



Operationalisation of ecological compensation – Obstacles and ways forward

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ABSTRACT

Ecological compensation (EC) has been proposed as an important tool for stopping the loss of biodiversity and natural values. However, there are few studies on its actual operationalisation and there is high uncertainty about how it should be designed and implemented to be an effective way of performing nature conservation. In this study we focus on ecological compensation in Sweden, a country where it is in the process of being implemented more broadly. Using interviews and a workshop we investigate how the work with the implementation is carried out and what challenges exist. The results show that implementation of EC is at an early stage of development and there are many practical obstacles, linked to both legislation and routines in the planning processes. There is a lack of holistic perspective and large-scale thinking, a quite strong focus on a small number of individual species, and an overall attitude that anything is better than nothing, all of which can have negative consequences for biodiversity conservation overall. Based on the results we discuss the need for better integration of EC into the entire decision-making process and for a holistic approach to preservation of biodiversity and ecosystem services, by increasing the focus on landscape perspective and considering delays in compensation outcomes. There is also a need for a national level standard for EC, making good and worse examples of compensation measures available and systematic monitoring of EC projects. Finally, a spatially explicit database to document all EC areas should be introduced both to ensure consistency in protection from future development plans and to enable long-term monitoring of EC outcomes.

1. Introduction

Human activities influence most parts of the earth (Moreno-Mateos et al., 2015; Sanderson et al., 2002), often resulting in habitat loss. This is one of the major causes of biodiversity decline and has consequences for delivery of important ecosystem services (Tucker et al., 2013). To halt biodiversity and ecosystem service loss, in line with the European Council's targets (Tucker et al., 2013), many countries have adopted regulations regarding the impact that developmental projects and land-use changes have on them. It is estimated that in 2018 almost 13,000 offsets had been implemented globally under no-net-loss policies (Bull and Strange, 2018). Ecological Compensation (EC), also known as Biodiversity Offsets, is included as a measure that should be considered

if the impacts are too large, following the so-called Mitigation Hierarchy: Avoidance, Minimization, Rehabilitation/Restoration and lastly EC (offset). Guidelines based on the Business and Biodiversity Offsets Programme (BBOP, 2012) are often used when designing and implementing EC.

Despite the increased interest, guidelines for EC are still very vague (although see e.g., Peterson et al., 2018 for a suggestion on a quantitative framework). For example, they provide little guidance on how to evaluate the effect on specific habitats or species groups, leading to concerns about the ability of EC to halt the loss of biodiversity (e.g. Bonneuil, 2015; Josefsson et al., 2021; Moreno-Mateos et al., 2015; zu Ermgassen et al., 2019). One fear is that the claims of a possible "no-net-loss" when implementing EC may lead to a belief that ecosystem

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damages can always be compensated (Gordon et al., 2015; Moreno-Mateos et al., 2015). To evaluate to what extent this is a real risk, knowledge is needed about the implementation of EC.

There are surprisingly few studies on how EC is implemented in practice and what challenges this implementation is facing. Existing studies indicate that often the methodological and operational aspects of EC are not well addressed, that the mechanisms for implementations are weak, that there are organisational and economic limitations, and that there is a lack of strong legal requirements (Guillet and Semal, 2018; Rega, 2013; Villarroya et al., 2014). Therefore, more research is needed on the obstacles of EC implementation and the solutions and approaches that could address them, in order to establish EC as a functional instrument for environmental management.

This study aims at exploring the practical implementation of EC, using Sweden as an example. Even though compensation has been possible since 1964 (Naturvårdsverket, 2016) and the concept of EC has been included as a potential instrument in Swedish legislation (Environmental Code) since 1999, it has not been applied widely. For example, Persson et al. (2015) found that while county administrative boards (CABs) have legal force to demand compensation in development projects, this has been rarely exerted. However, there is an increased interest in EC among authorities and practitioners, and since 2015 the Swedish Environmental Protection Agency (Swedish EPA) have been promoting EC as a good approach to minimise losses of natural values (Naturvårdsverket, 2015). Compensation is increasingly seen as a potential complementary method in biodiversity conservation (Koh et al., 2017), leading to an increase in compensation projects during the beginning of the 2010's (Sjöholm, 2019). Potential challenges faced during the initial work with the concept make Sweden a good study area for investigating the EC implementation process and could offer useful insights also for other countries that are currently launching their compensation efforts (Huitema et al., 2011; Massey et al., 2014). While EC in general can be conducted as either physical or economic compensation (SOU, 2017; Vaissière et al., 2020), in Sweden only the former one is usually an option (Naturvårdsverket, 2016), besides an exceptional case of indigenous Sami people who get monetary compensation for fodder for reindeer to compensate for damaged foraging areas. Thus, our study focuses on the physical EC.

The aim of this study is to increase the knowledge on what issues impact practical implementation, and thus ecological outcomes, of ecological compensation and how they could be handled. To achieve that we explore practical work with EC in Sweden, using semi-structured interviews across a selection of authorities and environmental consultants working with EC. We focus on the trends in the EC work, ways of implementation, and the interviewees' experiences during the implementation process. We particularly explore the obstacles that may hamper the EC work and potential solutions to addressing them. We discuss possible consequences that the encountered obstacles can have for EC and its outcomes for biodiversity conservation in Sweden and elsewhere, as well as potential solutions to improve EC implementation to make it a more useful tool for halting decline of natural values such as biodiversity and ES.

