. Considering that restoration is an important element in sustainable development, it needs to be planned strategically in order to be successful. Strategic, sustainable restoration is important, because if society does not repair damaged environments successfully or in a sustainable way, there will be less and less space to manoeuvre in 'the funnel'. An SSD approach can consist of many components such as Framework for Strategic

Sustainable Development (FSSD) or eight sustainability principles (SPs) (both described below), that aid to not losing a big picture view, and give tools and advice on how to plan strategically while being sustainable.

Five Level Framework. As previously highlighted, ecological systems are unpredictable, nonlinear, and complex (Choi et al. 2008). In order to plan and select relevant measures for complex issues, upstream thinking and backcasting need to be included in the planning procedure. As well as robust non-overlapping principles that define the outcome as to not create new problems (Robèrt 2000). That is where the Five Level Framework (5 LF) can be applied as it was developed to aid understanding and assist simplification and categorization in complex systems. This framework is designed for analysing problems, decision-making or strategic action plans. When moving strategically towards success it provides analytical clarity to avoid getting lost in the inherent complexity. It does this through organizing the important information that is needed for planning into five categorical levels: 1) The systems that the planning take place in. The analysis of the system during the planning for restoration can help in having a big picture view and not forgetting about any element belonging to the system. 2) The definition of success, when applied to restoration, includes a definition of success for the specific restoration site. 3) The strategic level ensures that planning include a clear vision and goals and efficiently lead to success. 4) The actions strategically built from the vision and goals; and 5) Tools that are used in planning and implementation in order to enhance the restoration process (Robèrt 2000).

Framework for Strategic Sustainable Development (FSSD). When the 5LF is applied to sustainable development the resulting planning framework is referred to as the Framework for Strategic Sustainable Development (FSSD). It supports groups working towards a goal, in this study towards restoration planning, to use a shared language with respect to sustainability. FSSD just as the 5LF, consists of five levels, but include specific criteria for all levels, such as: 1) systems-level include analysis of restoration in the global socio-ecological system and overview of the sustainability challenge, 2) success level, when applied to sustainability, it additionally includes eight Sustainability Principles (SPs) described in the coming paragraph. 3) Strategic level includes backcasting from the success principles, restoration's vision and goals. This level also consists of three prioritization questions as a minimum; 4) Actions level include specific actions applied towards sustainability, and 5) Tools level include tools that enhance sustainability implementation, assessment, analysis, etc (Robèrt 2000).

Sustainability Principles. In order to plan strategically, a clear definition of the goal is needed. In a sustainability context, success has been defined as eight Sustainability Principles (SP). The SPs are divided into three ecological and five social principles. Ecological principles state that "in a sustainable society, nature is not subject to systematically increasing 1) concentration of substances extracted from the Earth's crust, 2) concentrations of substances produced by society, 3) degradation by physical means. The social principles state that in the sustainable society people are not subject to structural obstacles to 4) health, 5) influence, 6) competence, 7) impartiality, and 8) meaning-making'' (Missimer, Robèrt, and Broman 2016). These act as constraints within which humanity must operate in, in order to be ecologically and socially sustainable. To restore you must exceed the expectations within the SPs since we do not want to sustain a destroyed ecosystem, we want to enhance it, to reverse the effect of the violation/destruction that has occurred. As illustrated earlier in section 1.2 in the example from Missouri, the knock-on effects can continue even after the operations cease. The initial operational impacts may not systematically violate various SP's, however, the knock-on effects are likely to since they spread over long distances. Restoration, if done successfully, can put a stop on these effects.

ABCD Strategic Planning Process. In order to implement the FSSD in an organizational context, the ABCD Strategic Planning Process was created. In the A step, the planning team build a shared understanding and vision of the organization within a sustainable society in the future. In the B step, the team assess the current reality using the SPs as metrics of success. In the C step, potential actions to reinforce positive areas and mitigate negative impacts found from the B step are brainstormed. Finally, in the D step, actions are analyzed and prioritized based on three criteria as a minimum such as the right direction of the actions, flexibility and return on investment (Ny et al. 2007).

If restoration guidelines were to follow the FSSD, guidelines would have a clear socio-ecological system view and connection to sustainability challenge; a clear success definition of restoration including SPs as a success criteria; they would be strategic including a clear vision, goals and prioritization process; they would recommend actions that are sustainable; and they would recommend tools in order to enhance the process of restoration. In this way, guidelines would support both the key processes in restoration projects, and full sustainability as defined by the SPs in the FSSD, which would lead to successful projects. The FSSD is a valuable tool that when compared to restoration guidelines, can show if they are strategic and sustainable and can highlight the potential areas for improvement.

1.6 Purpose/aim of research

The aim of this thesis is to incorporate full sustainability, which is defined through compliance with the eight SPs, into restoration planning. This is done by analysing current restoration guidelines and opinions from experts working in the field, from an SSD perspective. The goal is to surface deficiencies and current issues within restoration and subsequently develop advice as to how to improve guidelines to work towards a more strategic sustainable restoration practice.

The audience for this thesis is restoration, sustainability, or environmental management level professionals that are involved in decision-making processes with regards to restoration practises of different quarry sites. Our geographical scope for this thesis is northern Europe, due to access to information, delicate and unique landscapes, and close proximity for site excursions.

1.7 Research Questions

Primary Research Question. In what ways could an SSD approach enhance quarry restoration guidelines?

Secondary Research Question. To what degree do current restoration guidelines take a strategic perspective on sustainability?

2 Methodology

2.1 Research Design

2.1.1 Overview

In order to answer the primary research question of 'In what ways could an SSD approach enhance quarry restoration guidelines?' a qualitative pragmatic approach was used for this thesis. A qualitative pragmatic method was chosen because it is a specific human problem that was being addressed and this approach focuses on exploring and understanding the meaning of an individual or a group. It is a pragmatic standpoint in the sense that it is the application of the findings that is important, as well as the solution, and what will actually work to be implemented. The data collection was conducted through an extensive literature review, a comparative study using the FSSD, and explorative interviews. The data analysis was iterative and cyclical. Content and thematic analysis (Savin-Baden and Major 2012) was conducted on the printed literature and on the interview results.

2.1.2 Research Phase 1

The first research phase included a literature review and a comparative study of five guidelines against the FSSD. The FSSD was chosen as an assessment tool to find strengths and gaps of the five guidelines used in this study through comparison to strategic sustainability standards. The FSSD analysis demonstrated if the guidelines explain the restoration process, connecting it to the bigger socio-ecological system, or the sustainability challenge. It helped in determining if the guidelines had a clear success definition for restoration that also included the SPs. Moreover, this analysis helped in assessing if the guidelines demonstrated strategic planning and if their actions will lead to sustainable development. Overall, the FSSD was a straightforward method for analysing if the guidelines were strategic and fully incorporating sustainability (Robèrt 2000).

The assessment of the guidelines against the FSSD was undertaken to examine similarities and highlight discrepancies between SSD and restoration practises. This helped in answering the secondary research question, "To what degree do current restoration guidelines take a strategic perspective on sustainability?" The first three levels of the FSSD, in particular, were the most useful in answering the secondary research question. See the appendix for Table 3.1, a summary chart of the comparison study of the five guidelines. The full version of this chart can be made available upon request to the authors. After the initial FSSD comparison was completed, a deeper SP analysis of the guidelines principles was conducted to get a fuller scope of how the success level was covered. The results for which are presented in Table 3.1.1.

2.1.3 Research Phase 2

Interviews. In the second phase of this study explorative open-ended, semi-structured interviews were conducted. The objective of this second phase was to compare if the gaps found in phase one would also appear in conversation with industry experts. The idea behind this was that by doing this it would provide another layer of information to the results. Both in order to triangulate recurring gaps found earlier in the comparative study as well as in interviews, but also to extrapolate the most crucial areas for improvement for restoration to

become fully sustainable. Therefore, our assumption was that this would help answer the primary question, 'In what ways could an SSD approach enhance quarry restoration guidelines?' This answer partially came from the interviewees experience with applying restoration guidelines in their projects and partially from what changes they believed would be most helpful in their guidelines. The gaps found in the interviews were key focus areas for improving guidelines.

2.2 Research Methods

2.2.1 Phase 1

Literature Review. The defined criteria for articles to include in the literature review were the following: the article can not exceed a publication date of 20 years, must be from a scientifically viable source, the article must assist in answering the thesis questions, or in the basic understanding of the research context. The literature review was done for an intersystem analysis of the field of restoration, and to find other relevant background information.

Sampling Guidelines. The initial search for guidelines showed that there were hundreds, if not more, restoration guidelines currently in existence. An extensive selection of guidelines within restoration, conservation, environmental management and even a few from the quarry industry were gathered and skimmed through. In particular, the guidelines the research team wanted to look at were the ones our audience of project managers were using. There was no unifying location to access these types of guidelines targeted for use of our audience. This made sampling a rigorous process with many stages. The initial selection from the above-mentioned topic criteria included 38 guideline documents. From this selection five guidelines were chosen for the study based on the more specific criteria: Being a guideline for restoration or rehabilitation of a natural area, with the intended audience being project managers, and it should be in some form applicable to a quarry setting. These five (referenced to in section 3.1 by the name in brackets) are: *Ecological Restoration for Protected Areas: Principles, Guidelines and Best Practices* (IUCN), *Guidelines for Developing and Managing Ecological Restoration Projects* (SER), *Promotion of Biodiversity at the Mineral Extraction Sites of HeidelbergCement* (HC), *HANDBOK:* Inspiration till att skapa bra natur i täkter. Åtgärder under drift och i samband med efterbehandling [Inspiration for developing great nature in quarries. Measures for operations and in conjunction with after-treatment; translation by thesis group] (Handbok), and *Guidelines on Quarry Rehabilitation* (CSI).

