ASSESSING THE PERFORMANCE OF ECOLOGICAL COMPENSATION IN SWEDEN

A COMPARATIVE CASE STUDY OF AN EMERGING TOOL IN DIFFERENT CONTEXTS
ABSTRACT

The concept of ecological compensation (EC) assumes that ecological values are substitutable across spatial units. EC is increasingly recognised in Sweden as a novel policy instrument for land-use planning, however, it suffers from inconsistency in application and outcome. For example, there are no legal provisions to require EC for urban development or new roads and railways. This study shows that there are many context dependent variables affecting the performance of EC in Sweden, which can partly be explained by authorities’ lacking experience in administrating these questions, and by the absence of a standardised structure for handling the full EC process. These shortcomings together with an inadequate legislation may cause EC to result in “license-to-trash” and fails to guarantee no net loss of ecological values. The performance of EC in Sweden was assessed through two case studies: the Sigtuna trading estate and the Aitik mine expansions. Implementation procedures and compensation designs were investigated by analysis of written documents and semi-structured interviews. The data was structured in an analytical framework, displaying similarities and context dependent disparities. The results suggest that, for the Aitik-case, licence-to-trash is a risk if compensation schemes are reviewed by the regulatory authorities during the processing of the application. The Sigtuna case suggests, opposed to earlier findings, that the Plan and Building Act can be utilised for EC if the compensation measures are regulated in a development agreement between the municipality and the landowner/developer. Both cases suggest that additionality can be met by appropriate institutional design, whereas no net loss of biodiversity and ecosystem services hardly can be achieved within the existing Swedish legal framework. To improve the performance of EC, structures for handling the process from quantification of social and ecological values, to monitoring of compensation outcomes must be implemented in all development projects affecting nature.
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<tbody>
<tr>
<td>BBOP</td>
<td>Business and Biodiversity Offset Programme</td>
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<td>CAB</td>
<td>County Administrative Board</td>
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<td>EC</td>
<td>Ecological Compensation</td>
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<td>EIA</td>
<td>Environmental Impact Assessment</td>
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<td>ES</td>
<td>Ecosystem Services</td>
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<td>EV</td>
<td>Ecological Values</td>
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<td>LEC</td>
<td>Land and Environmental Court</td>
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<td>LECA</td>
<td>Land and Environmental Court of Appeal</td>
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<td>NNL</td>
<td>No Net Loss</td>
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<td>PBA</td>
<td>Plan and Building Act</td>
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<td>SEPA</td>
<td>Swedish Environmental Protection Agency</td>
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<td>SLU</td>
<td>Swedish University of Agricultural Sciences</td>
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1. Introduction

In the Anthropocene, human activities keep altering the planet at a geological scale (Waters et al., 2016), pushing at the planetary boundaries for our safe and sustainable existence (Castree, 2017; Folke et al., 2016). As a result, the conflict between environmental conservation and human land-uses intensifies, and the planet’s stock of natural capital continues to diminish (Tilman et al., 2011). Decrease in biodiversity is mainly caused by habitat loss (Balmford & Bond, 2005), and as green areas, both in proximity to urban areas and in the countryside, are subjected to development, ecosystem services are likely to become altered or lost (Colding et al., 2013).

In order to halt this erosion of ecological values, the European Commission has stipulated an initiative for “No Net Loss (NNL) of Biodiversity and Ecosystem Services”, where ecological compensation (EC) is a considered policy instrument (European Commission, 2011). EC, or biodiversity offsets, has also been identified by the Convention on Biological Diversity as one of five “Innovative Financial Mechanisms” to sustain biological diversity (CBD, 2011). The Business and Biodiversity Offsets Program (BBOP) is another internationally strong advocate for this tool (BBOP, 2012). EC is a broader term than “biodiversity offsets”, as the former include not only the spatial offset itself but also the compensatory measures (Conway et al., 2013), which is why EC was chosen as central expression for this study.

Cuperus et al., (1999) defines EC as: “the substitution of ecological functions or qualities that are impaired by development”. An important criterion for EC is additionality. This means that the compensation, including restoration measures, would not have been conducted if it had not been part of a compensation scheme. In other words, the compensation must generate ecological values that would not have been restored or preserved otherwise (Ferraro & Pattanayak, 2006).

When development within the EU affects areas included in the Natura 2000 network, legal requirements for EC are clearly defined. Outside protected areas however, EC legislation is somewhat ambiguous and varies considerably between Member States (EFTEC et al., 2010a).

Compensating for ecological degradation is a complex issue. It is hard to perceive if the EC will result in NNL, as it is difficult to measure losses and gains, especially if the losses and gains concern different qualities. Furthermore, the effect of time lags (i.e. the time needed for compensation goals to be realised) makes the calculations of losses and gains uncertain (Maron et al., 2012). Several existing schemes have been reproved for not achieving their ecological goals, and concurrently posing social risks (Brown & Veneman, 2001; Curran et al, 2014; Gibbons & Lindenmayer, 2007).

An institutional risk specific for EC is that the presence of a compensation project might cause authorities to approve a project that would not otherwise have been permitted. In other words, EC could spill over into being a “license-to-trash” (McKenney & Kiesecker, 2010). This poses a significant risk, and there are studies suggesting this has already occurred in Sweden (Lerman, 2014, p. 75; Schultz et al., 2013). Among EC advocates (BBOP, 2009; EFTEC et al., 2010a), and scientists (Burgin, 2010; Clare et al., 2011; Hough & Robertson, 2009), there is a broad consensus that license-to-trash must be prohibited via solid regulations, if EC is to be become an effective tool for conservation of ecological values.

Despite these difficulties, legislation and practice for EC is currently being developed in multiple countries, Sweden being one of them (Koh, Hahn, & Ituarte-lima, 2017; SEPA, 2016). Presently, compensation practices in Sweden are rather ad hoc, determined via best professional judgment by involved civil servants and consultants (EFTEC et al., 2010b, p 88). This is due to both uncertainties
regarding legislative interpretations, and the fact that there has yet to be a nationally applicable method for weighing of losses and gains developed and standardised.

Due to the increased focus on EC in Sweden, the Swedish Environmental Protection Agency recently released a handbook (SEPA, 2016) on how to utilise EC nationally based on already existing legislation. Today though, there are still a limited number of cases where EC actually has been implemented. This study explores two recent cases in order to increase our understanding in relation to three key challenges identified above: license-to-trash, additionality, and quantification and comparison of losses and gains to determine NNL. The first case concerns mining, with an impact on hundreds of hectares of forest and wetlands. The second case is a small scale industrial development in the outskirts of Stockholm, were the restoration measures have had some years to mature.

1.1 Research questions
This study aims to explore via two case studies how EC is currently being applied in Sweden, and how it could be further developed to increase its efficiency as a conservation/development tool to meet the EU goal of NNL. Based on the critical issues identified above, three research questions are defined:

i) Does the ambiguous legislation regarding EC in Sweden impede the effectiveness of this tool, and does it enable licence-to-trash?

ii) What parameters are used to determine compensation measures?

iii) To what extent have additionality and NNL been achieved?
2. Theoretical Framework

2.1 The Value of Nature

Social and ecological systems are highly interconnected and cannot be understood in isolation from each other. They are therefore regarded as complex social-ecological systems (Berkes & Folke, 1998; Folke, 2006). For our wellbeing, humans are inseparably dependent on goods and services derived from nature. These benefits, coined as ecosystem services (ES), are for example food, fresh water, pollination, wood and areas for recreation (Watson et al., 2005).

A cornerstone of ES is biodiversity, at the genetic, species, and ecosystem level (Balvanera et al., 2006). Many ES are dependent on biodiversity; if the diversity decreases, ES are weakened, lessened or even lost (Daily et al., 2000). Biodiversity in itself however, is not considered an ES (Watson et al., 2005). Therefore, for the structure of this study, I use ecological values (EV) to embrace both ES and biodiversity. In this thesis, any natural features that have a value for human well-being [classical ES], including biodiversity, are termed EV. A surface supporting any kind of biogeochemical process has EV and is therefore here regarded as nature. Hence, NNL implies that when an area of nature is “developed”, the EV should be restored.

2.2 Ecological Compensation

The concept of EC assumes that EV are substitutable across spatial units. Meaning that actual or anticipated decrease of EV, caused by exploitation of natural resources, can be compensated for as to decrease, or even reverse, negative ecological impacts (Cuperus et al., 1999).