2. Material and methods

2.1. Study area

Sweden is recognised as a country on the forefront of environmental work (GOS, 2018; Juhola et al., 2011). Nevertheless, it faces challenges, particularly with regards to its declining biodiversity and ecosystem services (OECD, 2014; SEPA, 2012). Ecological compensation is one of the approaches to address this issue that has been recently promoted by the Swedish government.

The possibility to request compensation actions for lost natural values has been part of the Swedish environmental regulation since 1964 (Naturvårdsverket, 2016), and from 1999 EC is mentioned as a

potential instrument in the Environmental Code. Today, EC can be demanded by regulatory authorities based on several regulations in the Swedish Environmental Code (SFS, 1998:808, 1998), which are partly linked to the European legal requirements for EC. This includes habitats protected by the EU Birds and Habitats Directives, and the Environment Liability Directive in case of damage to a Natura 2000 site, i.e. a protected area of European importance as defined by the EU Directives (EC, 2014). There is a compulsory demand on EC for damage caused to nature reserves and Natura 2000 sites (Chapter 7, section 7 and 29 in SFS, 1998:808, 1998), and a general regulation for EC for permits and exemptions based on species protection and biotope protection areas (Chapter 16, section 9 in SFS, 1998:808, 1998). Still, EC has only rarely been demanded during the period 1965–2015 (Naturvårdsverket, 2016). Many of the interviews in the present study mentioned that the use of EC started when a specific ecological consultancy company, also engaged in the BBOP, began to promote and implement it. When noticing this trend, Swedish EPA developed an EC guidebook aimed towards CABs and municipality officers (Naturvårdsverket, 2016). Internationally, Sweden is collaborating with the other member states within the Nordic co-countries to educate the CAB officials in the matter (Moilanen and Kotiaho, 2018a).

A typical EC process starts when the developer of a project (for example a private company or a municipality), that potentially will harm protected natural values, needs to get a permit or an exemption from a prohibition from a responsible authority. This authority can be either a county administrative board (CAB), a municipality or the Swedish Forest Agency, depending on project and location. An EC can be required based on legalisation in connection to species protection, protected areas (nature reserves and Natura, 2000 sites), and habitat protection areas. Project approval, that is getting a permit or exemption, is conditional on an environmental impact assessment (EIA) that the developer must conduct. The EIA is usually contracted to an ecological consultant. If the approval is given, then a second decision is taken, where all mitigation steps, i.e. avoidance, minimization and remediation of damage, and compensation, proposed in the EIA are evaluated. If the authority estimates that there will be persistent harm to nature values, they may require the developer to perform EC. The decision can be legally tested by the Land and Environmental Court. Both municipalities and other actors may conduct EC that is not demanded based on a legal process, and therefore called voluntary EC.

2.2. Method

Our study was based on 17 semi-structured interviews following predefined protocol (after e.g. Kallio et al., 2016). Interviews were held independently by three researchers (LW, JJ and MH), who also partook in developing the protocol. The questions were about the following five themes: 1) interviewees' understanding of what EC is; 2) the target for compensation actions, 3) how often and for how long the interviewees and their organizations have worked with EC, 4) their view on EC as an instrument for conservation, and 5) obstacles they see for using EC. Additionally, we asked about possible solutions the interviewees saw for the identified obstacles and their view of the future for EC in Sweden. Each interview took 60–90 min and was conducted with either one or two interviewees from each organization. All interviews were recorded and transcribed.

As our intention was to identify a broad range of important aspects that could impact practical implementation of EC, we aimed at interviewing representatives of all relevant groups of stakeholders. As such, we did not intend to generalise the findings, but to provide insights on the challenges faced by the work with EC, as well as potential solutions. Thus, the interviewees were selected based on their professional role as either representative of a national, regional or local authority requesting EC (approving authority), an authority conducting the EC or an ecological consultancy who helps the developers and authorities with the EC projects (Table 1). Thus, we focused on the organizations who are

Table 1

The seventeen interviews were distributed among four categories of interviewees with different roles in the EC.

Interviewee affiliation	Role in EC process	No. Interviewees	Code
Municipality	Developer or approving authority	4	MUN
County administrative board	Approving or advisory authority	5	CAB
National authority	Developer (STA) or advisory authority	5	NA
Ecological consultant	Assisting in conducting EIA and EC-plan	3	CONS

Developer = conducting EC in practice; Approving = approves the permit or exemption, in the next step leading to requesting EC; Advisory = provide suggestions and guidelines to developers and municipalities on how to conduct EC.

working with EC in practice and are part of how it is implemented. We selected county administration boards and municipalities to include local and regional authorities from both northern and southern Sweden, as well as both densely populated (urban) and sparsely populated areas, since these factors influence both which habitats are affected, and the type of development that could cause biodiversity decline. Additionally, we included representatives for national authorities working with issues related to nature conservation and EC: Swedish EPA, Swedish Transport Administration (STA, two interviews), the Swedish Board of Agriculture and the Sami Parliament. These responded on a more general level, while the other categories were asked to give examples from projects that they had worked with.