Data Collection Guidelines. Data collection from the guidelines had to be delegated to the research members due to time constraints since the documents were over 100 pages in length. To be most efficient two members were assigned two guidelines and one was assigned to read the last one. The members read their assigned guideline(s) and made extensive notes on the information provided in these documents from each level of the FSSD. For success, in particular, the principles from the guidelines were examined closer against the eight SPs for an SP analysis. A group discussion about the sustainability gaps and strengths from each guideline concluded the data collection.

Data Handling Guidelines. The group discussion on each guideline was put into a large paper chart. A sheet was divided into five rows (one for each guideline) and five columns (one for each FSSD level). During the discussion about the results from reading the guidelines, one researcher wrote the findings on post-it notes and put them in

the appropriate box on the paper. These post-it notes were color coded: red for clear gaps, green for clear strengths, and yellow for unclear. This paper chart was then typed digitally into a nine-page table. This was too detailed for the purposes of this study (not looking at specific guidelines but guidelines overall) so a smaller summary chart was made. This chart included the overall gaps and strengths from each FSSD level common across at least three guidelines.

Returning back to the success level of the guidelines the research team conducted the SP analysis. This was done by making another table. There were nine columns (one for each SP and one for the total score) and six rows (one for each guideline and one for the total score). The table, which can be found in section 3.1 has five rankings for each principle and every ranking was given a numeric point. These rankings and corresponding points were: fully addressed (5 points), clearly addressed (4 points), addressed (3 points), semi-acknowledged (2 points), and avoided (1 point).

Fully Addressed meant a clear reference to the SP and the principle was covered fully and left no room for sustainability violations. This cannot be seen in table 3.1 since no guidelines fulfilled its criteria. *Clearly addressed* meant a clear reference to the principle but not necessarily covering the full scope of it. For example, SP4 only addressing physical health and not mental or emotional. *Addressed* meant it was indirectly referenced and not fully covered. *Semi-acknowledged* meant that it was not directly spoken to but was more likely to comply than to violate. However, it was still unclear and so could potentially lead to sustainability violations. *Avoided* meant it was very unclear or that it indirectly promoted violations. The rankings' points helped quantify both how much each SP was covered in the guidelines and which guideline covered the most SPs. For the individual SPs, the total potential score was out of 25, and the guideline score was out of 40. The points system was denoted by the thesis team to illustrate the SP gaps of the guidelines.

Data Analysis Guidelines. The results from the comparative study not only helped answer the secondary research question but also formed the basis for suggestions for how to address the current sustainability gaps in restoration guidelines. The SP table provided specific gaps from the guidelines success level. Furthermore, these highlighted gaps formed the foundation for the second phase of this study.

2.2.2 Phase 2

Sample Interviews. A list of interview candidates and quarries were provided by a Finance & Sustainability Project Manager at a large international company within the cement and quarry industry. This company will be referred to hereon out as company 1. This list contained individuals from independent consulting firms that work with restoration. Included were also names of contact persons from different quarry sites located in the whole of Northern Europe. Northern Europe as a geographical boundary from company 1 refers to where they have their main operations: Denmark, Estonia, Latvia, Lithuania, Norway and Sweden. Interview participants were contacted if they met the following criteria: currently working in a management position (or similar) with restoration, sustainability or the environment at a quarry site; or were independent sustainability or restoration consultants. Furthermore, they either spoke English or Swedish, due to language knowledge within the research group. Based on these criteria, only interviewees from Norway, Estonia, and Sweden were contacted. Of all candidates contacted, only those from Sweden responded and as a result, all six interview participants in this study were located in Sweden.

Data Collection Interviews. In order to cover all topics and areas necessary, the questions that the participants were asked were based on an interview protocol that followed a list of pre-set questions, see appendix for the full list of these. The semi-structured design allowed questions to be added in response to the participant's comments and reactions (Savin-Baden and Major 2012). There were two interviewers present during all interviews, one who was observing and taking notes, along with the one conducting the interview. All interviews were digitally voice recorded with participant agreement. Interviews were conducted in English or Swedish based on the preference of the interviewee. Any interview conducted in Swedish was transcribed and then translated into English.

Data Handling Interviews. We used a verbatim transcript method (Savin-Baden and Major 2012) to transcribe the recorded interviews. After which, two researchers individually coded the transcripts in order to enhance the validity of the study. The codes set were a priori codes based on the themes and meanings found from the first stage of this study and co-occurring codes were included when a segment of data got more than one code (Savin-Baden and Major 2012). The coding was categorized based on the five levels of the 5LF. These five main codes were system, success, strategic, actions, and tools, and each of these codes had sub codes in the coding matrix made. These sub codes were not necessary to distinguish in the final results section. The coding matrix can be made available upon request to the authors.

Data Analysis. After coding, a content and thematic analysis was conducted in order to discover and bring forth any similarities and discrepancies between the different interviewee's answers. Themes that emerged during these interviews were cross-checked and evaluated with the findings from the comparative study in phase one, in order to triangulate recurring gaps and extrapolate the most crucial areas for improvement for restoration to become fully sustainable and to formulate advice to practitioners.

2.3 Validity, Assumptions, and Biases

A meticulous record was kept in order to ensure 'trustworthiness' of findings (qualitative reliability and validity) and to account for personal biases. As to demonstrate a clear decision trail and thought process throughout the research in order to ensure interpretations of data was consistent and transparent. A comparison case was established to ensure different perspectives were represented, including the different perspectives of the interview participants as well as the different guidelines. Data triangulation was used in order to produce a more comprehensive set of findings.

In particular, since three interviewees were working directly/permanently in daughter companies for company 1, opinions only given from these participants were analysed with higher scrutiny. Their statements were directly compared to the other three to check the validity of their statements. Whenever the majority was in agreement it was assumed that this meant it was not made in bias. However, unavoidable limitations on the scope are acknowledged in limitations as all interviewees were from the same country. The research team assumed that this limited scope would not provide inaccurate results. For additional rationale for why the FSSD and 5LF were chosen tools for the study refer to section 1.5.

3 Results

3.1 Results from the comparative study of guidelines

3.1.1. Systems Level

Some gaps at the systems level that appeared in the guidelines included no connections made to the larger socio-ecological system, sustainability challenge, or bigger picture; did not help the reader understand the system of study; and biased writing for the particular industry. However, not all of these occurred in every guideline. The IUCN guideline made very strong connections at the systems level to the larger socio-ecological system, the sustainability challenge and avoided biased language (Keenleyside et al. 2012).

3.1.2. Success Level

Most of the guidelines had some elements of strong success in relation to sustainability and restoration. For example, the HC guideline success criteria were that after-use of a site must be long-lasting, safe for humans, efficient, promote biodiversity and sustainable (HeidelbergCement 2014). However, none had success defined clearly enough to avoid sustainability violations in the process. Some of these recurring gaps about the success criteria included: an incomplete coverage of the SPs; a lack of overarching guiding principles of success; vagueness in how goals should be reached, leaving room for misinterpretation; a narrow scope; no clear definition of success for restoration; and their own success principles were overlapping. All of these individually and in combination with each other have the potential to lead to sustainability violations due to lack of clarity and direction.

Another relevant aspect of success specifically for restoration guidelines is the success orientation or in FSSD terminology the vision/ ultimate goal. The main categories of these (found in section 1.3.1) are returning to a historic state, heading towards an intended trajectory, and raising the resilience level. One said that it depends on what is most appropriate for the specific site, one made direct reference to a higher resilience level but the other three were focused on historic state orientation.

The success boundaries for the FSSD are defined within the SPs as introduced in chapter 1.6., Table 3.1. below shows the SP analysis for the guidelines.

Table 3.1. Eight SPs Compliance / Violations Table

	IUCN (Principles)	SER (Actions)	HC (Principles)	Handbok (Actions)	CSI (Principles)	Total
1 (Earth's crust)	+ Addressed	? + Semi-acknowledged	? + Semi-acknowledged	? - Avoided	? + Semi-acknowledged	40% (10/25)
2 (Made by society)	+ Addressed	+ Addressed	+ Addressed	? - Avoided	? + Semi-acknowledged	48% (12/25)
3 (Physical degradation)	+ Clearly addressed	? + Semi-acknowledged	? + Semi-acknowledged	+ Clearly addressed	? + Semi-acknowledged	56% (14/25)
4 (Health)	+ Clearly addressed	+ Addressed	? Semi-acknowledged	+ Clearly addressed	? + Semi-acknowledged	60% (15/25)
5 (Competence)	+ Clearly addressed	+ Clearly addressed	? - Avoided	? - Avoided	? + Semi-acknowledged	48% (12/25)
6 (Influence)	+ Clearly addressed	+ Addressed	+ Addressed	? - Avoided	? + Semi-acknowledged	52% (13/25)
7 (Impartiality)	+ Clearly addressed	? - Avoided	+ Addressed	? - Avoided	? + Semi-acknowledged	44% (11/25)
8 (Meaning-making)	+ Clearly addressed	+ Addressed	? + Semi-acknowledged	? + Semi-acknowledged	? + Semi-acknowledged	52% (13/25)
Total	75% (30/40)	52.5% (21/40)	45% (18/40)	37.5% (15/40)	40% (16/40)	

With this analysis, it is not possible to explicitly state whether these guidelines would lead to violations or compliances. In most of them, there is freedom of choice for how goals are reached and these are not strictly regulated by the guidelines. A number of guidelines give action examples that would be difficult to control to one area, such as the use of pesticides. For the specific contexts in which these SPs were used in the guidelines, see chapter 4.1.1.