BBOP (2009) has developed a four-step framework called the mitigation hierarchy (Figure 1), which serves to operationalise EC (Conway et al., 2013; Tucker et al., 2013). In line with this hierarchy, developers should undertake:

1) **Avoidance**: meaning that negative environmental impacts should be avoided as far as possible. This implies careful selection of impact site so that areas supporting high EV are avoided as far as possible.

2) **Minimisation**: implies that during the development, measures should be taken to minimise the unavoidable negative impacts as far as possible.

3) **Restoration**: post development, on-site measures should be conducted as to restore degraded EV as far as possible.

4) **Compensation**: this last step is conducted off-site, to compensate for losses that could not be avoided, minimised or restored on-site, thus achieving a NNL of EV.
It is important to emphasise that EC is the last step in this hierarchy. Compensation should not be regarded as a way to place development in ecologically valuable areas, with the argument that the environmental degradation will be compensated for elsewhere. Only when the first three steps have been carefully considered, should the developer resort to EC to ensure NNL of EV, thus avoiding licence-to-trash (BBOP, 2009).

In order to achieve NNL of EV, measures can (ideally) either be focused on the same EV as degraded, called like-for-like compensation, or on EV perceived as more valuable in the given context, then referred to as like-for-better compensation (Benayas et al., 2009). Hence, the practice of EC presents an opportunity to increase an areas’ total bundle of EV (Net Positive Impact in Figure 1).

EC adheres to the polluter-pays-principle (OECD, 1972), transformed into a developer pays principle. The actor responsible for the decrease of EV, i.e. the developer conducting the project, is bound to bear both the economic and practical responsibility for compensation (Koh et al., 2017).

To calculate the scope of compensatory measures required, EV have to be spatially quantified for the impact and compensation sites respectively; preferably by using the same metrics to ensure comparability (Quétier & Lavorel, 2011). Quantification needs to consider the quality of EV in relationship to the area bearing them. Thus, NNL can be achieved by compensating with a spatially smaller area if it has a higher density of EV than the impact site, and vice versa (SEPA, 2016). BBOP (2009) e.g. has developed metrics applicable to the process of EC, which have been applied to one case of EC in Sweden so far. However, the process was considered complex and in the end, rather

Source: BBOP, adapted from Rio Tinto & Govt of Australia

Figure 1: Mitigation hierarchy, showing the four steps of avoidance, minimisation, restoration and compensation (BBOP, 2009).
non-transparent (Koh et al., 2017). In Sweden, there has yet to be a nation-wide applicable, quantification method developed.

The compensation per se can consist of active measures increasing EV, e.g. ecological restoration or intensification, creation of new habitats, or protection (e.g. establishment of nature reserves). To be considered as compensation though, measures conducted must create true conservation benefits in comparison to a scenario without EC. This criterion is called additionality. This could e.g. imply that the area secured for compensation would otherwise be threatened to undergo development or logging, reducing its EV (SEPA, 2016). See Figure 2 for examples of possible outcomes of additionality.

![Figure 2: A compensation meets the criterion of additionality if it generates a result where EV increase in comparison to a scenario without EC. Example A – D displays four scenarios of how EV can develop at a compensation site with or without EC. The EC generates additionally in all cases. Only A – C fulfil NNL.](image)

**A.** EV Increase with EC or decrease without it.

**B.** EV increase in both scenarios, however it does so faster and to a greater extent with EC, as the values are stagnant for a period without EC.

**C.** EV do not increase with EC. Instead it preserves values that would otherwise decrease. This can represent a scenario where an area threatened by development is given protection.

**D.** EV decrease in both scenarios, with EC however, the decrease is slower and minimised.

Adapted from SEPA (2016)
2.3 Legislative framework for EC in Sweden

In Sweden, EC is prescribed by law in three instances. Firstly, Chapter 16§9 of the Environmental Code apply to any kind of landscape harbouring traits perceived as valuable to people. Secondly, the Species Protection Ordinance, falling under the EU Habitats Directive, can also be applied to support EC in the “everyday landscape”. Finally, in the case that development affects protected nature areas (basically Natura 2000 sites and nature reserves), EC is demanded by Chapter 7 of the Environmental Code. Compensation projects however, tend to be ad hoc and lacking holistic ecological goals in favour of specific biodiversity values (Hägglund & Enetjärn, 2014, p. 9).

There is no clear national policy regulating EC with explicit focus on achieving NNL (Koh et al., 2017). Nevertheless, it is stated that any compensation should be “reasonable”, i.e. affordable enough for the developer as to not pose an economic threat to the project (SEPA, 2016). Hence, developers do not have to aim for NNL if the process is perceived as too costly. Normally, both transportation infrastructure and housing development (which is regulated under the Plan and Building Act (PBA)), are exempted from EC unless the development impacts on a protected area. However, as one of the cases reveals, the PBA offers a loophole.

According to Chapter 6 of the Environmental Code, the developer of a project is required to conduct an Environmental Impact Assessment (EIA). The EIA provides information on the developer’s responsibilities concerning the first three steps of the mitigation hierarchy, but rarely addresses the fourth step of compensation (Rundcrantz, 2006). The EIA then serves as a foundation for the legal approval of the project. If the approving authority (usually County Administrative Board (CAB) or Land and Environmental Court (LEC)) deem the presented first three steps as insufficient, they can require the developer to compensate. This is far from common practice and a review published by SEPA, (2015, p. 23) shows that of all decisions approved under the Environmental Code in 2011 – 2014, only 11.4% required EC.

There are strong tendencies indicating a growing demand for EC in Sweden. Authorities application of Chapter 16§9 and Species Protection Ordinance is increasing, and several municipalities are developing guidelines for EC (Hägglund & Enetjärn, 2014; Schultz et al., 2013, p. 233).

2.4 Decisive factors to assess

To design a policy framework that allows for EC to fill its intended purpose, i.e., offset loss of EV, several challenges must be overcome. Several authors acknowledge the risk of license-to-trash (Maron et al., 2012; Pilgrim et al., 2013; Walker et al., 2009). Licence-to-trash is often coupled to failure of adhering to the mitigation hierarchy’s first step: avoidance (Clare et al., 2011; Hough & Robertson, 2009). As stated in the previous section, the Swedish legislation regulating EC is somewhat ambiguous (Koh et al., 2017) and inconsequently applied (SEPA, 2015). Therefore, in order to contribute to the establishment of a functional policy framework in Sweden, I post the question (i) does the ambiguous legislation regarding EC in Sweden impede the effectiveness of this tool, and (ii) what parameters are used to determine compensation measures, i.e., how are losses and gains quantified and weighed in the respective cases.
The quantification as such is inseparably linked to questions regarding NNL (Clare et al., 2011; Sonter et al., 2014). It is only possible to determine if a compensation has resulted in NNL if there are reliable quantifications displaying lost and gained values (ibid.). Maron et al. (2012) argues, based on reviews of ecological restoration literature, that expectations (NNL) set by current EC policies are unsupported by evidence. Moreover, in a review of the US system of wetland mitigation banks, Burgin (2010) claims that the outcome of EC at best is “modestly successful”. NNL together with additionality are two underlying principles of EC (Maron et al., 2012; Quétier & Lavorel, 2011). I dwell into these issues by investigating the question (iii) to what extent have additionality and NNL been achieved?

By addressing these three research questions, the aim is to contribute towards increased accessibility of EC in a Swedish context.
3. Case study descriptions

Two cases were selected to capture some of the diverse potentials and risks of EC. By selecting two disparate cases I hope to display some context dependent variations and similarities to the current application of EC in Sweden. The first case is a small case of industrial expansion posing challenges for solving trade-offs with urban development and protection of green areas in the outskirts of Stockholm county. The second case concerns mining and raises the question on how to compensate for old-growth forests. By choosing two contrasting cases, the ambition is to shed light on various challenges of EC in Sweden.

3.1 Sigtuna municipality trading estate

In 2011, as Sigtuna municipality in Stockholm county was in the process of finalising a land-use plan [detaljplan] (Figure 3a), for the southern expansion of Rosersbergs’ trading estate; the developer, Kilenkrysset AB, requested further land access for the development than was previously stated in the land-use plan.

According to the PBA, urban development should be confirmed in a development agreement [exploateringsavtal] between the involved parties. In this process, the municipal ecologist took the opportunity to present a proposal of EC to the developer, to balance the new more extensive development requests. The developer accepted this proposal and the details regarding it, i.e. specifications of compensation measures and obligations, were included in the development agreement (Sigtuna, 2012). The plans were finalised in January 2012 (ibid.).