The interviews were complemented with a stakeholder workshop with additional authority representatives (Swedish EPA and municipalities), as well as landowners and landowner organizations and developers, to further broaden the perspective on future EC and potential improvements to its implementation. Altogether 12 additional stakeholders (who were not interviewed for this study) participated in the workshop. The inputs from the stakeholder workshop were used to understand the Swedish EC situation better and to derive additional solutions to the EC challenges. The workshop discussions were recorded. The researchers listened to the records and summarized solutions mentioned and new information that complemented the interviews. As such, the findings from the workshop are indicated in the Result section.

We analysed the interview transcripts using a qualitative content approach with open coding, where we organised the interview material into pre-selected categories (Bryman, 2012) representing our five main themes (see above). Our open approach also allowed for creation of additional categories that emerged during the coding. For example, pre-defined categories for interviewees' view on the EC were about it being something positive, its pedagogical value, its marginal role in relation to exploitation, its importance for the future and risks it represented, while the emergent categories were about its limits, costs linked to it or its cost-effectiveness.

The coding was conducted by two researchers. To ensure validity and reliability, initial coding was done independently by the authors MB and LW. Between interviews, MB and LW cross-checked and discussed coding and, particularly, new emerging categories. Each interviewer also double-checked the coding of their interviews. After initial coding, we used memos (Glaser and Strauss, 2009) to synthesise relevant information across categories and interviewees. We used the constant comparison approach (Glaser and Strauss, 2008). This meant extracting key information for each category across the whole sample of interviews, and developing a coherent narrative, which we present in the Results. Interviewee statements (translated and sometimes shortened for clarity) are presented within quotation marks, followed by the interviewee's affiliation code (see Table 1) in brackets. For each interview, we used the number of mentions of a category, as a quantitative estimate of its relevance for that person. Further for interviewees talking about typical projects for their organization, the types of natural values that the implemented EC aimed to compensate were identified, as well as the types of action conducted and in connection to what regulation. The type of exploitation conducted was also identified.

3. Results

3.1. What is considered as ecological compensation?

Most of the interviewees defined ecological compensation (EC) as an activity that compensates for lost natural values in another location, although several stakeholder workshop participants mentioned that it was also sometimes used in relation to compensating for recreational areas. All interviewees mentioned two types of EC: "legally defined" EC that is conducted in relation to the Environmental Code regulations and "voluntary" EC that is not linked to legal demands.

Many interviewees highlighted that EC is only done if it is not fully possible to consider the earlier steps in the mitigation hierarchy and suggested that as a reason for why there are so few EC projects. However, several interviewees mentioned that there are cases where mitigation measures are called "compensation". Some interviewees also did not seem to recognise the difference between compensation and mitigation.

While some interviewees thought that EC should always compensate the same values (in-kind offset; e.g. restore a lost old growth pine forest with another old growth pine forest), most of them said that it is acceptable to compensate with different values (out-of-kind offset; e.g. to restore a deciduous forest as a compensation for a lost old growth pine forest), particularly if the distance was right (i.e. close by). In addition, several interviewees mentioned that EC is often about what is easy to implement and there is often little thought of whether the action should match the values lost.

3.2. Where and why is EC used today?

Different regions in Sweden are at different stages in the implementation of EC. Representatives of southern CABs in more densely populated areas mentioned that they have many EC projects every year, while the other CABs and most northern municipalities in more sparsely populated areas stated that EC projects were completed quite seldom, although they were becoming more frequent during the last few years.

While different types of stakeholders mentioned different reasons behind EC, among legally demanded EC projects more were related to species and habitat protection than to nature reserves and Natura 2000 sites (Supplementary Material, Table 1). At the same time, species protection was seen as problematic as it is the species' legal conservation status that defined the possibility to use EC, and not its threat status or importance for the ecosystem. Most of the interviewees mentioned voluntary EC, either done by municipalities in connection to development on their own land, or by private companies. Some consultants believed that the companies did EC as a precaution in case of future demands for EC.

Interviewees most often mentioned *Individual trees and avenues* as habitats of focus for EC, particularly in urban or agricultural areas in southern Sweden. Particularly, moving trees from development areas to new areas or planting new trees, was a common practice (Supplementary Material, Table 2). *Individual trees and avenues* were followed by *forests* compensated mainly through protection and some restoration, and *wetlands and mires* compensated through restoration. Other habitats that were relatively often subject to EC were *ponds and streams* and

Table 2

Key obstacles for implementing Ecological Compensation in Sweden, as identified from the interviews. Recommendations to address obstacles from interviews and stakeholder workshop (empty cells = interviewees and stakeholders did not provide information). The section where the obstacles and recommendations are described in the text are given as number in brackets.