3.1.3. Strategic Level

Some of the guidelines had some strategic elements to them. The SER guideline used both forecasting and backcasting and included public participation throughout the process (Clewell, Rieger, and Munro 2005). However, there were also recurring gaps in the guidelines with no prioritization criteria; no explanation for the practitioners how to incorporate principles into the planning; a lack of interlinkages between actions and goals, and actions and vision; no indication of the potential magnitude of certain impacts or urgency; and no follow-up guidance. In addition to these gaps, backcasting was only used in two guidelines.

3.1.4. Actions Level

The most recurring gaps at this level included generalizations and lack of clarity; no restrictions or boundaries for actions; a limited scope, and actions only covered one specific success criteria. They also did not necessarily aid in transitioning towards sustainability since they did not incorporate all SPs. The Handbok guideline had the

following strengths in this level: Actions were connected to both goals and habitats; and an entire chapter was dedicated to actions including descriptions of which and how actions are appropriate under particular contexts (Almefelt et al. 2015).

3.1.5. Tools Level

For the majority of the guidelines information at this level was lacking. Three of five had no recommended tools for any of the stages of restoration. The CSI guideline was one of the two guidelines that included recommended tools to aid the practitioner. Two examples of these were ESR (Corporate Ecosystem Service Review), and ESIA for evaluating and managing all impacts of a site and describing the context of the project (Cement Sustainability Initiative (CSI): Guidelines on Quarry Rehabilitation 2011).

3.1.6. Summary

Overall all of the guidelines had at least one strong aspect with each level excluding the tools level. The tools level only had two guidelines with recommended tools to use for implementing the stages in the guideline. Each guideline had gaps in every level of the FSSD. The main gaps that occurred in the majority of the documents were: no connections to the larger socio-ecological system, success criteria did not cover all SPs, no prioritization criteria, no recommended follow-up actions, and no recommended tools for implementation.

3.2 Interview Results

3.2.1 Systems Level

The interviewees, when asked about the definition of restoration, made emphasis on terminology. For example, one of the consultants said that they do not use the restoration concept but they call it after-treatment. However, all six interviewees had a sense of what restoration is. Four of the interviewees expressed that restoration should be based on ecological functions and not just physical features.

Four interviewees had difficulties answering the question about the definition of sustainability. The most common responses were either their own company's definition or from the Brundtland report, as one of the consultants expressed, "I think the Brundtland Commission definition is the best with the fundamental idea being that each generation has a responsibility not to leave fewer opportunities for future generations" (Interviewee 2, 2016). The majority of the explanations that came from follow-up questions had an immense focus on ecology. Not a single participant had an explanation that fully encompassed sustainability. All interviewees saw the connection between restoration and sustainability. They mentioned that restoration is a small, necessary part of sustainability and one of the consultants articulated, "Restoration is like a toolkit for sustainability goals" (Interviewee 2, 2016).

3.2.2 Success Level

A multitude of aspects reflecting success were addressed during the interviews. One of which was the type of orientation the restoration success should have. The three main orientations in section 1.3.1 were not told to the interviewees to ensure they would say the ones they actually use. Two interviewees claimed that higher

resilience was best and that historic state should never be aimed for. Three explained that they always aim for an intended trajectory but their explanation of this was highly overlapping with higher resilience. These three also said a historic state is not an appropriate goal. The last interviewee had no opinion on this matter.

The only overarching theme throughout all of the expressed goals of the participants was biodiversity. Only two of six participants mentioned any type of social aspect for goals while the other four strictly referred to biodiversity and/or ecosystem functions. However, when asked about what were the key criteria for a successful restoration project, five of six solely referred to social aspects as being the key drivers. Specifically, one such factor was having the right people involved in, and to positively contribute, to the project. One of the consultants made reference to multiple instances where they had to do more work to fix the mistakes made by others than they would have if they had just done the restoration project correctly in the first place. This was due to people being hired for the job without the required expertise but with the lowest proposed budget. It happens occasionally that the budget allocated for these projects is so low that you end up with half done, bad results.

One consultant gave an example of a lake with mercury-contaminated sediments in Hultsfred. After the sediment had been pumped somewhere else and covered in a moraine, the re-vegetation process was supposed to begin. The people hired for this step did not care about the importance of local species and planted a seed mixture used mainly for ditches. In the end, all of the species in the area died from these introduced species, which also later died. The process of re-vegetation had to be conducted from scratch.

Key factors limiting success were more related to the results of the initial stages. These included no vision, not everyone involved knew the vision, the wrong people were involved that had private agendas clashing with that of the success of the project, no indicators, and doing it without experts. The interviewees all had different experiences here and brought forth a variety of answers to this.

With regards to vision, there was no clear answer about this; three of them stated that visions differ from project to project with the aim to do a good job that will improve ecosystem services or other values. To have an agreed upon vision was mentioned twice. For the connection of goals with the vision, three of them expressed that it is important that the vision is realistic and good but made no reference to the goals needing to be aligned with said vision. Only one reflected that the goals should follow the vision. According to an environmental engineer "[...] you would not reach the definition of success if you do not incorporate targets stated in the framework" (Interviewee 1, 2016). Two stressed the importance of following legal requirements and to follow the permit. Four of them talk about setting clear goals and three of them stressed that there should be a follow-up or a measurement. However, none of them talked about making strategic goals or matching them with their key success criteria or vision.

3.2.3 Strategic Level

When asked what guidelines were used, there were different responses and one interviewee answered, “We really follow what is most common” (Interviewee 6, 2016). Moreover, they expressed that the restoration guidelines that they were currently using were applicable in their work. However, only one interviewee mentioned that their guidelines gave clear objectives. Other themes that interviewees said (included in the guidelines they were using) were strong biodiversity goals and actions as well as adaptive management. However, unfavourable factors were also expressed: applicability of the guidelines, as well as the frameworks; and extra knowledge or

experts are necessary in order to do a project. It was also expressed by five that there was a risk of losing the overarching view over the big picture and that not all aspects, for example, social ones, were addressed.

All but one of the interviewees talked about including some sort of assessment, analysis, or mapping as a step that they would include when it came to procedures or processes that they used in restoration projects. One talked about the importance of having a process in the first place and how important it was to evaluate and follow-up, especially in complex issues. Backcasting was indirectly mentioned by one interviewee when talking about the importance of reaching a target goal. However, no other interviewee talked about it as a process. A key take away from what was found most important to one interviewee is presented below.

> "What you agree on from the beginning, that is the frame that you decided on in the application, it is that which constitutes the framework and which can then be corrected with time. It is an important part of the process. Then the most important thing is that there is a process and that it continues. It's not just mothballed and forgotten, that the company rustles over this final stage. But rather that it should be discussed, it should be taken up at regular intervals, discussed with the regulatory authorities and perhaps with interest groups. What happens is not always as you planned from the beginning, and therefore, it is important to be open to change" (Interviewee 6, 2016).

For prioritization, every interviewee had different answers. Results ranged from no process at all, to "[...] it happens quite naturally, it's done during core activities, it's done when it's possible" (Interviewee 5, 2016), and that every site is different. Time as a factor was mentioned twice, and drinking water issues was mentioned by one. One of the consultants said that "[...] in the best of worlds that it rarely gets [...] you have action-alternatives of measures that you compare and then do a test of how cost effective they are, but it's almost never that there will be time or money for that. It's more about trying out a model if it seems to work and is not too expensive" (Interviewee 2, 2016). Only two interviewees had comments about prioritization but these did not include all of the three most important prioritization questions from the FSSD (see section 1.5).

3.2.4 Actions Level

Four interviewees did not have a standard list of actions and said that it was mostly site specific. However, topics that surfaced when asking what stages were most essential, comprised of communication, planning, piloting, and assessment before implementation in full scale, and formulate objectives.

> "A very good step is when you have a restoration hypothesis, that you do not make it all at once, but you do pilot testing to see that you have taken the right decision. And if you have not made the right decision, then you have to go back and see [...] what is it that we have misunderstood then, so to speak, did we make the action correctly or was it the wrong action and then, to pilot scale, in complex systems, are always good" (Interviewee 2, 2016).

Six of the participants revealed how actions need to be specific for each quarry and only two participants had actions that were applicable to multiple projects. Three made it clear that they do not care about the actual restoration activities so long as it is done to keep the stakeholders happy and that it did not interfere with ongoing operations.

3.2.5 Tools Level

Overall the tools used by the interviewees when dealing with restoration of quarry sites are tools for mapping the area, measuring parameters, taking inventory of species, and monitoring progress. Only one participant was able to clearly address that there was a need for certain types of tools that are currently lacking from both guidelines and restoration projects. According to this participant, "[...] almost every project is missing some sort of quantitative measurable indicator, or some measurements of key deliverables" (Interviewee 2, 2016).

4 Discussion

4.1 A strategic perspective on guidelines

The research questions that this thesis set out to answer was ‘To what degree do current restoration guidelines take a strategic perspective on sustainability?’ and ‘In which ways could an SSD approach enhance quarry restoration guidelines?’ As this study showed, there are gaps that could be improved in order for a more strategic and sustainable-based restoration process. As presented earlier in section 1.5, analysing and presenting results according to the 5LF can help practitioners understand the system of study. What is most essential to understand when implementing this framework on restoration, is the interrelationships between the system, success and strategic levels since this is the foundation for identifying and developing appropriate actions and tools. That is why there is more emphasis on those first three levels and how they could be improved, in the following discussion.