The land-use plan concerned in total 64 ha, of which 27 ha was used for development (Sigtuna, 2011). The impact site was mainly arable land and some forest areas, and included a number of microhabitats falling under the general biotope protection, Chapter 7§11 of the Environmental Code. However, the CAB Stockholm gave these exemptions from protection (Ramböll, 2011). The area has been identified as a “weak ecological connection”, important for species dispersal between two green wedges (RUFS, 2010). Therefore, it should be protected and conditions for species dispersal enhanced (ibid.). The development caused habitat loss and an intensified barrier effect further inhibiting species dispersal between the green wedges (Ramböll, 2011).

As compensation, 34 ha of land owned by the developer was set aside as “nature” in the land-use plan, and the property rights of this area were signed over from the developer to the municipality. The developer also agreed to pay a bit over 5 million SEK for compensation measures, over a period of four years, to the municipality. The compensation measures mainly consisted of signing a lease [arrendevtal] to an estate with The National Property Board regarding an additional compensation site (6 ha), and then restoring it to open pasture as well as constructing a wooden platform for bird watching. See Figure 3a for a picture displaying the affected areas, and Figure 3b shows an aerial photograph of the present-day area.
Figure 3a: The area affected by the land-use plan (inside red line), and the area secured via lease (orange) with The National Property Board. The green and the un-coloured area within the red line were tagged as nature in the land-use plan. Adapted from Ramböll, 2011.
Figure 3b: Aerial photograph of the present-day area, with border for the land-use plan inserted. Retrieved from Google Earth (2017-05-15).
3.2 Aitik Mine Sand Magazine

In January 2016, the Land and Environmental Court of Appeal (LECA) approved the final proposal for expansion of the Aitik mine sand magazine, by the mining company Boliden Mineral AB (LECA, 2016). Already in the early process of constructing the proposal, Boliden concluded that this development would require EC. They recognise that parts of the impact site is of high or very high ecological value, and that in a parallel application process regarding another mine, LKAB Mertainen, 70 km to the north, the court had demanded EC (Forsgren, pers. comm.).

The impact site consists of 376 ha of forest and wetland habitats, of which 250 are of high or very high ecological value (Enetjärn, 2012). Although the area has high conservation values and harbours numerous rare species listed by the Species Protection Ordinance, it is not legally protected. Furthermore, the impact site is used for reindeer grazing by two Sami communities (Enetjärn, 2014).

Reindeer husbandry is considered a national interest, and should therefore be protected “as far as possible” according to the Environmental Code, Chapter 3§5. Thus, in this area there are three competing national interests; biodiversity protection (Chapter 3§6), mineral extraction (Chapter 3§7) and reindeer husbandry (Chapter 3§5) that should all be protected as far as possible. When such is the case, precedence should be given to use(s) that “promote a sustainable management of land, water and other aspects of the environment” (Chapter 3§10).

Boliden therefore put forth compensation proposals that were presented to the Land and Environmental Court (LEC) prior to the court hearing in 2014 (Forsgren, pers. comm.). The LEC gave approval of the development. The decision states that the developer is bound to “reasonably compensate” for the impact, and that this shall be done on an area of “at least 250 ha” to have a safety margin ensuring compensation (LEC, 2014). The compensation sites and measures were to be presented in a comprehensive compensation plan to the regulatory authority at the latest a year after the judgement (ibid.). However, the SEPA appealed the decision to the LECA, which made minor revisions in the decision and then approved the development proposal and compensation requirements in January 2016 (LECA, 2016).

In June 2016, Boliden presented a compensation plan where they together with two landowners, Sveaskog AB and the Swedish University of Agricultural Sciences (SLU), had identified two compensation sites of totally 837 ha. Compensation measures mainly consist of movement of species rich coarse woody debris from the impact to the compensation site, and actions to create old growth forest characteristics. The developer and land owners agreed on an easement agreement [servitutsavtal] for the first 50 years, after which the CAB Norrbotten has the opportunity to give the areas nature reserve status without any additional expenses (Forsgren et al., 2016). See Figure 4 for a map displaying the affected areas.
Figure 4: Map showing area affected by the expansion of Aitik mine sand magazine (red), and the compensation sites (green). The present mine is shown as yellow. The "eco-park" is owned by Sveaskog, and forestry in the park is conducted with high nature conservation ambitions. Adapted from Forsgren et al., 2016.
4. Methods

4.1 Comparative case study
Addressing the research questions requires an in-depth empirical analysis of EC processes. A comparative case study is suitable when the research strives to display some of the complexities regarding a problem, but circumstances do not allow for the relevant factors to be manipulated by experimental design (Yin, 2013). By collecting and processing a broad variety of data, the aim is to ground the research empirically whilst retaining a holistic real-world perspective, and thus creating a broad base for analysis and discussion of the research questions. The research questions then serve to display some aspects of the process of EC that have been subject to debate (Maron et al., 2012), and are important for the increased applicability of this tool (SEPA, 2016).

As EC is a novel practice in Sweden, and has yet to become a standardised procedure, I chose to explore two cases to be able to derive more in-depth results, displaying context dependent variations and similarities to the current application of EC, rather than collecting data from various cases. I seek to identify numerous variables and map out their interactions in order to obtain a rich understanding of a complex process, rather than trying to falsify a hypothesis (Kvale & Brinkmann, 2009).

As only two cases have been investigated, any definite conclusion on how EC is generally applied in Sweden cannot be made. Nevertheless, despite this limitation, converging evidence from the case studies allow for some generalisations if the observations are supported by the empirical literature (Kvale & Brinkmann, 2009).

The data was collected from written documents and semi-structured expert interviews with key informants. The data was then structured and queried with the help of an analytical framework developed for the research questions (Yin, 2014).

4.2 Investigation of written documents
The publicly available information on the jurisdictional and ecological components of each case were collected. The documents reviewed were predominantly municipal grey literature, legal and policy documents, court judgements, as well as reports and/or data from nature inventories and environmental impact assessments.

As no systematic documentation has been produced concerning the Sigtuna-case, and the existing documents are general in character, all literature regarding the case was perceived as relevant. In the Aitik-case however, large quantities of documentation have been produced, including an elaborated compensation plan. Thus, only the core documents, e.g. compensation plan and court judgements, were reviewed in detail.

The first step to retain the relevant documents was via internet searches. Reading of these findings often gave information on other relevant documents. If these could not be obtained online, key stakeholders, municipalities or other authorities were contacted with requests for documents.

There is a chance that all existing written information concerning the cases was not gathered, and/or that all the information needed to address the research questions does not exist in written form. Furthermore, the literature survey gave rise to numerous questions. Therefore, the expert interviews were conducted in such a way as to overbridge these information gaps.
4.3 Interviews

In total, 8 semi-structured expert interviews with key informants were conducted (see Appendix B for list of interviewees), usually with a duration of 1 h. They were either conducted face-to-face in different settings; out on site, in an office environment etc., depending on what was suitable for the interviewee. Some interviews were conducted via telephone. They were recorded and notes were taken during the interviews should follow-up questions arise; expanding the depth and richness of the data (Kvale & Brinkmann, 2009). Afterwards, the interviews were transcribed based on the recordings.

The final number of interviews was not decided beforehand; instead, the idea of “empirical saturation” was applied. When answers did not add anything new addressing the research questions, the interviews were ended (Bryman, 2012).

The interviewees were selected with the aim of finding people who could tell the story from different perspectives (environmental-, business-, landowner-, and jurisdictional perspectives), thus allowing for triangulation of the data with support from the literature. Hence, people with central positions who had affected the outcome of the processes were contacted, e.g. the municipal ecologist who had been the driving force behind the work with EC in Sigtuna municipality, as well as the developer who had conducted the EC. In the Aitik-case, the main author of the compensation plan, the landowner of the compensation sites, as well as judges and legal advisors were interviewed.

With interviews, there is always the risk of that the interviewee adjusts her answers in line with what she perceives as “expected/desired answers” on behalf of the researcher; called interviewer bias (Kvale & Brinkmann, 2009). To prevent this, the questions were formulated as open as possible (Patton, 2002), all answers were received as good answers, and the interviews always took place in a setting in which the interviewee was thought to feel secure (e.g., at her working place). The interviews served to fill the gaps in the analytical framework (see below), thus, the questions in the analytical framework served as interview guide. All questions were not asked to all respondents, questions asked were adapted to match the respondents’ expertise.