Obstacle	Expressed problem and need	Recommendation
Weak legal system (3.4.1)		
Limited possibilities to request EC	EC required in too few circumstances (Environmental Code too narrow) which give uncertainties in remaining cases. Lack of legally binding requirements	
Timing in decision process	Practical need to include early in decision process, but difficult since it should not be part of permit or exemption decision	Integrate EC better in the decision process, increasing the holistic thinking in the whole process (3.5.1)
Not integrated in decision process	Since EC is often not obligatory in most decisions the level of demand depends on how familiar the authority is with the process	Integrate EC better in the decision process, increasing the holistic thinking in the whole process (3.5.1)
Lack of long-term protection	No guarantee that compensation areas will be protected long term, servitude contracts possible for max 50 years	Change the legislation to allow for longer time spans (3.5.1)
EC possible for everything	No legislation considering that some values are not possible to compensate for	
Too restricted in area of EC	Authorities are not allowed to demand compensation large enough to be ecologically justified	It should be possible to compensate with a larger area than the one damaged, to increase nature's values by EC (3.5.2)
Unclear system, lack of routines and control (3.4.2)		
Lack of uniform system and practice of EC	Large differences between counties and municipalities in use of EC	EC standard for the whole country to avoid differences between geographical areas (3.5.3)
Lack of routines	Lack of routines causes insecurity; level of implementation is dependent on single individuals	Implement routines and standard approaches, making the process smoother (3.5.3)
Lack of control	Usually there is no possibility to check if compensation was conducted as promised and had expected effect	A better control system for EC and obligation for long term monitoring of outcomes (3.5.1) A national GIS-based system with all EC areas to ensure future protection (3.5.1)
Lack of resources, knowledge, and experience (3.4.3)		
Too little resources	Lack of adequate personnel resources within authorities prohibit advanced work	Smaller municipalities could take advantage of experiences from larger municipalities with more resources (3.5.3)
Reasonable costs	Need to balance the cost of EC with the benefit of the compensation	Compiled information about the price of different EC measures (3.5.3)
Lack of knowledge and experience	Projects are planned by non-biologists; too low knowledge among authorities	Established examples and better spread of knowledge among authorities, for instance through a database (3.5.3)
Lack of holistic view	Each small project is evaluated separately, making it hard to apply a landscape perspective	Apply landscape perspective, integrate into green-infrastructure plans, create lists of shortage habitats in a landscape (3.5.1); spatial information system about EC (3.5.3)
Practical issues	Discussion between authority and developers determine EC, not the ecological needs and knowledge	
Restricted access to land (3.4.4)		
Restricted access to land	Hard to find land where the compensation can be done, especially for large infrastructure projects	Bring up EC early in investment planning process, and include landowners (e. g. agricultural sector) early (3.5.1)

certain structures in agricultural landscapes, such as stone walls cultural cairns.

EC often targeted a specific species, commonly determined by the species' legal status or the CABs action plans for preservation of threatened species and habitats. Birds and amphibians were mentioned most frequently, followed by sand- and wood-living invertebrates, vascular plants including trees, and reptiles (Supplementary Material, Table 3).

3.3. Perceptions on ecological compensation

In general, EC was seen as something positive with high potential to support preservation of biodiversity and fulfilling Swedish environmental objectives, providing authorities with the mandate to demand more conservation action. Many of the interviewees were very engaged in EC and wanted "to be at the forefront of this and work forward" (CAB 1). Several interviewees mentioned the pedagogical value of EC, as it helps highlight what impact the exploitations have, engage different actors, and encourage the ones that do not usually care about natural values to take conservation actions. EC was also described as a win-win that allows for exploitation and getting natural values simultaneously, "... an entrance that makes those who want to exploit not feel so slowed down" (MUN 1). However, one municipality interviewee believed that developments could become more expensive with EC, and that this could lower the interest in voluntary EC by politicians.

The interviewees also highlighted risks with EC. Several mentioned that an EC option influences the decision-making process and can make

it easier to obtain permits for environmentally hazardous activities that would otherwise not be granted. The idea of mitigation banks (or habitat banking, i.e. a system of restoration projects instigated regardless of developments that developers can finance afterwards as compensation for their project) was mentioned by several interviewees from CABs and national authorities. This is not a system used in Sweden today, and many highlighted the risk of "greenwashing", and that "... it [EC] can be a way to buy yourself free from responsibility or from adjustment" (CAB 4). Consequently, it is important to have high standards and not allow developers to "buy themselves out with EC" (CAB 1), increasing exploitation. Also, it was further mentioned that if some actors believe that one can compensate for all interventions, they may go straight for EC and not even try to make sure to first avoid and prevent damages.

Several interviewees mentioned that because the compensation areas were usually not included in any spatial plan or database, there was a risk that they would be used for development later on, and potentially compensated with another area. In that case, there would not be any additionality, only moving around nature and "... all areas end up developed" (MUN 3).

Most of the interviewees mentioned that not all values can be compensated, because some habitats develop slowly and for some habitats there are few ecologically important areas left that could be used for compensation. For example, old-growth forests, mires and semi-natural hay-meadows are all very difficult to compensate if lost. One of the consultants complained that there is no legislation that specifies what habitats cannot be compensated, and that there is also little discussion about it. Also, several interviewees were sceptical to the idea of

“no-net-loss”. One of the municipality employees even claimed that “If you are strict, you can never compensate” (MUN 4). A representative from Swedish EPA warned that it could even be counter-productive to mention no-net-loss since it gives a false sense of not damaging natural values.

3.4. Obstacles for implementing EC

The interviewees described a range of obstacles to implementation of EC in Sweden, and they also provided thoughts on improvements to tackle these obstacles (section 3.5; for summary see Table 2). Most of the obstacles considered legal and practical issues, such as weak legal system, lack of routines or access to land. At the same time, there was less focus on biology. As one of the CAB interviewees summed it up: “I think we will get more into biology in the future. And what it is that we really want to achieve. But now we are working hard to handle these practical pieces” (CAB 1).