4.1.1 Systems Level

Three of the guidelines made some connection to different factors within the system, but they where not all encompassing. This lead to the assumption that this might be a common issue in other guidelines to, which in turn increases the chance for bigger or more recurring implications. This gap was confirmed in the interviews as well, which similarly showed a lack of systems view and an extra focus on ecological aspects, social aspects were usually lacking. However, all the interviewees saw the connection between sustainability and restoration but they had problems defining both of them.

A lack of connection between the larger socio-ecological system and restoration is problematic since a system perspective is crucial for understanding the system of study and it includes the basic outlines, interactions and behaviour which are relevant in reaching the overall goal. An understanding of the relevance of the restoration project in the bigger picture could also instil pride in the workers involved in the project and create a drive for a successful outcome. Without a system perspective, there is potential for missing aspects or conditions that are necessary for success. This may lead the practitioner to not completely understanding the system of study or the need for restoration or its role in sustainable development for the future. This can in turn cause a more narrow view on restoration, which could cause downstream problems, knock-on effects, or simply resulting in an unsuccessful restoration project. Since nature is both complex and nonlinear there might also be transgression of thresholds that may affect key ecosystem services, as for example cause the climate to shift more rapidly. Limiting the amount of knock-on effects in a restoration project can be time sensitive. Starting certain stages over again in the process (such as re-vegetation) extends this time frame and can have potential impacts in other areas. An example of why knock-on effects are important to avoid was presented in section 3.3.2. in the Hultsfred example. At this lake, the seeds could have been transported by wind and water to other areas outside the project boundaries and kill out the plant species there as well.

Associated with this issue of not knowing the definition is the challenge caused by using different words to describe the same thing. The interviewees used different words in describing restoration, for example, rehabilitation, remediation, and after-treatment. This is also one of the critiques of restoration, mentioned in section 1.3 since it can create problems with the understanding of the overall purpose of restoring damaged

areas. This can further lead to possible sustainability violations, stakeholder disengagement or ineffective restoration measures.

4.1.2 Success Level

A clear definition of successful restoration was lacking within the analyzed guidelines. At least four of the guidelines had some sort of goal presented, however these were not clearly defined. The overall vision, or success orientation, differed from guidelines and interviews. The guidelines were more focused on a historic state whereas five interviewees made it explicitly clear that a historic state was not the best ultimate goal. These are problems since the success level is the key level within the planning process and a clear definition and vision assist in the selection of what strategic guidelines, actions, and tools should be used. Thus, every project should have a clear, agreed-upon definition and vision of successful restoration that is based on basic, non-overlapping principles. It is also crucial that successful restoration corresponds to success for sustainability in order to facilitate long-term success and resilience of the restored area. Without presenting a clear idea of what restoration success should encompass, and how it should look like in the guidelines, there is a possibility for misinterpretations with regards to in what ways goals could be reached. Moreover, by not including a complete definition of sustainability within the boundary of a successful restoration project, there is potential for sustainability violations, even though the restoration project has reached the level of success as it has been defined in the guideline.

The main message from the SP analysis is that suggested actions or principles within the restoration guidelines are either too specific or too general. A guideline that scored low points does not necessarily lead to violations, but rather that it could potentially be easier to misinterpret. The same goes for high scoring guidelines, since ‘clearly addressed’ did not mean it covered the full aspect of the principle. For example, the Handbok only mentioned 37.5% of the SPs and the IUCN guideline reached 75%. This does not necessarily mean that the Handbok is less useful for sustainable development, it just means that it has a too narrow focus with regards to sustainability. However, it may still be useful when looking for specific guidance in a particular habitat.

A closer look at the representation of the particular SPs within the restoration guidelines showed a large focus on SP3 (degradation by physical means) and SP4 (health). An example for how SP4 was portrayed was advising about the safety of workers during the restoration process, as well as the safety of visitors when the restoration was done. In terms of SP3, guidelines were mainly focused on bringing biodiversity value back to the damaged site. However, an overrepresentation of one single aspect can create a limited scope and shift focus away from other important factors. Thus, creating a skewed picture of the diversity of actions to take, minimizing their equal importance for success to be reached. There is also the risk of a too narrow focus could lead to a systematic degradation of the biosphere simply by being a to confined.

Contradictory, there was a lack of coverage of SP1 (concentration of substances extracted from the Earth’s crust). It was covered by the five guidelines by only 40%. This could potentially mean a slight bias towards the quarry industry or a lack of understanding of the potential implication inherent in quarrying. An example is mentioned in section 1.2. about the karst environments. If the quarry industry assumes that quarrying will always bring a higher biodiversity value then what the area had before quarrying was introduced, they are underestimating the ecosystem services provided by the unique animals living in karst environments, such as bats as pest control.

Other principles such as SP2 (concentrations of substances produced by society), SP5 (competence), SP6 (influence), SP7 (impartiality), SP8 (meaning-making) were usually semi-acknowledged or avoided in the guidelines. This may lead to potential sustainability violations or evasion in these areas when using the guidelines.

As the results showed from the SP analysis, none of the guidelines completely addressed sustainability as defined by the SPs. This gap was further confirmed by the interviewees were only two participants mentioned social aspects of sustainability in their goals, however, five participants said they were key factors for successful restoration. Without including goals for social aspects into restoration it is difficult to strategically plan and prioritize actions that target these. If these key factors for success are not included in clearly articulated goals there is a chance that they will not be reached.

Furthermore, the implication of not including all factors important for sustainability is also that there is no guarantee that when trying to fix a problem in one area, you do not cause a problem in another, causing knock-on effects. This issue was clearly presented in a case study (see appendix B) within one of the analysed guidelines. Here they described the use of pesticides to save time and resources, but there were no directions on how to control the substance so that it did not spread further than intended and affected other species or areas. Systematically using pesticides leads to an increased concentration of substances produced by the society in the biosphere, causing a lot of problems, as for example health issues.

To address these issues it would be good to incorporate the SPs into restoration guidelines. This could be done by, for example, explaining the problems associated with the use of pesticides and the importance of using them in a controlled manner (SP2); making sure that employees of the company performing the restoration have the opportunity to increase their knowledge and have sufficient opportunities for personal development (SP5); involving more local people into the process by presenting the restoration plan to them and continuously updating them with the restoration progress (SP6); making sure that the choice for which stakeholders to involve is not excluding anybody based on demographic reasoning (SP7); Finally, to make sure that purposeful conditions for workers are created (SP8). However, most important are to make sure that, for the first three SPs, there is no systematic hindrance and with the last five SPs, there are no structural obstacles within the restoration process.

When interviewees were asked about their opinion about eight SPs being applied to the restoration planning, the range of answers varied from being valuable but a bit overarching to not understanding them enough to have an opinion. The eight SPs were presented during the interview by phone, and they were not related to the restoration itself but to sustainability, so not understanding them or how they could be incorporated into restoration may be the issue in most of the cases. One expert had participated in multiple workshops learning first hand about these principles and had access to them in their mother tongue but still said that they could not, based on their knowledge of them, say whether or not they were useful. Therefore, the principles should perhaps be re-formulated to better relate directly to restoration in quarries.

4.1.3. Strategic Level

The comparative study and the interviews showed that there was no understanding of the interlinkage between the steps in strategic planning. In the guidelines there was no overall guidance for the practitioners on how to plan for restoration in a strategic way and there was a lack of clear prioritization criteria. The interviewees highlighted that clear goals and incorporating a follow-up were necessary. However, making strategic goals or matching them with their key success criteria or vision was only mentioned by one of them. This is interesting with regards to strategic planning for sustainable development where these are crucial steps and important links to make in order to be efficient and successful with the implementation of restoration plans. Without having a clear and mutually agreed on vision that informs the strategic goals and the following prioritized actions, it may negatively influence the long-term success of the project. It would also be hard to evaluate if the project has indeed reached success. As seen in section 1.2, restoration in northern ecosystems carry special challenges where failure is more problematic due to time sensitivity, hence increasing the significance for strategic planning.

Both prioritization and backcasting are important aspects of strategic planning. Both were lacking in the guidelines and within the knowledge of the practitioners. This leads to the assumption that prioritization is often overseen or not done strategically and that backcasting needs to be introduced into the guidelines.

During the interviews, there were expressed issues in regards to the usability and how to follow current restoration guidelines, as well as that extra knowledge or experts, are necessary in order to do a project. This could mean that the guidelines the practitioners were using are not supporting them as much as they need. However, only two could explain or give examples of misinterpretations of guidelines that had occurred. This could mean that without a strong vision, and subsequent goals to follow, it will be hard to evaluate if it is a successful restoration project or not. There were also many different recommendations about other guidelines that interviewees found useful. This implies that there are no mutually agreed on set standards, which further shows a need for a more overarching strategic framework.

4.1.4 Actions Level

There was no explicit interlinkage between the vision, goals, and the actions that were recommended in the guidelines. With no clear linkage between actions and goals or the actions and vision, there is a higher risk that implemented actions may not lead towards reaching the goals. It can also create a situation where the goals are reached in a way that jeopardizes the overall long-term success of the project. For example, when the goal for restoration is not flexible enough and does not take into account the need for adaptability in the constantly changing environment, the goal may end up being successful in a short-term period, but it can lead to failure in the future. Therefore, the assumption is that the actions presented in the guidelines would not aid in transitioning towards a sustainable society since they are not connected to the vision.

The majority of the interviewees did not have a standard list of actions and said that it was mostly site specific. This could have a negative outcome depending on what level of knowledge the person in charge of restoration have. Especially with regards to implementation of appropriate actions and measures for certain types of environments.
At least three of the guidelines included actions and measures for restoration of different types of environment. However, if the guidelines that are used are not up to date with the current best practices with regards to sustainability and restoration, there is a lower chance for long-term success of the implemented actions since they might be out-dated and not adequate. Correspondingly, the actions within the compared guidelines

presented a limited scope by only covering biodiversity for the most part. This could similarly pose a lower chance for long-term success, especially if practitioners only guide their decision-making based on the actions found in guidelines without considering other factors for success.