When the interviews were transcribed and analysed, source critical principles following Olden-Jørgensen (2005) and Thurén (2013) were applied. For example, if independent sources (e.g., both respondents and literature) provided the same information regarding an aspect, the credibility of this information was perceived as high. When data from different sources did not converge, motivations for any source to provide biased answers were analysed, and respondents were contacted again to ensure that I had not misinterpreted their answer.

4.4 Analytical Framework

The basic outline of the analytical framework (Appendix A) was drawn from review of scientific literature on the application of EC/biodiversity offsets, and Swedish policy documents regarding these tools (see section 2.4). Most of the analytical framework was developed prior to the interviews, but was then dynamically refined during the research/analysis process with support by findings from the case studies. The data collection provided insights on which the “right questions to ask” were in order to decipher the cause of events and outcomes of the cases, thereby providing material to address the research questions (Figure 5). The analytical framework is designed to enable a qualitative analysis permitting cross-case conclusions (Yin, 2014).
Each research question concerns several aspects of the EC process and require information from different categories: A. **Process initiation**, B. **Baseline quantification**, C. **Focal scale**, D. **EC objectives**, E. **Implementation outcomes**, F. **Management**, G. **Monitoring**. These categories draws on aspects regarding the application EC that have pinpointed as incoherent and/or problematic by the literature (Jones et al., 2014; Maron et al., 2012; Pilgrim et al., 2013; Sonter et al., 2014; Walker et al., 2009), see section 2.4 above. Hence, it is crucial to develop solutions to these problems to secure that EC fulfils its intended purpose, thus linking back to the aim of this study.

The categories and questions asked are organised to display the timeline along which these events played out, from when EC was first considered, to future management and monitoring of implemented compensation measures. Answers to the research questions are then derived from this structured data. The first research question, regarding legislation and license-to-trash, links to A, F and G. The second question, regarding metrics, links back to category B and C. And the final question, regarding NNL and additionality, links to D and E. Table 1 displays the questions from the analytical framework organised in conjunction to the research question they address.

As the written materials reviewed were organised in different ways, and the interviewees far from always could produce stringent answers to the questions, sorting and structuring the data according to the selected method was challenging. The work could be compared to completing a “jigsaw puzzle” with pieces of data from varying sources.
Table 1: The research questions and questions from the analytical framework that correlates to each respective question.

<table>
<thead>
<tr>
<th>Does the ambiguous legislation regarding EC in Sweden impede the effectiveness of this tool, and does it enable licence-to-trash?</th>
<th>What parameters are used to determine compensation measures?</th>
<th>To what extent have additionality and NNL been achieved?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who was the initiator of EC in this case? (developer, authority or other actor)</td>
<td>Were (social-)ecological values quantified? How were the results presented?</td>
<td>Was there an ambition of like-for-like?</td>
</tr>
<tr>
<td>Who were the main parties responsible for the process?</td>
<td>What (social-)ecological parameters constituted the basis of the quantification?</td>
<td>Was there an ambition of no net loss?</td>
</tr>
<tr>
<td>Upon what part(s) of the Swedish legislation were the decisions of EC based?</td>
<td>Were losses and gains weighed? How?</td>
<td>Were there expressed ambitions of additionality?</td>
</tr>
<tr>
<td>What kind of contract(s) was agreed upon between which parties?</td>
<td>Ecological: What was the ecological unit of focus? (species, population, community, ecosystem, habitat or nature type)</td>
<td>Was the EC targeted towards any specified nature types? Which?</td>
</tr>
<tr>
<td>Who owns the compensation site(s)? Was ownership transferred in the process? From who to whom?</td>
<td>Social: Was an analysis made to identify social groups affected by the development and the compensation measures?</td>
<td>Was the EC targeted towards any specific ecological functions/ES? Which?</td>
</tr>
<tr>
<td>Would the development have been approved in a scenario without EC?</td>
<td>Temporal: Over how many years will the compensation measures be conducted?</td>
<td>Was the EC targeted towards any specified species? Which?</td>
</tr>
<tr>
<td>Is the design for future management included in the contract?</td>
<td>Temporal: How is ecological succession discussed (when is the compensation estimated to be achieved?)?</td>
<td>Was the EC targeted towards any specified social groups or functions? (who/what)</td>
</tr>
<tr>
<td>Who will be responsible for the management?</td>
<td>Spatial: What is the distance between the compensation site and the impact site?</td>
<td>How large was the impact site?</td>
</tr>
<tr>
<td>Who funds the management? For what duration?</td>
<td>Spatial: Is landscape context, relative position and/or connectivity discussed in the compensation plan?</td>
<td>How large are the compensation site(s)?</td>
</tr>
<tr>
<td>Has stakeholder involvement and co-management been discussed?</td>
<td>Spatial: Is there focus on creating/conserving ecological corridors with the compensation measures?</td>
<td>On what criterions were the compensation sites selected?</td>
</tr>
<tr>
<td>If additional value-enhancing measures are needed to meet the (social-)ecological goals, who is responsible for the execution?</td>
<td></td>
<td>What kind of jurisdictional/environmental protection is given to the compensation sites?</td>
</tr>
<tr>
<td>Is there a monitoring program to survey the outcomes of the EC?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Who finances the monitoring?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Who conducts the monitoring?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How frequent will the results be reported and to whom?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. Results

5.1 Legislation & licence-to-trash

5.1.1 Sigtuna municipality trading estate

The subject of EC did not emerge until the developer requested a larger area for construction than they had at the start of the land-use planning process (Franzén pers. comm., 2016); the municipal ecologist, somewhat opportunistically, raised the subject. Due to good social relationships between the actors, and experience from similar cases they had been involved in previously, an agreement regarding EC was reached smoothly (Eklund pers. comm., 2016; Franzén pers. comm., 2016). However, they used a truly unconventional part of the legislation to support the EC; namely the PBA. According to the literature (Koh et al., 2017; SEPA, 2016), the PBA does not offer any legal space for EC. Nevertheless, these actors grounded the agreement on EC with a development agreement under the PBA. Such development agreements focus on measures the developer should take to minimise harm at the impact site, but was in this case used to also include measures outside the impact site, i.e. compensation measures. The process can be summarised as somewhat of a Wild West, with the municipal ecologist playing the lead part of the benevolent sheriff shooting from the hip.

The result being that the developer transferred ownership of 34 ha to the municipality, as well as funds for EC (more than 5 M SEK), which were to be paid to the municipality over the coming five years. The municipality then had the responsibility to ensure that the funds were used for the practical implementation of compensation measures.

To secure that the transferred area would maintain its green values, it was planned as nature in the legally binding land-use plan. Furthermore, the funds from the developer was utilised to secure yet another nature area at the southeast border of the main compensation site via lease (see orange area in Figure 3a).

The compensation as such was perceived as a “bonus” (Franzén pers. comm., 2016), meaning that this development would have taken place despite the compensation. Thus, it is not a case of licence-to-trash. The details regarding compensation measures were slipped into the EIA and the development agreement. No “compensation plan” as such was made. Instead, the EIA is the document that most clearly states both what the developer and municipality are obliged to do in terms of EC. However, as no scheme for monitoring exists, there is no way of controlling and evaluating that the measures stated have actually been conducted and achieved expected effects. After reading the relevant documents, field visits to the compensation site, interviews, and requests to the municipality for the policy documents that were to be produced coupled to this process, it is clear that the municipality has not implemented all the measures they set out to do.

According to the EIA, the municipality is obliged to conduct a variety of compensatory measures with funds from the EC. Among other things, this included producing several environmentally guiding documents (water-, urban runoff-, forestry-, and nature conservation-plan), that were to guide future decisions on development (Ramböll, 2011). Today, only one of these have been written (not published) and most of them do not seem to be on their way. Furthermore, an approximately 200-year-old stonewall was to be relocated from the impact site to the compensation site. The Development Agreement states that the developer is responsible for the relocation and application of all necessary permits. If the wall has not been re-erected by 2013-06-30 at the latest, the municipality is to conduct the work and charge the developer for it. It is unclear if the developer has
transferred funds to the municipality for this project. What is clear, is that the stones of the wall are currently resting in an unsorted pile within the compensation site, a “No one will ever care to rebuild it” situation according to Franzén (pers. comm., 2016).