3.4.1. Weak legal system

Most of the interviewees complained that the Environmental Code was limiting and “unfair, inconsistent and arbitrary” (CONS 3), and that EC could be legally enforced only in some specific cases, e.g. for water-related activities and for developments affecting protected areas or species. In other cases, only voluntary compensation was possible, requiring the developer’s willingness and also the landowner’s consent about the use of land.

Some interviewees also expressed their concern with the decision process. While not compulsory, there is a general paragraph in the Environmental Code stating that EC can be requested *after* the localisation decision is made. Many CABs consider EC in their decisions, but it is not an integrated part of the decision process (for exemption). Other interviewees mentioned that the timing of including EC in the legal process presents some difficulties in itself. While a good EC process should start early on, from a legal perspective EC should not be taken into consideration when granting permission to the project.

Legislation did not define which natural values are irreplaceable and thus cannot be compensated for. Some interviewees also experienced that they were not allowed to demand compensation areas much larger than the area destroyed, even though it would be ecologically justified (if using multipliers to consider, for instance, uncertainty in outcomes and time-lags). Several interviewees mentioned that, as compensation areas are not included in the juridical determination regulation (detailed development plan), there was no guarantee that they will be secure after the time of specific contract with the developer (which could be at most 50 years but often much shorter, i.e. not much from an ecological perspective). It was also unclear who is responsible for a compensation area and for how long.

3.4.2. Unclear system, lack of routines and control

Many interviewees suggested that, as there was no uniform national system, there were large differences between different Swedish counties and municipalities in when and how EC was used. In addition, many of them expressed that they did not know how EC was done elsewhere and thus could not learn from good practices. The interviewees experienced that there were no established routines or guidelines for EC and thus large uncertainty in the process, for instance regarding who is responsible and who should bear the costs. Due to the lack of guidelines, there was a local variation in how advanced and systematic the EC was, which depended on individuals’ knowledge and ambition, and could easily change if certain committed persons quit. One of the municipality interviewees called it a “*very fragile system*” (MUN 3).

Representatives of all CABs and some national authorities also mentioned the lack of a control system for EC that would enable checking if compensation really occurred or if it achieved its objectives. Monitoring of the outcomes of compensation actions were mostly limited to larger projects, and so far, there was no systematic approach

to monitoring of EC. Several interviewees mentioned that existing monitoring was short-term, as most of the EC projects were relatively recent and many projects still running, but that more monitoring was planned. It was generally believed that long-term monitoring is needed to learn from successes and failures in EC projects. Several interviewees suggested that if monitoring was mandatory in EC projects, the likelihood for it being conducted would be higher.

There were also no sanctions, and only very small ones, if one broke any environmental rules. As one CAB interviewee believed: “*in the environmental field in Sweden we have a permissible policy on some crimes*” (CAB 2).

3.4.3. Lack of resources, knowledge, and experience

Some interviewees and stakeholder workshop participants complained about the lack of adequate resources, particularly in smaller municipalities, which limited more advanced work with EC. As one of the CAB representatives expressed it: “*It is a stressed work situation. It becomes like an additional step in the project (...) So, we choose something and are very proud and happy when we succeed with [at least] something*” (CAB 1). Also, many interviewees expressed an uncertainty in how much and how costly compensation could be requested from developers and mentioned that authorities that demanded EC were expected to “be reasonable” about its costs. As one CAB representative described it: “*... there is a reasonable balancing act in all projects. (...) we must have a basis to demand some compensation, that it will be reasonable for the costs*”. One consultant believed that the level of compensation was mainly determined by the level of demand that the approving authority had, not the ecological need.

Many interviewees emphasized the lack of knowledge and experience (although it is growing), e.g. on different species, their ecology, but also on the general effectiveness of EC, particularly given that it was usually road or spatial planners, not biologists, who planned for EC. There was also a lack of knowledge regarding a larger “*holistic*” view (in terms of landscape perspective) and including considerations for ecosystem services. Generally, compensation cases were handled individually, at detail plan level. According to one of the consultants, EC was too connected to each particular development project, while “*each development project may not affect a population. But together you get an impact*” (CONS 2). Another consultant had an impression that authorities still did not know much, and stated “*it feels like I could fool them*” (CONS 1), and wished that they better scrutinised the EC suggested by developers. As the EC depended on a negotiation between developer and the responsible authority, biological needs of the ecosystem were often disregarded as authorities preferred to ask for just a little, to at least get something. As it was explained: “*Nature never gets much, so we are happy when we get at least something*” (CAB 2), and “*we, biologists, are so starved. We are used to getting so little and nothing*” (CONS 3).

3.4.4. Restricted access to land

All the interviewees mentioned the problem with access to land to perform compensation on. This was particularly the case in large infrastructure projects. Authorities usually do not have any land for compensation. Therefore, they must negotiate with landowners or, alternatively, conduct compensation in nature reserves. Thus, EC projects were often not only about what needed to be done, but also about what was possible to find land for.