4.1.5 Tools Level

There was an inconsistency between the analyzed guidelines in the comparative study. Two recommended tools and three of them did not suggest any. Similarly, only one, interviewee accounted for situations during the restoration process where they would use different tools. Examples of situations were mapping the area, measuring parameters, taking inventory of species, and monitoring progress. However, five of six participants could not suggest further tools that could help make restoration projects stronger in regards to strategic sustainable development. This could mean one of several things. Potentially they believe that the restoration projects they are involved in already are fully sustainable and there are no obstacles in their way for achieving success. It is also a possibility that they do not know or understand what tools could help what areas in the restoration process. Part of being strategic means using the best available tools for the situation to be efficient in reaching your goals and vision in the most sustainable way. The result shows that including suggestions for best available tools for certain tasks in the guidelines would be beneficial for practitioners in order to raise the overall standard.

Even if there were few tools recommended within the restoration guidelines there was none to support the planning process. To include a suggested list of best available tools, for example, the ABCD and a tool for strategic assessment, it could aid the practitioner towards successful strategic planning and thus an increased chance of project success. Since planning for restoration, in most of the analysed guidelines, has too many gaps to be fully strategic and sustainable, the ABCD could be a good tool to incorporate. The benefits of using this tool are highlighted in section 1.5. Additionally, the urgency associated with the sustainability challenge reinforces the benefits from incorporating PBs into the guidelines. PBs represent the urgent issues on which society should take immediate actions such as biodiversity loss, so it helps in taking appropriate actions, which are crucial to sustainable development and not losing the big picture view. Although PBs did not come up in the guideline comparison or interviews more can be seen about them in section 1, and in appendix A.

4.2 Limitations

The relatively short time span of 12 weeks for the thesis had to be considered when selecting participants to be interviewed. Due to these time constraints, a small sample was interviewed, which may not show as much diversity as needed in answering the research questions in the best possible way. This could have unintentionally generalized in favour of ideas generated from a similar group of respondents.

4.3 Recommendations

4.3.1 Further research studies

Due to time, resources, scoping, and some inconclusive results, there are areas for further investigation and development. A continuation from this thesis could be writing a guideline document that incorporated everything discussed previously with the SSD approach in mind.

This guideline should include:

- A clear connection to the system and sustainability challenge.
- SPs formulated in a way that is more directly relevant for the quarry industry.
- How to plan strategically.
- Give guidance on how to prioritize actions.
- Give suggestions of best available technology and tools for a successful restoration project that contributes to a sustainable socio-ecological system.

This way the guideline could be tested and evaluated in the field. Generating speculations and theoretical assumptions is just the first stage but it is also vital to apply and evaluate it in the real world. Piloting is especially important for complex issues.

Another research project on an SSD approach in other types of environmental degradation sites would be influential. These could include oil spills in water bodies, deep underground mining, and agriculture. This would show the applicability of this approach in other areas, and if it is needed more urgently elsewhere: urgency being from the perspective of the sustainability challenge. An additional research project could be focused on answering, 'what problems exist from not using a full sustainability scope when applying quarry restoration guidelines?' Information about this in this study was mostly hypothetical so an exploration of this would further show or disprove why an SSD approach would be beneficial for restoration success.

Although future studies and development of this thesis are significant for the improvement of restoration guidelines and practices, they will not occur in the immediate future. The next step for this body of research is practitioners testing and using the advice developed to assist them towards adopting an SSD approach in order to contribute to the opening of the funnel walls.

4.3.2 Advice to practitioners

This section is based on the findings from this study and includes a list of advice for practitioners on how to tackle gaps in restoration guidelines and current practices. These recommendations are meant to assist practitioners in the transition towards including SSD in restoration projects before better guidelines are developed. There is the possibility that the following list may only be applicable for practitioners within the scope of this study. However, they are assumed to be easily applicable elsewhere.

Systems Level

What: The connections of the project to the larger socio-ecological system should be understood by everyone involved in the project.
Why: In order to better align ideas for the project and give a sense of greater purpose to the stakeholders. Without understanding the sites role for local ecosystem services, decisions that could

result in negative and expensive long-term consequences could be decided solely based on short-term and site-specific parameters.

What: A common language should be shared by all key stakeholders. Every project description should include a definition of sustainability and restoration, which should be known and agreed upon beforehand by stakeholders.
Why: In order to work strategically and optimally.

Success Level

What: The aim of the project should be clear from the beginning. Including what success orientation for restoration, this project follows.
Why: It is hard to evaluate if a project is successful without stating what it aims to do beforehand.

What: Restoration goals should highlight the functionality and structure of an ecological system.
Why: Historic state success orientation is not the strongest success for restoration and therefore higher resilience is more optimal.

What: The vision should not be limited to only increase biodiversity, but should be more adapted to the specific site and best solutions should be selected for the area.
Why: Biodiversity is a pivotal success factor for most restoration projects. However, this is not necessarily the most appropriate for every site. For example, some quarry sites have very sensitive environments and it may be difficult to increase biodiversity in such an area. In this case, another goal should be taken into consideration. One of the solutions could be building a hotel in this area. The benefits of doing this are that there will be no need to destroy another area in order to build a hotel and the surrounding area will also need to be restored to a certain degree in order to make the place attractive. Moreover, this kind of solution would bring economic and social benefits, see section 1.2.

The interviews show that the eight SP's acting as boundaries of success can be difficult to understand and use without having a deep understanding of them. Below is a slightly altered formulation of the SPs in order to more specifically be applicable and relevant for the quarry industry.

In a sustainable society, the environment is not subject to exponential increases in

1) Concentration of substances extracted on site, meaning that the materials (final products and wastes) are handled in a controlled manner so that they do not spread in ecosystems

2) Concentrations of substances produced by society, meaning that substances created by society, such as pesticides, are only used in a controlled manner so that they do not spread in ecosystems

3) Degradation by physical means, meaning that habitats and species are not destroyed through the activity.

People are not subject to structural obstacles to

4) Health, such as safety of workers and visitors on site,

5) Influence, such as involving more local people into the process,

6) Competence, such as making sure employees has opportunities for contributions to the project,

7) Impartiality, such as the choice of stakeholders involved is not based on demographic reasoning, and

8) Meaning-making, such as connecting the project to the bigger socio-ecological system to bring meaning and pride to employees work.

Strategic Level

What: Backcasting from the success orientation (vision) should be used.
Why: Backcasting helps keep actions in line towards the vision but also is flexible for incorporating better future technologies as the project progresses.

What: Goals and actions need to be aligned with the vision.
Why: In order to be progressing towards the desired outcome and to ensure long-term success.

What: A process in how to prioritize actions according to the SPs, vision, and to criteria best suitable for the site should be developed.
Why: Criteria and planned prioritization is part of good strategic planning. For example, other types of return on investment should be considered that would help with other actions. This could include the aesthetics of a small area, getting locals motivated about the project which leads them to donate, which helps finance more expensive actions.

Actions Level

What: To create and map out the action plan visually to show which stages overlap and which stages are interdependent. If a standard list of actions is used, it is recommended that these only be the starting point and be tailored to the specific site.
Why: This recommendation stems from the evident lack of a complete understanding of linkages between essential stages beneficial in planning for complex issues. Further, a standard list of actions is not always great in order to optimize results for the unique characteristics of the different sites.

Tools Level

What: A stronger dialogue between the hired experts and the managers with regards to what tools are most suitable are encouraged.
Why: The tools included in restoration guidelines today are limited in function and there are not tools for every stage of the process suggested. Part of being strategic means using the best available tools for the situation. This will aid in being efficient in reaching the goals, and therefore be successful.

5 Conclusion

Quarry restoration can be a significant part of the movement towards sustainability. The industry has both ecological and social impacts and it's final products play an imperative role in the high standard of living around the world. Restoration can lower the impacts during the operations and also ensure that the end-of-life has ecosystem services, social value, or both. There is no reason for a degraded environment to be left to spread its pollutants when a restoration project investment can yield benefits across the board. Improving restoration guidelines for quarries is a step in the right direction for opening the walls of the funnel.

This thesis set out to answer the secondary question of, 'To what degree do current restoration guidelines take a strategic perspective on sustainability?' which lead to the primary question, 'In which ways could an SSD approach enhance quarry restoration guidelines?' As this study showed, there are gaps that could be improved in order for a more strategic and sustainable-based restoration process. For a full overview of the gaps found in the study refer to sections 3 and 4.

5.1 To what degree do current restoration guidelines take a strategic perspective on sustainability?

Some guidelines talk about vision and all of them talk about goals. However, none of them help you prioritize actions, explain that the actions should lead you to the vision, and very few offered any sort of follow-up or tools for measuring progress. Visions and goals were often very narrow in scope, which could be problematic for long-term success since these may not be the most important things in 50 years. For example, the social goals mainly focused on legal requirements but in 50 years the permits could have stayed relatively the same but the environmental problems could have exceeded many dangerous thresholds, meaning the permit was not the level that is necessary to make real change happen.

These results clearly show that guidelines are not strategic enough in terms of supporting the restoration practitioners effectively towards sustainable development. Some guidelines partially met strategic criteria but overall no guideline encompassed all aspects of the FSSD.

5.2 In which ways could a SSD approach enhance quarry restoration guidelines?

SSD elements were seen in nearly all guidelines and mentioned in all interviews but none of these data sources covered all aspects of SSD. This suggests that they are, for the most part, on the right way but their approach just needs some fine-tuning at the FSSD levels. To add to the critical issue of getting it right from the first place, the critiques of restoration being ad hoc, without consideration of its wider application, speaks in favour of an SSD approach to be included.