Active measures were only undertaken for a few years. Then due to outflow of competence from the municipality (many people quit their jobs, both civil servants and politicians) the compensation work stagnated (Franzén pers. comm., 2016). Today the municipality has shifted their policy and completely quit working with EC as a policy tool, as they are convinced it will lead to license-to-trash (Eriksson pers. comm., 2016), despite the relative successful case analysed here.

5.1.2 Aitik mine sand magazine
In contrast to Sigtuna, in the Aitik case it was the developer who suggested EC in the early stages of the application process. The developer produced a draft of a compensation plan, which was presented to the court prior to the proceedings. In the judgement, the court does not refer to any specific paragraphs regarding EC, however SEPA comments that they believe this decision to be in line with Chapter 16§9 of the Environmental Code (LECA, 2016).

The developer together with the two landowners Sveaskog and SLU were the driving forces behind this process. Sveaskog saw it as an opportunity for a new kind of business (i.e. future compensation pools or habitat banks) (Nordin pers. comm., 2017), and SLU as an opportunity to expand into a new research field: restoration ecology (Forsgren pers. comm., 2017).

To secure the compensation sites, easement agreements have been signed between the developer and the landowners, transferring the management of the sites to the developer for 50 years. Additionally, three-party-agreements [trepartsavtal], have been signed between the developer, landowners and CAB Norrbotten to regulate the forming of nature reserves once the easement agreements expire, thus securing the compensation sites for eternity (ibid.).

The demand for EC is clearly stated in the judgement (LEC, 2014). It is however difficult to determine if/how the proposal of EC affected the courts judgement, as the court never had to consider a scenario without EC. Hence, this could be a case of licence-to-trash.

It is possible, that if the developer had not proposed EC, demand for it could instead have been put forth by the court. If so, before considering EC, the court (LEC) would have to evaluate the legality of the proposed expansion in relation to the mitigation hierarchy. The interviewees at LEC dismissed this question as “hypothetical”, and explained that they had no responsibility nor interest to take anything but the information presented at the court into consideration. This case illustrates the importance of adhering to the mitigation hierarchy.

The developer is legally and economically responsible for the management of the compensation sites for the coming 50 years (Forsgren pers. comm., 2017). The practical compensatory measures and their results will be conducted and monitored by independent professionals hired by the developer (ibid.). The results are to be reported to the CAB 1, 2, 3, 9 and 10 years after the project-start in 2016 to document if the compensation goals are reached (Forsgren et al., 2016). If the goals are not reached, the developer will consider conducting additional compensation measures (Forsgren pers. comm., 2017), although it is not legally required.
5.2 Parameters used to determine EC — Baseline quantification & Focal scale

5.2.1 Sigtuna municipality trading estate

Quantification
As this initially was no clear case of EC, no attempts to quantify or weigh EV were made (Franzén pers. comm., 2016). The EIA lists EV identified in the plan-area [planområdet], both at the impact sites, and the area planned as common nature [allmän platsmark] (Ramböll, 2011), i.e. the larger compensation site. The evaluation of EV is not particularly detailed as this is not required by the Swedish standards for EIAs (Swedish Standards Institute, 2014). The EIA describes the plan-area in general terms (nature types and such), lists some species included in the Species Protection Ordinance, and habitat types considered as biodiversity hot spots (Ramböll, 2011).

The additional compensation site secured via lease (see Figure 3a) had been identified by the municipal ecologist as valuable and with high restoration potentials before this land-use plan process commenced (Franzén pers. comm., 2016).

Social focus
The EIA states that the social groups most affected by the development are people living in proximity to the impact site, employees at the trading estate, and inhabitants of the close by urban area Rosersberg (Ramböll, 2011). The compensation therefore targeted these groups (Franzén pers. comm., 2016).

Temporal scale
The temporal scale regarding compensation measures is short term from a biogeological perspective. Measures listed in the development agreement are limited to the coming four years (Sigtuna, 2012), whilst long-term perspectives on development of EV are lacking. However, long-term perspectives spanning over decades were not lacking on behalf of the municipal ecologist. The interviews with him clearly shows that he and the department he represented had long-term ambitions and ideas regarding these areas (Franzén pers. comm., 2016). It was however not jurisdictionally possible to include these in the documents regulating this process.

Landscape ecological focus
It was stated from the municipality that the compensation should benefit the same social groups and ecological functions as were impaired by the development (Ramböll, 2011; Sigtuna, 2012). The compensation site is therefore adjacent to the impact site.

The southern part of the plan-area acts as an ecological corridor connecting two of Stockholm’s green wedges (RUFS, 2010). The EIA elaborates on the importance of high EV in the remaining corridor, to secure connectivity supporting species dispersal at a regional level (Ramböll, 2011). Focus is also placed on the river at the south border of the compensation sites, and its connection to bodies of water beyond the plan-area (ibid.). The compensation measures therefore targeted these qualities carefully. The restoration of the pasture at the smaller compensation site (see orange area in Figure 3a) benefits conditions supporting species dispersal, thus making up for some of the implications caused by the development (Franzén pers. comm., 2016).
5.2.2 AITIK MINE SAND MAGAZINE

Quantification
In this case on the other hand, quantifications were thoroughly conducted, with main focus on habitat type and species composition, and presented in several documents (Enetjärn, 2012, 2014; Forsgren et al., 2016). The final results were presented by Forsgren et al. (2016) in a detailed compensation plan. No specific standards were used (like BBOP e.g.) to weigh gains and losses. The classification of nature areas into value groups and their spatial dispersal (Table 2) were conducted according to the Swedish Standards Institutes’ standard for nature value inventories (Enetjärn, 2012). The same standards were used to classify nature and quantify values at the compensation sites (Enetjärn, 2014).

Table 2: Summary of spatial dispersal of nature types at the impact site of the Aitik-case. Adapted from Forsgren et al., 2016.

<table>
<thead>
<tr>
<th>Total area</th>
<th>Ecological values</th>
<th>Nature type</th>
</tr>
</thead>
<tbody>
<tr>
<td>376 ha</td>
<td>high – very high EV: 250 ha</td>
<td>old growth forest with very high EV: 130 ha</td>
</tr>
<tr>
<td></td>
<td>low – very low EV: 126 ha</td>
<td>old growth forest with high EV: 37 ha</td>
</tr>
<tr>
<td></td>
<td>roads &amp; power lines: 18 ha</td>
<td>oligotrophic wetlands: 65 ha</td>
</tr>
<tr>
<td></td>
<td>pine forest ripe for thinning: 126 ha</td>
<td></td>
</tr>
</tbody>
</table>

Landscape ecological & social focus
For sites to qualify as a compensation site, they have to fulfil the following requirements:
- approximately the same habitat types as the impact site
- restoration potential
- good connectivity with other ecologically and socially (culturally) valuable areas
- be beneficial to affected social groups
- be as close as possible to the impact site
- be owned by Sveaskog/SLU (Enetjärn, 2014)

The ambition is for the compensation is to generate like-for-like/better “As far as possible”, regarding both ecological and social values (Forsgren pers. comm., 2017). The social focus mainly resides on affected Sami communities who conducts reindeer husbandry at the impact site. The compensation should therefore benefit these communities (Forsgren et al., 2016). These are no residents living in nor in proximity to the impact site (ibid.).

The compensation sites are located 3.7 and 8 km from the impact site (see Figure 4). They serve to enhance the ecological connectivity between valuable areas in the landscape (Enetjärn, 2014). To further increase species dispersal possibilities between the compensation sites and adjacent areas, some compensation measures (e.g. movement of species rich coarse woody debris from the impact site) will be conducted outside the compensation sites (Forsgren et al., 2016).

Temporal scale
The temporal aspect of this project is arguably long term. Most of the active measures will be conducted during the first decade (Forsgren et al., 2016). The involved stakeholders’ goal however, is for the compensation sites to become nature reserves (i.e. protected for eternity) (Forsgren pers.
The developer is therefore prepared to conduct additional measures towards the expiration of the easement agreements (50 years) to secure this goal (ibid.).

### 5.2.3 SUMMARY OF CONVERGING FOCUS SCALE

In both cases, the spatial focus is on a landscape context. Ecological connectivity beyond the development and compensation sites as such, are partly targeted with the EC. Hence, in both cases the compensation sites are used to improve ecological infrastructure at landscape level. The compensation also primarily targets the social groups affected by the development, which is in line with present Swedish guidelines regarding EC (SEPA, 2016, p. 76). Table 3 summarises size of impact and compensation sites for both cases.