3.5. Development needs and recommendations

Key recommendations provided by interviewees and during the stakeholder workshop focused on the transparency when implementing standards, routines and control systems to ensure consistency in how similar cases were handled across the country, and a change in the legal system (Table 2).

3.5.1. Long-term strategies, holistic approach, increased control, and transparency

Several interviewees mentioned the importance of introducing EC already at the onset of the planning process. It was suggested that the agricultural sector and particularly landowners should be included in the compensation projects from the beginning to improve possibilities to access the land. It was also recommended both by some interviewees and workshop participants that agreements with landowners longer than 50 years should be possible according to the legislation.

Most of the interviewees mentioned the need to plan for EC with a landscape perspective: *“because in a small detailed development plan there can be such a small intervention that you think ‘no, it does not need to be compensated’. But then maybe we have four or five similar plans in the same area”* (MUN 1). Some suggested incorporating EC thinking in the new green-infrastructure plans presently being developed at the county level in Sweden, while others recommended creation of lists of “habitats in shortage” for each landscape, and considering species’ status in larger areas. Such list could be used for compensation and then facilitate a “net gain” (NA 3) in the landscape. As the Swedish EPA’s interviewee described it: *“... if you think about this with flexibility, that you can exchange apples with pears, you want the outcome to be that it becomes better for nature conservation”* (NA 1). Several of the interviewees mentioned that there should be more focus on *“the whole spectrum of values”* (CONS 3), including both common species or habitats and ecosystem services. The representative of the Swedish Board of Agriculture also believed that the economic value of habitats created in compensation projects could be calculated to show the environmental gain.

Higher requirements for the developers, a better control system for EC and obligatory long-term monitoring of the EC’s outcomes were also proposed. In addition, it was suggested by several interviewees that the compensated area should either be legally protected or be included in some GIS-based spatial plan, to avoid future exploitation.

3.5.2. Higher standard and increased natural values

Several interviewees claimed that compensation should be about increasing values and proposed that it should be possible to compensate with much larger areas than the damaged ones, i.e. *“overcompensate”* to *“pay off an environmental debt”* (CONS 2). As one of the STA representatives explained: *“society or the exploitation business should give back a lot more”* (NA 5). Another representative of STA also suggested that *“repairing old sins”* (NA 2), e.g. improving possibilities for animals to pass across existing roads should be allowed as compensation for new road developments.

3.5.3. Standards, routines, knowledge and good examples

All CAB representatives suggested the need to have an EC standard across Sweden. One of the CAB representatives said: *“For the CAB, it is important to have a uniform process on how to handle it [EC] so that everyone practices it fairly similarly across the country”* (CAB 1). Many interviewees suggested the need for routine approaches for EC projects and that the EC process should be very simple, *“like other processes in society, for example buying a house”* (CONS 3). In addition, a few interviewees and stakeholder workshop participants mentioned the need to have established examples of EC, best practices and *“what works and what does not work”* (NA 5). It was explained during the workshop by one of the municipality representatives that *“being a smaller municipality we need to glance at how the larger municipalities do”*. Some workshop stakeholders also brought up the need for spatial information about important habitats in the landscape and mapping tools that enable their identification. Also, information about the price for different measures would be useful for the developers, as they are often willing to include EC from the beginning of the project if they know the price in advance.

4. Discussion

In this study we explore the practical implementation of ecological

compensation (EC) and obstacles that can make it harder to achieve the biodiversity conservation goals. Although the results are from the Swedish context, we believe that they highlight the complexity of EC and problems that occur also in other countries and as such provide inspiration for policy makers and practitioners that are working with EC elsewhere. The interviewed actors held generally positive attitudes towards EC, but they also pointed out risks associated with the practice. While conservation actors felt that EC is an instrument that enables them to finally do something for biodiversity, it is also difficult to ensure that EC generates positive outcomes. Here, the biggest culprits were a missing rigorous implementation system, legal obstacles and the lack of monitoring. However, in general, interviewees working with EC in Sweden seem to have a more positive attitude to EC than the international scientific community (Curran et al., 2014; Gordon et al., 2015; Maron et al., 2016, 2012; Moreno-Mateos et al., 2015; zu Ermgassen et al., 2019).

4.1. Ecological compensation – a new concept facing many challenges

Our study shows that the implementation of EC is still relatively new in Sweden, and that it is interpreted and being used in different ways by different actors. There are still very limited national level recommendations or routines, the definitions used differ and the EC work is not fully integrated in the legal system or in the practical work routines of different authorities. This is also true in other countries where EC is being implemented (Guillet and Semal, 2018; Rega, 2013; Villarroja et al., 2014). The concept is relatively new globally (Bull and Strange, 2018), and implementation of novel concepts usually needs a long time and consideration of multiple factors to be fully integrated in a consistent national level system (Blicharska and Hilding-Rydevik, 2018). As in case of implementation of other policies and concepts (Berry and Berry, 2007; Blicharska and Hilding-Rydevik, 2018; Massey et al., 2014), there are both internal (e.g. lack of resources and knowledge) and external (e.g. weak legal system) factors that are important in operationalising EC.