An SSD approach can enhance guidelines by incorporating all of the recommendations depicted in section 4.4.2 under all five levels of the FSSD. Some of these include having clear connections to the sustainability challenge to show its relevance and significance for sustainability and having the eight SPs as overarching boundaries for success. These were all concluded to be gaps in some or all of the interviews and guidelines. Incorporating these recommendations would fill these gaps aiding in the practitioner's ability to be strategic and have long-term

success within sustainable limits. Misinterpretations and other inconveniences of the guidelines would expectantly lower.

Language use. There is still the issue with the language used, however, with an all-encompassing framework this problem can, to some extent, be mitigated. Further, as shown, incorporating an SSD approach into restoration guidelines will inevitably help in the planning for restoration as a complex problem.

Goals and success. As mentioned in sections 1.3 and 3, in order for restoration to contribute to a solution for environmental problems, there is a need for multiple clear, and articulate goals. These need to highlight the functionality and structure of an ecological system and take into account the dynamic nature of the socio-ecological system.

Furthermore, the issue with the definition of success and to restore a damaged ecosystem to an ecological state located within acceptable limits, which allows that ecosystem to function (Hobbs 2014) would be more in line with sustainability thinking then to restore to a historic state. Restoration of ecological processes rather than structures should also be highlighted. However, the most appropriate goal for restoration, with regards to sustainability, is to bring back the ecosystem to a certain level of resilience with the aim to enhance the adaptive capacity according to both a literature review and opinions from the restoration experts in the field.

By incorporating sustainable boundary conditions to the definition of successful restoration, it can minimize the problems occurring when attempting to move society further towards sustainability. Table 3.1. illustrated that there are gaps and a lack of clarity in the guidelines that could potentially lead to violations. It is this reasoning that lead to the conclusion that the SPs would be strong over-arching principles to use when deciding on which actions best meet their own goals, principles, actions, and so on. Having boundaries for success would help mitigate potential negative environmental and social consequences from lack of guidance with action choice from the guidelines.

The SSD makes sure that both a sociological and ecological perspective is brought into consideration. This approach would include and facilitate a higher awareness over the social influences, which were concluded to be the most essential factors to having a successful restoration project.

Strategic guidelines. An SSD approach could also enhance restoration guidelines by aiding the practitioners in strategic planning by showing the crucial steps for successful restoration plans or introducing strategic planning tools as for example the ABCD process.

References

Almefelt, Monica Soldinger, Martin Lagerkvist, Susan Enetjärn, Sonja Preuss, Nic Kruys, and Anders Enetjärn. 2015. *HANDBOK: INSPIRATION TILL ATT SKAPA BRA NATUR I TÄKTER ÅTGÄRDER UNDER DRIFT OCH I SAMBAND MED EFTERBEHANDLING*. Enetjärn Natur.

Aronson, James, Andre F. Clewell, James N. Blignaut, and Sue J. Milton. 2006. 'Ecological Restoration: A New Frontier for Nature Conservation and Economics.' *Journal for Nature Conservation* 14 (s 3–4). Elsevier. doi:10.1016/j.jnc.2006.05.005.

Aronson, James, James N. Blignaut, Suzanne J. Milton, David Le Maitre, Karen J. Esler, Amandine Limouzin, Christelle Fontaine, et al. 2010. 'Are Socioeconomic Benefits of Restoration Adequately Quantified? A Meta-Analysis of Recent Papers (2000-2008) in Restoration Ecology and 12 Other Scientific Journals.' *Restoration Ecology* 18 (2). Wiley-Blackwell: 143–54. doi:10.1111/j.1526-100x.2009.00638.x.

Blignaut, James, James Aronson, and Rudolf de Groot. 2014. 'Restoration of Natural Capital: A Key Strategy on the Path to Sustainability.' *Ecological Engineering* 65 (April). Elsevier: 54–61. doi:10.1016/j.ecoleng.2013.09.003.

Broman, Göran, John Holmberg, and Karl-Henrik Robèrt. 2000. Simplicity without reduction: Thinking upstream towards the sustainable society. *Interfaces* 30, no. 3: 13-25.

Cement Sustainability Initiative (CSI): Guidelines on Quarry Rehabilitation. 2011. Wbcsd.

Choi, Young D. 2004. 'Theories for ecological restoration in changing environment: Toward 'futuristic' restoration. *Ecological Research* 19: 75-81.

Choi, Young D. 2007. 'Restoration Ecology to the Future: A Call for New Paradigm.' *Restoration Ecology* 15 (2). Wiley-Blackwell: 351–53. doi:10.1111/j.1526-100x.2007.00224.x.

Choi, Young D, Vicky M Temperton, Edith B Allen, Albert P Grootjans, Melinda Halassy, J Richard, M Hobbs, Anne Naeth, and Katalin Torok. 2008. 'Ecological Restoration for Future Sustainability in a Changing Environment.' *Écoscience* 15 (1): 53–64. doi:10.2980/1195-6860(2008)15[53ERFFSI]2.0.CO;2.

Clewell, Andre, John Rieger, and John Munro. 2005. *Guidelines for Developing and Managing Ecological Restoration Projects*. 2nd ed. Society for Ecological Restoration International. www.ser.org.

Costanza, Robert, Ralph D 'arge, Rudolf De Groot, Stephen Farberk, Monica Grasso, Bruce Hannon, Karin Limburg#, et al. 1997. 'The Value of the World's Ecosystem Services and Natural Capital.' *NATURE* 387 (15). http://www.esd.ornl.gov/benefits_conference/nature_paper.pdf.

Crow, James Mitchell. 2008. “The Concrete Conundrum.” *Chemistry World*, February, 62–66. http://www.rsc.org/images/Construction_tcm18-114530.pdf.

Davis, Mark A, and Lawrence B Slobodkin. 2004. ‘The Science and Values of Restoration Ecology.’ *Restoration Ecology* 12 (1): 1–3. doi:10.1111/j.1061-2971.2004.0351.x.

Dodds, Walter K., Kymberly C. Wilson, Ryan L. Rehmeier, G. Layne Knight, Shelly Wiggam, Jeffrey A. Falke, Harmony J. Dalgleish, and Katie N. Bertrand. 2008. ‘Comparing Ecosystem Goods and Services Provided by Restored and Native Lands.’ *BioScience* 58 (9). Oxford University Press (OUP): 837. doi:10.1641/b580909.

‘EverestEvRest.’ 2016. Accessed February 24. http://www.reno.is/Pages/2614.

Forbes, B. C., and J. D. McKendrick. 2002. Polar tundra. Pages 355-375 *in* M. R. Perrow, and A. J. Davy, editors. *Handbook of ecological restoration. Volume 2. Restoration in practice*. Cambridge University Press, Cambridge.

García-Serna, J, and M J Cocero. 2008. “Fig. 3. The Natural Step Metaphor of the Funnel.” https://www.researchgate.net/figure/222532758_fig3_Fig-3-The-natural-step-metaphor-of-the-funnel.

Gunderson, Lance, C S Holling, Brian Walker, Thomas Elmqvist, Steve Carpenter, and Carl Folke. 2009. ‘Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations.’ *AMBIO: A Journal of the Human Environment*. Royal Swedish Academy of Sciences. March 11. doi:10.1579/0044-7447-31.5.437.

Hagen, Dagmar, and Marianne Evju. 2013. ‘Using Short-Term Monitoring Data to Achieve Goals in a Large-Scale Restoration.’ *Ecology and Society* 18 (3). Resilience Alliance. doi:10.5751/es-05769-180329.

Hawken, Paul. 2010. ‘Ecology of Commerce: A Declaration of Sustainability | Clc.’ New York: Harper Business. http://library.wur.nl/WebQuery/clc/1948967.

HeidelbergCement. 2014. *Promotion of Biodiversity at the Mineral Extraction Sites of HeidelbergCement*.

Hem, Priyadarshi. 2012. “Open Pit Mining and Quarrying.” *TechnoMine Mining Technology*. November. http://technology.infomine.com/reviews/pitsandquarries/welcome.asp?view=full.

Hobbs, Richard J. 2014. *Foundations of Restoration Ecology*. Edited by Margaret A Palmer, Joe B Zedler, and Donald A. Falk. Washington, D.C.: Island Press.

Hobbs, Richard J., and David A. Norton. 1996. “Towards a Conceptual Framework for Restoration Ecology.” *Restoration Ecology* 4 (2). Wiley-Blackwell: 93–110. doi:10.1111/j.1526-100x.1996.tb00112.x.

Holmberg, John, and Karl-Henrik Robèrt. 2000. 'Backcasting from Non-Overlapping Sustainability Principles — a Framework for Strategic Planning.' *International Journal of Sustainable Development and World Ecology* 7: 291–308.

Hull, R. B., and D. P. Robertson. 2000. The language of nature matters: we need a more public ecology. P 97-118 in Gobsters and Hull, editors. *Restoring nature: perspectives from the social sciences and humanities.* Island series. Wildlands CPR, Missoula, Montana. USA.

Kajikawa, Yuya. 2008. 'Research Core and Framework of Sustainability Science.' Sustainability Science 3 (2). Springer Science + Business Media: 215–39. doi:10.1007/s11625-008-0053-1.

Kates, R. W., W. C. Clark, R. Corell, J. M. Hall, C. C. Jaeger, I. Lowe, J. J. McCarthy, et al. 2001. Environment and development. Sustainability science. *Science (New York, N.Y.)* 292 (5517): 641-2. doi:10.2139/ssrn.257359.