*Table 3: Summary of sises of impact and compensation sites for both cases. Note that in the Sigtuna-case, the compensation sites are 148% larger than the impact site In the Aitik-case the compensation sites are 223% larger than the impact site, and 335% larger than the parts of the impact site that constituted the basis for EC.*

<table>
<thead>
<tr>
<th>AREA</th>
<th>Aitik mine sand magazine</th>
<th>Sigtuna municipality trading estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area of impact site</td>
<td>376 ha</td>
<td>27 ha</td>
</tr>
<tr>
<td>Area of the impact site that constituted the basis for EC</td>
<td>250 ha</td>
<td>n/a</td>
</tr>
<tr>
<td>Total area of compensation sites</td>
<td>417 + 366 = 837 ha</td>
<td>34 + 6 = 40 ha</td>
</tr>
</tbody>
</table>
5.3 Additionality & NNL

5.3.1 Sigtuna municipality trading estate
It is clear that several of the compensation measures in Sigtuna would not have been conducted without the EC. It was a way for the municipality to secure funds for nature conservation that they had the ambition, but not the resources to conduct (Franzén pers. comm., 2016). Hence, even though there were no expressed ambitions of additionality, it can be argued that this EC did indeed produce additional values. This especially regarding the smaller area secured via lease (see Figure 3a), where measures have been meticulously conducted, restoring it into an open pasture. A platform for birdwatching has also been built, giving a nice overview of the valley with the open pasture, thus creating additional recreational values.

The compensation measures were not limited to the actual compensation site. Funds were also utilised to renovate the lit running track in Rosersberg. This was justified with the argument that the local inhabitants were negatively affected by the development of nature areas, an example of like-for-better compensation.

It is hard to conclude if the EC resulted in NNL. Losses and gains are difficult to compare as a) the EIA is not detailed enough, and b) no written data regarding the ecology of the additional compensation site (see Figure 3a) could be retrieved. The comparability across the impact and compensation sites is poor, as they consist of different nature types. The EIA gives some information on lost social values, but there is no documentation on values gained. However, the compensation sites are in total about 40 ha which is 13 ha (48%) larger than the impact site (27 ha). If it had been possible to weigh losses and gains, it is plausible that the result would be positive, however this is merely a guesstimate based on existing data. Conducting new ecological inventories to enable a thorough comparison of losses and gains are outside the scope of this thesis.

5.3.2 Aitik mine sand magazine
The compensation plan expresses clear goals of additionality, both in terms of increased EV via measures that would not have been conducted in a scenario without EC, and an increase in the total amount of protected areas (837 ha) (Forsgren et al., 2016, p. 31).

There is no strict ambition regarding like-for-like. Approaches to calculate ecological quality in relation to spatial dimension is perceived as complicated to use due to the inherent complexity of nature (Forsgren pers. comm., 2017). Furthermore, a strict like-for-like approach does not offer any flexibility when searching for suitable compensation sites.

The court stated that the developer is to “reasonably compensate”, and that this shall be done on an area “at least” as large as the part of the impact site that has been classified as “high or very high ecological value” (250 ha) (LEC, 2014). Thus, the EC does not necessarily render the same values as have been lost (i.e. no like-for-like), although the developers ambition is to achieve NNL “over time” (Forsgren pers. comm., 2017).

Compensation measures are explained in detail in the compensation plan. Both in terms of measures, location within the compensation sites, and frequency. They will mainly consist of a palette of actions to create old growth forest characteristics. E.g. movement of species rich coarse woody debris from the impact to the compensation sites (Forsgren et al., 2016).

In order to secure the reindeer husbandry, the affected Sami communities have been consulted for the composition of the compensation plan. The ambition on behalf of the developer is to fully compensate for any negative social consequences (ibid.), although at this point it cannot be
concluded if this is likely to be achieved or not. Furthermore, although the impact site was not utilised for outdoor recreation to any notable extent, hiking trails will be constructed within the compensation sites (ibid.), thus creating new recreational values.

As these development and compensation measures are just starting, it is too early to evaluate the outcomes of the compensation measures. Numerically, the compensation sites cover areas >3 times larger than the part of the impact site that constitutes the basis for compensation. On the other hand, it has been displayed by similar cases (Koh et al. 2017) how difficult it is to compensate for old-growth forests. Even if the forest at the compensation sites is protected for the future, forestry may be intensified elsewhere as a form of biodiversity leakage (ibid.). Sveaskog who owns the greatest part of the compensation sites in this case, is a state-owned company that has pledged to set aside 20% of its productive forests for conservation. The compensation land will not be included in these 20% according to Sveaskog (Nordin, pers. comm., 2017). If this is correct, additionality is achieved. However, due to the difficulty of compensating for old-growth forests, long-term NNL may not be achieved.
6. Discussion

Swedish legislation
The Swedish legislation on EC does not require NNL today. It only states that impacts should be "reasonably" compensated. Concurrently, NNL is strongly recommended by SEPA (2016), and there is an EU initiative supporting it (European Commission, 2014). In neither of the cases investigated were there any initial, officially grounded, ambitions to achieve NNL. Consequently, it cannot be clearly stated if either of the cases resulted in NNL or not.

It can be concluded that both cases resulted in additionality. In the Sigtuna-case, funds secured via EC gave the municipality opportunity to conduct conservation measures that they had the ambition, but not the money, to implement. In the Aitik-case, the forest areas secured via compensation would most probably have been subject to logging in a scenario without EC. Hence, the results suggest that EC may deliver additional EV, in comparison to a scenario of industrial development without compensation. However, this requires that biodiversity leakage is avoided, which is a risk if forest owners are not committed to safeguard additionality (Koh et al., 2017).

Theoretically, additionality is easily achieved, as it only requires that the measures justified by EC would not have been implemented without it. In a theoretical scenario, a legally sanctioned major exploitation of natural resources could be compensated with a birdhouse, i.e., exploitation and EC has little to do with each other. Therefore, NNL is a more suitable goal if we are to sustain important social and ecological values.

In the Aitik-case, the principle of "reasonable" compensation is evident. It was stated by the court that the developer only had to compensate for the 250 ha that were of "high – very high value" (LEC, 2014), the remaining 126 ha of the impact site were an acceptable ecological loss. If all nature other than the one of "high – very high value" is consequently subjected to degradation, the result will be a net loss of EV before EC is actually applied (Jones et al., 2014; Moilanen & Laitila, 2016).

I argue that this indicates that the Swedish legislation does not fully apply to the mitigation hierarchy. The legislation instead generates discounts for exploitation. If developers were to pay the full cost of compensation, the avoidance step would receive appropriate focus, thus, projects would have to relocate if the site is ecologically too valuable (Rundcrantz, 2006).

This analysis suggests that the Aitik-case might be a case of licence-to-trash; although Boliden rejects this (Forsgren pers. comm., 2017). This was made possible due to the lacking experience of the court in handling this type of cases. The SEPA handbook (2016) clearly states that the court shall not let any suggestions regarding EC affect the judgement. However, this handbook was released after the closing of this case. This lack of adherence to the mitigation hierarchy is an indication of unsatisfactory legislation and institutional capacity.

Monitoring of implemented outcomes
This research clearly demonstrates the importance of monitoring. In the Sigtuna-case, many promises regarding measures were made, but less than half were conducted. When the same authority that defines the goals for EC, also is responsible for the practical implementation, there is a risk that the practical measures will be suffering. In the Boliden-case, there is a monitoring scheme, but the developer is not legally responsible to conduct additional compensation measures if the monitoring reveals that the measures depicted in the compensation plan are not sufficient to reach the ecological goals. Conclusively, if EC is to fulfil its purpose, it is crucial that there are sufficient
systems for monitoring, with mechanisms ensuring additional measures guaranteeing the ecological goals (Bull et al., 2013; Gonçalves et al., 2015).

Monitoring schemes should span over a period of at least the length of time it is estimated that the restoration/compensation measures require in order to develop expected values. When designing monitoring schemes, it should be kept in mind that many ecological processes are slow in comparison to human decision processes. If, e.g., a decision is taken to restore a forest into an old growth forest, the time required for the forest to develop old growth characteristics spans over several decades or even centuries. Thus, until the point where the forest has reached the ecological goals (NNL), we have an ecological net minus. We are borrowing ecological credits from “The Bank of Nature”, and we are an unstable client (Bekessy et al., 2010). This could possibly be balanced by additional conservation efforts elsewhere while we are waiting for the forest to develop old growth characteristics.