Particularly, legal limitations can be important when implementing EC, as revealed in the Swedish case. For example, in Sweden EC is only legally obligatory in cases of protected areas (nature reserves and Natura, 2000-sites), and is voluntary in other cases. When voluntary, it is implemented differently depending on personal experience and interest of the responsible official, making the system fragile and unpredictable. This highlights that a strong and comprehensive legal basis is a key factor for a successful adoption of EC. Restrictive regulatory systems have been identified as an important factor that limits possibilities of ecological compensation for infrastructure projects also in other studies from France and Sweden (Guillet and Semal, 2018; Persson et al., 2015), however, to date such studies are rare.

Another legal obstacle is the inability to instigate long-term protection of compensation areas. Although temporary offsets might be more agreeable for landowners, permanent offsets are more desirable from an ecological perspective reducing future uncertainty (Moilanen and Kotiaho, 2018b). While short term thinking is commonly prevailing in spatial and economic planning (Kumar, 2010; Wittmer and Gundimeda, 2012), it is usually not relevant ecologically, as ecological processes are slow and biodiversity conservation requires a long-term perspective. Thus, it is crucial that EC systems are designed with long time perspective in mind and that relevant legislation supports that. Similarly, an important issue revealed by our study is the need for applying a landscape approach in EC implementation. In Sweden EC is usually being done in small projects not taking the landscape context into account. In addition, even though there is no size limitation in Swedish legislation, the court often rules to not allow the use of multipliers (cf. Laitila et al., 2014). Such a narrow focus in terms of landscape planning, together with the spatially small extent of compensation areas is not effective for many species, which may need larger continuous areas of suitable habitat, or well-connected networks of habitats. This may lead to a continued net loss of nature values even as individual projects try,

but are unsuccessful, to compensate for residual losses. A potential solution to this problem could be, as suggested by the interviewees, to incorporate EC thinking in the regional plans. In Sweden, these could be the new green infrastructure plans that are presently being developed at the county levels. In addition, a GIS-database with all EC areas could be created to avoid their future damages.

The concept of EC is based on policies of ensuring no net loss of biodiversity, this in turn rests on the challenging assumption that complex multi-species networks – and their associated diversity (including genetic diversity) and processes – can be reduced to simple and readily quantifiable entities. Similarly, the spatial, evolutionary, historical, social, and moral contexts of ecosystems are at large lost when they enter the realm of EC (Moreno-Mateos et al., 2012). The balancing of gains from EC to losses from the exploitation also necessitates unfailingly effective habitat restoration, or any other method used to create gains in EC. However, an appraisal of the scientific literature on restoration has shown that this is far from always achieved (Maron et al., 2012). Thus, an important obstacle in the implementation of EC is a lack of a proper control system including long-term monitoring of outcomes. While there are some studies on the effects of ecological restoration (e.g. Jones et al., 2018; Winsa et al., 2015; Öckinger et al., 2006), the scientific literature evaluating EC efforts is still at large lacking, both in Sweden and in other countries (e.g. Bull et al., 2013; Josefsson et al., 2021; Maron et al., 2016). The Swedish case also highlights a lack of EC projects evaluations in practice. At the same time, a monitoring system is crucial, not only to ensure that EC investments lead to ecological benefits but also to provide material for learning from mistakes and for creating best practices, and thus it needs to be seriously considered by any country launching EC work.

With regard to monitoring of EC, Sweden and other countries could learn from experiences from USA, where EC (often referred to as biodiversity offsetting) was first implemented through wetland mitigation banking in the 1980's (Bonnieuil, 2015). This system is based on long-term management plans that include monitoring, which makes it transparent and more evenly implemented across the country because all documentation needs to be clear and time lags must be accounted for when selling credits (i.e. calculated natural value “gains” to be substituted for the values lost at development) prior to development. However, the wetland mitigation banking system only regards wetland function, so there is a need to develop standard approaches for measuring different dimensions of biodiversity and ecosystem services. Particularly, the latter can be challenging, as indicated by the interviewees, because the methods for assessing ecosystem services are still less developed than the ones for assessing biodiversity (Blicharska and Hilding-Rydevik, 2018; Häyhä and Franzese, 2014). To judge whether an EC effort should be considered successful, concurrent sampling of losses, gains, and ideally also of control habitat to account for background changes is needed (Peterson et al., 2018). Here, consideration of development-associated losses is completely overlooked in current EC evaluations (Josefsson et al., 2021). Without this important piece of information, it is impossible to say if biodiversity gains from offsets compensate for losses. Similarly, also background changes are overall neglected. A control system for EC should regulate how offset policies value, describe and measure biodiversity, to better capture important values, as compared to the commonly used area-based metrics of today (Marshall et al., 2020). Such a control system should also make certain that offsets build on, and simultaneously contribute to, scientific evidence (zu Ermgassen et al., 2019). These are some minimum requirements of a control system for EC, which however do not resolve some of the more fundamental problematics to EC described above. Lack of resources is often mentioned as an obstacle to structured monitoring, as was also confirmed by our interviewees. In relation to that, Maron et al. (2016) have suggested that monitoring should always be included in the full costs of offset projects and that clear audit guidelines, outcomes-based contracts, and withholding payment until the positive outcome of an offset is confirmed are necessary. They also suggested

wider public participation and scrutiny to ensure that offset projects keep high standards and provide desirable outcomes.