Keenleyside, Karen, Nigel Dudley, Stephanie Calrns, Carol Hall, and Sue Stolton. 2012. *Ecological Restoration for Protected Areas: Principles, Guidelines and Best Practices*. Edited by Peter Valentine. 18. IUCN WCPA.

Langer, William H. 2001. 'Potential Environmental Impacts of Quarrying Stone in Karst— A Literature Review.' *U.S. Department of the Interior U.S. Geological Survey*. This publication is only available online at: http://geology.cr.usgs.gov/pub/ofrs/OFR-01-0484/.

Lim, Wendy, Donald M Arnold, Veronika Bachanova, Richard L Haspel, Rachel P Rosovsky, Andrei R Shustov, and Mark A Crowther. 2008. "Evidence-Based Guidelines—An Introduction." *ASH Education Program Book* 2008 (1). American Society of Hematology: 26–30. doi:10.1182/asheducation-2008.1.26.

McCandless, Catherine. 2013. *NO LONGER JUST A HOLE IN THE GROUND the Adaptive Re-Use of Resource Depleted Quarries*. http://www.mit.edu/people/spirn/Public/Ulises-11-308/Quarrying.pdf. Date accessed: 11.05.2016

MEA - Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Missimer, Merlina, Karl-Henrik Robèrt, and Göran Broman. 2016. "A Strategic Approach to Social Sustainability – Part 1: Exploring the Social System." *Journal of Cleaner Production*, April. Elsevier BV. doi:10.1016/j.jclepro.2016.03.170.

Nilsson, Christer, and Ása L. Aradóttir. 2013. 'Ecological and Social Aspects of Ecological Restoration: New Challenges and Opportunities for Northern Regions.' *Ecology and Society* 18 (4). Resilience Alliance. doi:10.5751/es-06045-180435.

Palmer MA, Bernhardt ES, Allan JD, Lake PS, Alexander G, et al. 2005. Standards for ecologically successful river restoration. *J. Appl. Ecol.* 42:208–17

'Planetary Boundaries 2.0 – New and Improved - Stockholm Resilience Centre.' 2015. January 15. http://www.stockholmresilience.org/21/research/research-news/1-15-2015-planetary-boundaries-2.0---new-and-improved.html.

Robèrt, Karl-Henrik. 2000. Tools and concepts for sustainable development, how do they relate to a general framework for sustainable development, and to each other? *Journal of Cleaner Production* 8, no. 3: 243-254.

Rockström, Johan, Will Steffen, Kevin Noone, Åsa Persson, F. Stuart Chapin, Eric F. Lambin, Timothy M. Lenton, et al. 2009. 'A Safe Operating Space for Humanity.' *Nature* 461 (7263). Nature Publishing Group: 472–75. doi:10.1038/461472a.

Savin-Baden, Maggi, and Claire Howell Major. 2012. *Qualitative Research: The Essential Guide to Theory and Practice*. New York: Routledge.

Society for Ecological Restoration International Science & Policy Working Group. 2004. *The SER International Primer on Ecological Restoration*. www.ser.org &Tucson: Society for Ecological Restoration International.

Standish, Rachel J, Michael D Craig, Todd E Erickson, Michael P Perring, Richard J Hobbs, Katinka X Ruthrof, Jodi N Price, Andrew S Whiteley, and Leonie E Valentine. 2015. 'Advances in Restoration Ecology: Rising to the Challenges of the Coming Decades.' Ecosphere 6 (8). Ecological Society of America: 1–25. doi:10.1890/ES15-00121.1.

Steffen, W., K. Richardson, J. Rockstrom, S. E. Cornell, I. Fetzer, E. M. Bennett, R. Biggs, et al. 2015. 'Planetary Boundaries: Guiding Human Development on a Changing Planet.' *Science* 347 (6223). American Association for the Advancement of Science (AAAS): 1259855–1259855. doi:10.1126/science.1259855.

Suding, K. 2011. Toward an Era of Restoration in Ecology: Successes, Failures, and Opportunities Ahead. *Annual Review of Ecology, Evolution, and Systematics.* 42:465–87. Doi:10.1146/annurev-ecolsys-102710-145115.

Tropek, Robert, Tomas Kadlec, Petra Karesova, Lukas Spitzer, Petr Kocarek, Igor Malenovsky, Petr Banar, Ivan H. Tuf, Martin Hejda, and Martin Konvicka. 2010. 'Spontaneous Succession in Limestone Quarries as an Effective Restoration Tool for Endangered Arthropods and Plants.' *Journal of Applied Ecology* 47 (1). Wiley-Blackwell: 139–47. doi:10.1111/j.1365-2664.2009.01746.x.

Turner, Katrine Grace, Sharolyn Anderson, Mauricio Gonzales-Chang, Robert Costanza, Sasha Courville, Tommy Dalgaard, Estelle Dominati, et al. 2015. 'A Review of Methods, Data, and Models to Assess Changes in the Value of Ecosystem Services from Land Degradation and Restoration.' *Ecological Modelling* 319 (319): 190–207. doi:10.1016/j.ecolmodel.2015.07.017.

Ukpong, E.C. 2012. ‘Environmental Impact of Aggregate Mining by Crush Rock Industries in Akampa Local Government Area of Cross River State.’ *Nigerian Journal of Technology* 31 (2): 128–38.

Urich, Peter B. 2002. ‘Land Use in Karst Terrain: Review of Impacts of Primary Activities on Temperate Karst Ecosystems.’ *New Zealand Department of Conservation*, no. 198 (June).

Appendices

Appendix A: Planetary Boundaries (PBs)

Planetary boundaries were considered to be used in conjunction to the eight SPs to illustrate urgency, however due to time could not be investigated thoroughly. The following paragraph is the introduction to them and their relevance for restoration.

The planetary boundaries concept has been developed to define a safe operating space for humanity. It represents nine planetary boundaries within which humanity should operate in order to support economic growth and human development and to avoid the disruption of the Earth system stability (Steffen et al. 2015). The nine planetary boundaries are: climate change; change in biosphere integrity (biodiversity loss and species extinction); stratospheric ozone depletion; ocean acidification; biogeochemical flows (phosphorus and nitrogen cycles); land-system change (for example deforestation); freshwater use; atmospheric aerosol loading (microscopic particles in the atmosphere that affect climate and living organisms); introduction of novel entities (e.g. organic pollutants, radioactive materials, nanomaterial, and micro-plastics).

So far, four of nine planetary boundaries have been crossed as a result of human activities they are: climate change, loss of biosphere integrity, land-system change, altered biogeochemical cycles (‘Planetary Boundaries 2.0 – New and Improved - Stockholm Resilience Centre’ 2015). It is important to incorporate Planetary Boundaries framework into sustainability planning since it shows urgent problems and high risks for the planet, on which society should take immediate actions.

Appendix B: FSSD comparison to guidelines summary table

FSSD Level	Strengths (A summary of all 5 guidelines)	Gaps (A summary of all 5 guidelines)
System Some gaps, according to the FSSD, that appeared in guidelines included: No connections made to the larger socio-ecological system, sustainability challenge, or bigger picture; did not help the reader understand the system of study; and biased writing for the particular industry. However not all of these occurred in every guideline. The IUCN guideline made very strong connections at the systems level to the larger socio-ecological system, the sustainability challenge and avoided biased language (Keenleyside et al. 2012).	- Biodiversity and its importance is mentioned frequently. - Benefits from restoration are clearly illustrated. - Discussed that the reason for restoration is our obligation to nature. - Why, when, and how to restore are introduced. - Restoration is placed in the bigger Earth context. - Can be applied to different sectors and ecosystems. - Connections to the sustainability challenge, bigger system and planetary boundaries.	- No connections made to the larger socio-ecological system, sustainability challenge, or bigger picture. - Does not help the reader understand the system of stud. - No references (cited or incited). - Biased authors, clearly using biased language in the exaggerated promotion of their own clients/industries. . - Problematic for being strategic and long term planning.
Success Most of the guidelines had some elements of strong success in relation to sustainability and restoration. For example, the HeidelbergCement guideline success criteria included: after-use of a site must be long-lasting, safe for humans, efficient,promote biodiversity and sustainable (HeidelbergCement 2014).However none had success defined clearly enough to avoid sustainability violations in the process. Some of these recurring gaps about the success criteria included: Did not cover full sustainability as defined by the FSSD; potential for sustainability violations in how goals are reached due to room for misinterpretation, and lack of overarching guiding principles of success; narrow scope; no clear definition of success for restoration; and their own success principles were overlapping.	- Resilience, functions, services are success matrixes rather than physical features. - Success is beyond the boundaries of the working quarry area. - Success is long-term. - Success is reached by obtaining principles. - Health, integrity, promote and conserve biodiversity are all common principles throughout all guidelines. - After use success defined as: human friendly, long lasting, sustainable, and efficient. - Blended into surroundings on the site (The site should not be abrupt in its environment, there needs to be a buffer/transition zone). - Raising biodiversity is a repetitive and strongly reinforced factor of success along all 5 guidelines. - Each habitat type has an unique definition of success.	- Does not cover full sustainability as defined by the FSSD. - Potential for sustainability violations in how goals are reached due to room for misinterpretation, and lack of overarching guiding principles of success. - Narrow scope. - The key success criteria in some guidelines were best for business: saving time, resources, money etc. However these criteria without social or ecological boundaries are more likely to lead to violations in sustainability. One such example is a guideline that showed a case study that used pesticides to save time and resources. - No clear definition of success for restoration. - No sustainability success criteria. - Their own success principles are overlapping. - For the FSSD, SP1, and SP2 not directly/explicitly talked about in some guidelines.
Strategy Similar to all the levels there were guidelines that had strong connections to this level. For the SER guideline it used both forecasting and backcasting and included public participation throughout the process (Clewell, Rieger, and Munro 2005). However, there were also recurring gaps in	- They document the entire process because of their belief that documentation leads to honesty and transparency. - Incorporate environmental sustainability into planning process. - Highlight the importance of making a plan. - Have connections from goals to actions. - Plan should include actions that are short	- No clear prioritization criteria/ questions. - Potential violations in reaching goals. - No urgency presented. - Does not integrate full sustainability into guidelines. - Extremely generic. - No descriptions/clarifications on what certain aspects mean.