Baseline quantification of social and ecological values
The quantification of nature is one of the core issues with EC (Bekessy et al., 2010; Quétier & Lavorel, 2011; Walker et al., 2009). Quantification is necessary for its implementation, as losses and gains must be quantified if NNL is to be ensured (Brownlie et al., 2013; Gibbons et al., 2016; Rainey et al., 2014). Some things are easily quantified, such as area or wood volume. But if the ambition is to capture the inherent complexity of an ecosystem in equations, things become exponentially more complex (Bull et al., 2013; Walker et al., 2009).

There is a conflict on how quantification methods for EC should be constituted (Balvanera et al., 2006; Gotelli & Colwell, 2001; Jones et al., 2014). On one hand, there are pragmatic methods with high transparency. However, from an ecological perspective, these are very rough and runs with a high risk of overseeing important EV (Bull et al., 2013). Then there are complex calculation methods that strive to mirror reality more accurately, e.g. the method used in the Mertainen-case (Koh et al., 2017). They, on the other hand, easily become very complicated and impossible for someone without the required schooling to understand. Hence, they lose transparency (Maseyk et al., 2016; Virah-Sawmy et al., 2014).

A reflection on the risk of “false mathematics”. The planets’ surface is finite. If we apply (intellectual) tools like EC without careful reflection, we risk self-delusion. Allowing development with the argument that “the exterminated values will be compensated by intensification of values someplace else”, might lead to a scenario where nature is allocated to ever decreasing areas. Where are the biogeophysical boundaries for the sum of values a discrete area can sustain? If we do not recognise these boundaries, we risk a net loss of both ecological and social values (Bekessy et al., 2010; Bull et al., 2013).

To choose compensation site
When discussing EC, it is necessary to ask the question: “Compensation for whom?” Temporally, EC has the character of investments for future generations. Spatially, it becomes a question of locating compensation sites close enough to the impact site to ensure that the communities who suffered from the development also benefit from the compensation (Brownlie et al., 2013). This is important in order to adhere to the Convention on Biological Diversity and its goal of equal access to nature. If the compensation is located far away from the impact site, the EC generates leakage of EV (Harrison & Paoli, 2012; Moilanen & Laitila, 2016; Virah-Sawmy et al., 2014).
Furthermore, if EC is to be feasible close to the impact site, it is crucial that land owners of potential compensation sites are willing to submit property for compensation projects, which is far from always the case (Bekessy et al., 2010). In the cases investigated here, this problem was handled arguably smoothly. In the Sigtuna-case, the developer owned both the impact and compensation sites. In the Aitik-case, Sveaskog owned most of the surrounding areas and there were already well-established relationships between the actors (Forsgren pers. comm.). Moreover, Sveaskog were positive in submitting land for compensation, as they view EC as a business opportunity (Nordin pers. comm., 2017).

In summary, choosing a compensation site is complex. Not only is it a question of identifying areas with a) the right type of nature (like-for-like/better), and b) the right amount of EV (NNL), it also requires that the areas are c) available for EC. Without clear legislation and a proper system for handling these issues, EC is reduced to a good idea (Adachi et al., 2011; Coralie et al., 2015; Lapeyre et al., 2015).

**Implementation of EC in municipalities land-use plans**

The case in Sigtuna reveals several interesting aspects of how EC can be applied rather opportunistically. In this municipality, EC was an elaborated strategy to locate funding for conservation. As the former municipal ecologist said, “No one remembers a coward!”, i.e., a municipally has got nothing to lose by posing the question of EC to a developer. In a worst-case scenario, you receive a negative reply (Franzén pers. comm., 2016). They also utilised PBA to implement EC, even though existing national guidelines does not recognise this as a window of opportunity for EC (SEPA, 2016).

Another aspect highlighted by this case are organisational issues at municipal level (Bergsten et al., 2014) and its effect on the performance of EC. Usually, the municipal ecologist is placed at the department of “Environment and green structures” or similar. Franzén argues that the ecologist should be placed at the “Planning, building and development” department, to be able to a) clearly point out no-go-areas with high EV, and b) be arguing for EC from the start of a project, thus securing a level of compensation that can ensure NNL.
7. Conclusion

The analysis of these cases shows that there are many context dependent variables affecting the performance of EC in Sweden. This can partly be explained by authorities’ lacking experience in administrating these questions, and by the absence of a standardised structure for handling the full EC process (Hägglund & Enetjärn, 2014). These shortcomings together with an inadequate legislation may result in license-to-trash (Schultz et al., 2013) and failure to guarantee NNL (Koh et al., 2017).

For EC to become a functioning tool in Sweden, structures for handling the process from quantification of social and ecological values, to monitoring of compensation outcomes must be implemented in development processes affecting nature (SEPA, 2016). Two recommendations are that a) developers should not be allowed to present suggestions for compensation until the deciding authority have assessed the application according to the mitigation hierarchy, and b) monitoring must be included and legally binding to ensure that set ecological goals are achieved. Thus, if monitoring reveals that the compensation measures have failed to produce intended values, the developer is responsible to conduct additional measures to guarantee said values.

More research is needed to develop suitable methods for quantification of losses and gains. These should be pragmatic enough to allow for comparison of values across different nature types, as a like-for-better approach presumably is more accessible than a search for like-for-like. Moreover, a like-for-better approach has the potential of delivering a net increase of EV if degraded values consequently are compensated with higher values.
8. Literature cited


vetenskap/biologi-botanik-zoologi/ss-1990002014


## APPENDIX A – THE ANALYTICAL FRAMEWORK

### A. PROCESS INITIATION

<table>
<thead>
<tr>
<th>Aitik mine sand magazine</th>
<th>Sigtuna municipality trading estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who was the initiator of EC in this case? (developer, authority or other actor)</td>
<td>The developer Boliden.</td>
</tr>
</tbody>
</table>
| Who were the main parties responsible for the process? | - Boliden (developer)  
- Sveaskog (landowner) | - The municipal ecologist  
- Kilenkrysset AB (developer and landowner) |
| Upon what part(s) of the Swedish legislation were the decisions of EC based? | The court statement does not refer to any specific paragraphs, however the SEPA remarks that the decision to utilise EC is well in line with MB 16:9 § (LEC, 2014). | The compensation was regulated with a development agreement, regulated under PBL 6:40 §. |
| What kind of contract(s) was agreed upon between which parties? | Easement agreements between the developer and the landowners to transfer the management of the compensation sites to the developer for 50 years.  
Three-party-agreement between the developer, landowners and CAB Norrbotten to regulate the forming of nature reserves once the easement agreements have expired. | a) Development agreement between the municipality and the developer, where the developer hands over the property rights of the compensation site to the municipality. Hence, the municipality becomes landowner of the compensation site.  
b) In addition, a lease was signed between the municipality and the National Property Board to secure an area for EC on the southwest border of the main compensation site. The lease first runs over five years, 2012-2016, and is thereafter renewed automatically per year if neither of the parts propose any changes. |
| Who owns the compensation site(s)? Was ownership transferred in the process? From who to whom? | Sveaskog and SLU, ownership is not being transferred. | a) Sigtuna municipality, ownership of the compensation site was transferred from the developer to the municipality.  
b) The National Property Board, ownership is not being transferred. |
| Would the development have been approved in a scenario without EC? | Unclear. As the developer handed in suggestions for EC previous to the court proceedings, the court never had to consider a scenario omitting EC. The findings therefore suggest that this development might not have been approved if it hand not been for the EC. | Yes. The EC is described as a “bonus” (Franzén pers. comm., 2016). |

### B. BASELINE QUANTIFICATION

| | To some extent. A compensation investigation (Enetjärn, 2014), a compensation plan (Forsgren et al., 2016) as well as documents supporting these were produced. | Nothing beyond the regular EIA that is demanded for this kind of development was conducted. |
| Were (social-)ecological values quantified? How were the results presented? | | |
| What (social-)ecological parameters constituted the basis of the quantification? | Classification of nature areas was conducted according to the Swedish Standards Institutes’ standard for nature value inventories; SIS-TR 199001.2014. | The current (i.e. 2011) standards for EIA. Focus is mainly on species composition and expanse of nature types. |
Focus is mainly on species composition and expanse of nature types.

**Were losses and gains weighed?**

**How?**

To some extent, in order to “in an overarching way ensure that the loss is balanced” (Forsgren, pers. comm., 2017). Measurements were mainly qualitative, however, no specified method was applied.