Difficulty with access to land for conducting EC was identified by most of our interviewees, which is also in line with a study by Koh et al. (2017) of two EC projects in Sweden. This problem may also be relevant in other countries with high share of private land. One solution proposed in the literature is the use of habitat banking or compensation pools, as a way to increase land availability (eftec, IEEP et al., 2010; Ruhl and Salzman, 2006.; Wende et al., 2005). However, habitat banking systems have also been criticised because of the risk of harming biodiversity through “cutting corners in conservation” (Briggs et al., 2009). While some of our interviewees suggested compensation pools, they also expressed concerns about habitat banking and commodification of nature. The problems with a potential commodification of nature have been highlighted particularly in the ecosystem services literature (Glicksman and Kaime, 2013; McCauley, 2006), but also in relation to EC (Edvardsson Björnberg, 2020). It is increasingly recognised that to achieve environmental benefits, economic instruments cannot just rely on market logic but also require stricter regulation (Hahn et al., 2015), and thus such systems need to be designed with caution. For example, in Germany “compensation pools” have been managed by third-party agencies, instead of landowners or developers, resulting in a limited role of market regulation of price or quality (Hahn et al., 2015). However, in some contexts, such systems may not be possible without legal changes, like in Sweden where legislation does not allow for external actors to manage compensation projects. Credits, compensation pools and habitat banking have been used in some states in Australia, in Germany, UK and South Africa (Koh et al., 2014). Such systems usually include long-term management plans, ecological performance standards, monitoring requirements and standards of how the compensation value should be calculated, all of which are so far missing in the Swedish EC system and potentially also in other countries where work with EC has recently started.

4.2. Lack of conceptual clarity and limited ecological basis

There seem to still be confusion about what EC actually is and how and when it should be used, it is often mixed up with other stages of the mitigation hierarchy. In relation to that, it is important to remember that in many cases the need for EC could be avoided, if the damage can be avoided or mitigated instead. This is particularly important in case of values that could not be compensated for. In the Swedish case, the interviewees suggested “no-go” areas for exploitation, where damage should definitely be avoided (first step in the mitigation hierarchy). This particularly includes natural values that take a long time to develop. Yet, there are few science-based guidelines for the decision-making process in relation to what to avoid, as well as criteria for sites where avoidance is most important (Bigard et al., 2020; Kiesecker et al., 2010). There is a crucial need not only to develop such guidelines, but also to include specific directions about them in legislation.

There seem also to be no general agreement about whether EC should always be in-kind or could also be an out-of-kind offset. The latest research shows that offsetting policies may erode the strict protection of species and habitats, and criticise out-of-kind offsetting schemes for making promises about increasing biodiversity that are later not fulfilled (Maron et al., 2012; Moreno-Mateos et al., 2015). Most evaluated compensation projects do not reach no-net-loss even for the species and habitat values that they have measured (zu Ermgassen et al., 2019) and the calculations to determine the compensation area needed for reaching no-net-loss is often much more conservative than the estimates based on scientific evaluations (Moilanen and Kotiaho, 2018b). Clearly, there is a need for a more robust and transparent ecological basis to EC decisions, including not only a landscape perspective but also accounting for temporal trends in biodiversity, to ensure that offsets are designed to actually help avoid biodiversity loss (Overton et al., 2013). In the Swedish system, the ecological prerequisites are still downplayed, and a

holistic approach is not adopted, because the actors implementing EC need to focus on solving practical issues. This is symptomatic of new approaches in conservation that, before they can be fully operationalised, face numerous practical challenges that need to be solved first.

Limited focus on biodiversity needs is clearly illustrated by the practice of Swedish EC projects, where the species, or groups of species, and habitat types targeted by EC are a biased sample of all species and habitats within Sweden, reflecting the legislation rather than the threat status or function in the ecosystem or landscape. The targeted species and habitats appear to also reflect where compensation actions are comparably easy to achieve. This limits the potential of EC to achieve biodiversity conservation goals and thus calls for a need to identify all natural values that are in risk of being lost or damaged, and to develop approaches that consider multiple values in any efforts of promoting EC as a tool for conservation. While practical obstacles are important to overcome, ecological knowledge is central to counteract biodiversity decline.

5. Conclusions

Our study reveals that, as ecological compensation is still a relatively new concept, it has theoretical ambiguity and facing numerous challenges in practical operationalisation. While the findings are specific to Sweden, they are relevant for other countries that have recently started the work with EC and are struggling with the EC implementation on a larger scale. Particularly, we highlight the need for strong legal system that covers the EC considerations on long-term and in a comprehensive way, allowing integrating EC in the regional planning processes. We also highlight the need for better routines for the use of EC. A national GIS-based system with all EC areas (and development areas) can be an important tool for both ensuring their future protection and making it possible to monitor the regional outcomes of EC. To enable experience sharing and learning, a national level database of EC project would also be useful. Finally, there is a strong need to rely more on the ecological prerequisites and not get blind-sided by all practical obstacles in the EC work. While a large-scale practical application of EC as a conservation tool is still in its infancy, our study has outlined potential solutions that could improve the situation and thus contribute to the overall aim of mitigating biodiversity decline.

Credit author statement

MB and LAW designed the study with the help of all other co-authors, LW, JJ and MH conducted interviews, MB and LW analysed interviews and wrote first draft of the manuscript. All authors contributed to writing of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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