the guidelines: No prioritization criteria; does not integrate all SPs into guidelines; does not tell the practitioners how to incorporate principles into the planning; lack of interlinkages between actions and goals, actions and vision, etc; no potential magnitude of certain impacts or urgency; and no follow up guidance. The lack of prioritization criteria and urgency reinforces the benefits from incorporating the PBs into the guidelines.	and simple. -Principles, guidelines, processes, best practices, and a framework for planning are included. - Biodiversity, stakeholders, cultural values were key in most guidelines for the strategy. -Incorporate principles into guidelines - Easy to follow. - Takes into account non-linearity and complexity thinking.	- No strong ideas for strategic prioritization. - SSPs not covered. - Does not tell you how to incorporate principles into the planning. - No follow up guidance. - No potential magnitude of certain impacts, makes it difficult for a practitioner to prioritize high risk areas.
Actions The most recurring gaps with this level included: Generalizations and lack of clarity left room for misinterpretation and violations; no restrictions or boundaries for actions; limited scope, and actions only covered one specific success criteria. The Handbok guideline had the following strengths in this level: actions were connected to both goals and habitats; and had an entire chapter dedicated to actions including descriptions of which and how actions are appropriate under particular contexts (Almefelt et al. 2015).	- Contains Key Performance Indicators (KPIs). - Promotes dialogue around deciding on actions with stakeholders. - No habitats excluded from action plan. - Which and how actions are appropriate illustrated. - Guidelines' principles and actions can be followed to goals and habitats. - Actions can be made from their framework. - Actions for each stage of the process and habitat type provided. - General applications possible. - Room for adaptability. - Actions help move towards sustainability. - Includes 'What not to do' actions, which could be vital in avoiding sustainability violations. - Actions recommended for both currently operational sites and after-use of sites.	- Room for misinterpretation and violations. - Many generalizations. - No guidance on how to do actions, no directions. - No 'what not to do' actions presented. - Limited scope, actions only cover one specific success criteria. This is most commonly actions specifically targeting biodiversity. - Not strategic, full sustainability not covered. - Does not mention when to use actions presented. - Lack of interlinkages between actions and goals, actions and vision, etc.
Tools Overall this level was not covered at all for the majority of the guidelines. Three of five had no recommended tools along any of the stages of restoration. The CSI guideline was one of the two guidelines that included recommended tools to aid the practitioner. Two of these examples were ESR (Corporate Ecosystem Service Review), and ESIA for evaluating and managing all impacts of a site and describing the context of project (*Cement Sustainability Initiative (CSI): Guidelines on Quarry Rehabilitation* 2011).	- Recommends tools along all stages of restoration with different levels (monitoring, communication, etc).	- Very limited tools, no tools, or tools that are not applicable/useable.

Appendix C: Interview Results For Overall Better Understanding of The System

Systems Level
There was no clear and uniform definition of what the geographical boundaries are. All that interviewed experts agreed upon was that it is a working area as a minimum. Two made reference to the affected area or permit area. Directly affected areas were common in all definitions but indirectly affected areas were only in two. Five said that the geographic boundaries of restoration depend on the project.

Similarly, the opinion about the time boundaries also varied. Three conveyed that restoration should be planned from the beginning and go throughout the entire project, like one of the consultants said, "It should stop when the license period expires and it starts maybe really quite early, already when the thinking/planning starts. It should really already be there from the beginning when you begin the quarry" (Interviewee 6, 2016). Two interviewees mentioned the permit timeline being what should be followed. One expert considered that it is dependent on the timeline of the project. For example, if it is a short timeline of 10 years the restoration can start from the beginning. If there is a 30-year long timeline it should start after operations are done because of the big changes in the environment that will occur during that time. Another expert communicated that it depends on the type of habitat that it is restored to. For example, if the quarry is going to be restored to a lake afterwards the restoration should start after the operations end. If it is going to be restored for land use it should be a continuous restoration process in conjunction with quarry operations.

Success Level
In regards to internal versus external expectations of stakeholders, all of the interviewees seemed more or less consistent with each other. The main message here was that in order to balance these expectations communication is key. Compromising is a useful tool, but should be done with caution so that the project does not lose its integrity along the way. As one interviewee identified, “[...] compromising of external and internal goals for the project can become controversial” (Interviewee 6, 2016).

Appendix D: Importance for scientific grounding in goals, supporting the FSSD

Only one interviewee mentioned the importance of basing goals on what would be best from an environmental science perspective and this referral was indirectly made. It is clear that using the FSSD could aid in having scientific validity to support the project goals. When reading the actual guidelines for restoration in quarries, the majority of them do have goals with clear evidence of scientific support. For example, biodiversity goals came up in both guidelines and interviews from everyone. The value of this has been documented by multiple scientific journals and is showcased in the background of this thesis.

The importance of these goals and actions having scientific grounding is also crucial considering that a recurring comment from the interviewees implies that they would use the cheapest means necessary to fulfill these. This assumption comes from multiple statements made along the lines of them not caring what happened during the restoration activities so long as stakeholders were satisfied and it did not interfere with operations. The cheapest methods and best available technologies do not often overlap with each other.

Appendix E: Interview Questions

1. What is your job title?
    a. Can you give us a short description of what you do/your responsibilities?
    b. To what extent does your job require you to work directly with restoration?
2. What is your definition of restoration?
3. When a site is fully restored, what goals or objectives have been achieved?
4. Is there more included in defining a successful restoration project outside of reaching these goals? This will be referred to as your success criteria from now on.
5. Can you describe an example of a restoration project that met your success criteria?
6. Can you describe an example of a restoration project that did not meet all of your success criteria?
7. Do you have a working definition of sustainability?
8. For the understanding of the contexts of the restoration project, is it important to see the connections between ecological impacts and social impacts?
9. How do you define the geographical boundaries in a typical restoration project?
10. During the lifetime of a quarry when does restoration typically start and end?
11. When is the transition from restoration into environmental management?
12. Can you briefly describe what guidelines and frameworks are used by you/ your organisation when doing a restoration project?
    a. In your opinion what are the key pros and cons with the guidelines you are currently using?
    b. Have there been misinterpretations of guidelines that led to problems?
    c. Can you give examples?
    d. Do you suggest any further guidelines?
13. Can you briefly describe what procedures and/or processes are used by you or your company when doing a restoration project?
    a. Do you include a vision for each specific restoration project?
    b. How do you develop goals/objectives for the restoration project?
14. What tools are typically used in restoration projects?
15. What stages of the restoration process are essential to reaching your successful restoration criteria?
16. How do you prioritize between actions?

Appendix F: Interviewees number and job title table

Interviewee #	Job title/Role
1	Environmental Engineer
2	Ecology Professor + Consultant
3	Conservation Consultant
4	Environmental Manager
5	Quality & Environmental Manager
6	Consultant/ Project Manager

Appendix G: Initial Impression from interviews

The overall impression for the interviews varied with the person interviewed. Some of the interviewees were well prepared and confident in answering the questions. They provided valuable insight to nearly every inquiry. Others were not as well prepared and had difficulties to answer some questions or they did not answer to the point. People in consulting were more open and natural in their answers than environmental engineers/managers. Everyone directly working for company 1 were occasionally robotic in their answers and felt very biased towards their work place.

Appendix H: Is restoration the best solution?

As seen in section 1.2., ecologically focused restoration is not necessarily the only or best solution when aiming towards sustainability. This became apparent through the numerous other terminologies used for similar processes of environment treatment both during and after operations. After-use, which is also described in section 1.2, is another solution to be considered for a site depending on its applicability and the sensitivity of the habitats. After-use, like restoration, yields a variety of economic, social, and environmental benefits. In particular it is more appropriate for increasing public acceptance of quarrying, transforming degraded areas into new sustainable land uses, and having a larger focus on human usability of the area.

THE QUARRY LIFE AWARD

HEIDELBERGCEMENT

Project tags (select all appropriate):

This will be use to classify your project in the project archive (that is also available online)

Project focus:

- x Biodiversity management
- ☐Cooperation programmes
- ☐Education and Raising awareness
- ☐Endangered and protected species
- ☐Invasive species
- x Landscape management - rehabilitation
- x Rehabilitation
- ❑ Scientific research
- ☐Soil management
- ☐Urban ecology
- ☐Water management

Flora: (Not exclusive)

- X Conifers and cycads
- X Ferns
- X Flowering plants
- X Fungi
- X Mosses and liverworts

Fauna: (Not exclusive)

- x Amphibians
- x Birds
- x Dragonflies & Butterflies
- x Fish
- x Mammals
- x Reptiles
- x Spiders
- x Other insects
- x Other species

Habitat: (Not exclusive)

- x Cave
- x Cliffs
- x Fields - crops/culture
- x Forest
- x Grassland
- x Human settlement
- x Open areas of rocky grounds
- x Recreational areas
- x Screes
- x Shrubs & groves
- x Soil
- x Wander biotopes
- x Water bodies (flowing, standing)
- x Wetland

Stakeholders:(Not exclusive)

- x Authorities
- x Local community
- x NGOs
- x Schools
- x Universities