### C. FOCAL SCALE

<table>
<thead>
<tr>
<th>Ecological: What was the ecological unit of focus? (species, population, community, ecosystem, habitat or nature type)</th>
<th>Habitat-type.</th>
<th>n/a</th>
</tr>
</thead>
</table>

| Social: Was an analysis made to identify social groups affected by the development and the compensation measures? | Yes. Two Sami communities have reindeers in the impact site and have therefore been consulted for the composition of the compensation plan, in an attempt to ensure that they will not suffer any negative consequences (Forsgren et al., 2016). The impact site is not utilised for outdoor recreation to any notable extent, however, hiking trail(s) will be constructed at the compensation sites (ibid.). | The EIA (Ramböll, 2011) states that the main land uses of the impact site prior to construction were agriculture and forestry, and that it to some extent was used by locals for recreation (walking, cycling, horse-back riding, hunting). The compensation benefit locals, people working at the trading estate, and outdoor recreation in general (ibid.). |

| Temporal: Over how many years will the compensation measures be conducted? | Active measures will be performed successively during the first decade (2017-2027) of the easement agreement. If the CAB deems it necessary, complementing measures can be conducted throughout the duration of this contract to ensure that the compensation sites have high enough nature values to become reserves at the expiration. | The developer was contracted to transfer funds for compensation measures to the municipality at the beginning of each year during the first four years (2012-2016) after the adoption of the land-use plan. |

| Temporal: How is ecological succession discussed (when is the compensation estimated to be achieved?) | The ambition is to create high enough ecological values over the first 50 years, so that the CAB will find the compensation sites suitable to become nature reserves. The changes in ecological values will be monitored by the developer and researched in cooperation with SLU. | n/a |

| Spatial: What is the distance between the compensation site and the impact site? | - 3.7 km to Sarkanenä
- 8 km to Sjnírra (aerial way, measured from the closest borders) | Adjacent. |

<p>| Spatial: Is landscape context, relative position and/or connectivity discussed in the compensation plan? | Yes. Vicinity between impact and compensation sites, as well as other areas with high EV, are considered important. | Yes. With focus on the connectivity between affected green wedges and the effect on limnic habitats both at and beyond the compensation site. |</p>
<table>
<thead>
<tr>
<th><strong>Spatial:</strong> Is there focus on creating/conserving ecological corridors with the compensation measures?</th>
<th>Yes. The compensation sites enhance ecological connectivity between valuable areas in the landscape. Some compensation measures (movement of species rich coarse woody debris from the impact site) will also be conducted outside of the compensation sites to increase species dispersal possibilities.</th>
<th>Yes. The connectivity between the local green wedges, in and beyond the affected area, is discussed and regarded as important from a regional point of view. Focus is also placed on the connection of the river at the south border of the compensation site with other bodies of water beyond the affected area.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D. EC OBJECTIVES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Was there an ambition of like-for-like?</td>
<td>Not in a strict way, however the compensation sites have partly similar values to the impact site.</td>
<td>No.</td>
</tr>
<tr>
<td>Was there an ambition of no net loss?</td>
<td>To be &quot;achieved over time&quot; (Forsgren, pers. comm., 2017).</td>
<td>No.</td>
</tr>
<tr>
<td>Were there expressed ambitions of additionality?</td>
<td>Yes. Both with an increase of protected area and enhanced ecological values.</td>
<td>No.</td>
</tr>
<tr>
<td>Was the EC targeted towards any specified nature types? Which?</td>
<td>- broad-leaf rich needle-leaf forest - needle-leaf forest - broad-leaf forest</td>
<td>- pasture grazing landscape - limnic habitats</td>
</tr>
<tr>
<td>Was the EC targeted towards any specific ecological functions/ES? Which?</td>
<td>Reindeer grazing (provisioning/cultural ES)</td>
<td>- water infiltration - recreational ES</td>
</tr>
<tr>
<td>Was the EC targeted towards any specified species? Which?</td>
<td>Wood living species as a group. E.g. multiple species of fungi and insects.</td>
<td>In the EIA it is stated that the municipality will create a spawning ground for the fish asp (<em>Aspius aspius</em>) in the river running through the southern part of the compensation site.</td>
</tr>
<tr>
<td>Was the EC targeted towards any specified social groups or functions? (who/what)</td>
<td>Groups: The Sami communities. Functions: Reindeer husbandry.</td>
<td>Groups: Locals, people in the closest urban area (Rosersberg), and employees at the trading estate. Functions: Access to recreational areas.</td>
</tr>
<tr>
<td><strong>E. IMPLEMENTED OUTCOMES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How large was the impact site?</td>
<td>376 ha, though EC only concerned 250 ha that were assessed as having high/very high ecological values.</td>
<td>27 ha</td>
</tr>
<tr>
<td>How large are the compensation site(s)?</td>
<td>837 ha in total</td>
<td>40 ha in total</td>
</tr>
<tr>
<td>On what criterions were the compensation sites selected?</td>
<td>- vicinity to the impact site - similar ecological values - connectivity - beneficial value for the affected Sami communities - restoration potential (pers. comm. Nordin, 2017)</td>
<td>a) Availability, the criteria for availability being that the developer had to own both the development and compensation sites. The vicinity of the areas was a bonus. b) Local protection priority area with high ecological values.</td>
</tr>
<tr>
<td>What kind of jurisdictional/environmental protection is given to the compensation sites?</td>
<td>Easement agreement for 50 years, with the ambition of transcending into nature reserves at the expiration.</td>
<td>a) It is land-use planned as nature according to PBL. b) It is stated in the contract that the municipality shall conduct land-use according to best known environmental practise. The lease continues till either of the parties propose termination.</td>
</tr>
</tbody>
</table>
### F. MANAGEMENT

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the design for future management included in the contract?</td>
<td>Yes, indirectly. It is stated in the easement agreements that the land owners are not permitted to do anything beyond the compensation plan, which the developer have an exclusive right to conduct. The three-party agreement solely states the CAB:s right to convert the compensation sites to nature reserves, or other form of protection, without any additional costs.</td>
</tr>
<tr>
<td>a) On a short-term span. The compensation measures that the municipality impose to undertake during the foreseeable future (a few years) is briefly stated. b) In brief, it is stated that management shall be conducted according to best known environmental practise and that the land use continues as open pasture.</td>
<td></td>
</tr>
<tr>
<td>Who will be responsible for the management?</td>
<td>Boliden (developer).</td>
</tr>
<tr>
<td>The municipality.</td>
<td></td>
</tr>
<tr>
<td>Who funds the management? For what duration?</td>
<td>Boliden (developer), for 50 years.</td>
</tr>
<tr>
<td>Kilenkrysset (developer), for 4 years.</td>
<td></td>
</tr>
<tr>
<td>Has stakeholder involvement and co-management been discussed?</td>
<td>No.</td>
</tr>
<tr>
<td>No.</td>
<td></td>
</tr>
<tr>
<td>If additional value-enhancing measures are needed to meet the (social-)ecological goals, who is responsible for the execution?</td>
<td>Boliden (developer).</td>
</tr>
<tr>
<td>The municipality.</td>
<td></td>
</tr>
</tbody>
</table>

### G. MONITORING

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is there a monitoring program to survey the outcomes of the EC?</td>
<td>Yes.</td>
</tr>
<tr>
<td>No.</td>
<td></td>
</tr>
<tr>
<td>Who finances the monitoring?</td>
<td>Boliden (developer).</td>
</tr>
<tr>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Who conducts the monitoring?</td>
<td>Boliden (developer) via external consultants.</td>
</tr>
<tr>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>How frequent will the results be reported and to whom?</td>
<td>Year 1, 2, 3, 9 and 10 after the project start in 2016, to the county government (Forsgren et al., 2016).</td>
</tr>
<tr>
<td>n/a</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B – LIST OF KEY INFORMANTS

SIGTUNA MUNICIPALITY TRADING ESTATE

Owe Eklund, business developer at Kilenkryset AB
Helen Ericson, environmental strategist at Sigtuna Municipality
Jan Franzén, former municipal ecologist at Sigtuna, presently Uppsala

AITIK MINE SAND MAGAZINE

Nils-Gunnar Elisson, (retired) judge at The Land and Environmental Court
Anders Forsgren, senior project manager business development at Boliden Mineral AB
Lena Nilsson, technical judge at The Land and Environmental Court
Jessica Nordin, business developer ecosystem services at Sveaskog AB
Anna Tiberg, judge of appeal at the The Land and Environmental Court of Appeal